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# **Estimating non-use values of improved water quality and biodiversity from a discrete choice experiment on watershed protection measures**

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## **Abstract**

This paper measures the non-use values of water and biodiversity protection in a watershed in eastern France. It is generally assumed that measures to protect water quality generate direct use values for water consumers, and that the use and non-use values of biodiversity improvement are difficult to disentangle. We conducted a discrete choice experiment with a population of non-users to estimate the willingness to pay (WTP) for restrictions on pesticide and fertiliser use on agricultural land, hedgerow protection and planting, watercourse restoration and sustainable forest management. The mixed logit estimation results show significant positive preferences for measures that have positive impacts on water quality and biodiversity, but with strong heterogeneity in preferences for the different environmental attributes. We then explore this heterogeneity by first estimating the effect of individual characteristics on preferences for the status quo (no environmental project) and then regressing marginal WTP for each attribute on the individual variables. While individuals show strong opposition to the status quo and clear preferences for environmental attributes, we can see some trends in the effect of individual characteristics on the status quo choice, such as people with low levels of education or people who always drink bottled water. However, distance to the watershed has no significant effect on the status quo choice.

**Keywords:** Environmental co-benefits, ecosystem services, non-use values (NUVs), distance decay, heterogeneity, mixed logit

## 1. Introduction

Agriculture provides a number of ecosystem services (ES), but it also generates negative externalities, including contamination of drinking water resources. Therefore, mineral water companies and utilities responsible for drinking water supply need to take measures to protect catchments with agricultural land use. These measures provide tangible benefits to society by improving water quality and maintaining or even restoring biodiversity. They also have positive effects on landscapes, recreational services, etc., and provide large and diverse economic values to people at different scales (local, regional, global). In a first study, Amiri et al. (2022) focused on assessing the direct use values associated with recreational activities (hiking, hunting, picking) of the local population that could be improved by water protection measures in the Vittel impluvium operated by Nestlé Waters France. In this paper, we estimate preferences for measures implemented in the Vittel impluvium to protect water resources and biodiversity, focusing on the preferences of non-users, using a multi-attribute Discrete Choice Experiment (DCE).

The usefulness of ecosystem service valuation for measures to protect and restore aquatic environments has recently been recognised in France (Amigues and Chevassus- au-Louis, 2011). While water management policies initially focused mainly on water quality and availability, the good ecological status of water bodies has gradually become an important issue, in particular with the publication of the European Water Framework Directive (WFD) in 2000. Although the WFD does not explicitly mention the notion of ES (Amigues and Chevassus-au-Louis, 2011), actions taken to achieve good water status have a direct impact on ecosystems (Salveti, 2013; CGDD, 2014). However, the WFD can be seen as the starting point for the use of economic analysis in water management in France (MEDD, 2005), in particular through cost-benefit analysis (MEDD, 2005; Salvetti, 2013; CGDD, 2014, Feuillette et al. 2015, 2016). An important distinction in the economic valuation of ecosystem services is between use and non-use values. Use values are based on the benefits derived from the direct use (consumptive or non-consumptive) of natural resources or from indirect use (the conditions that allow use and satisfaction), while non-use values refer to the benefits derived by an individual from knowing that others will have access to the benefits of nature, whether other people living today or future generations (bequest value), or from knowing that something exists even if there is no direct access to or direct enjoyment of it (existence value) (IPBES 2022). The analysis of measures to protect and restore aquatic environments includes environmental benefits (and costs) for which non-use values (NUVs) can be significant (MEDD, 2005).

Over the years, the measurement of NUVs has become an important issue and environmental economists have developed valuation methods to account for these values (Adamowicz et al. 1998; Pearce, 2002, Banzhaf, 2016). Historically, the contingent valuation method (CVM) has been widely used to value NUVs (Bateman and Langford, 1997; Adamowicz et al. 1998; Colarullo and Peres, 2003; Kafy et

al. 2018), although the method has been questioned (Desvouges et al. 1993; 2010). Comparing the ability of CVM and DCE to assess such values, Adamowicz et al. (1998) concluded that DCE performed well. In addition, Alpizar et al. (2001) suggest that DCE is less subject to the warm glow effect than CV when making such valuations.

Following Adamowicz et al. (1998), some authors only estimated NUVs: for example, Windle and Rolfe (2005) assessed only NUVs for the protection of the Fitzroy estuary in central Queensland, Australia. Others, such as Johnston et al. (2005) and Moore et al. (2018), chose to examine both. An advantage of this approach is that it allows comparisons to be made between the two groups (users and non-users). Whether researchers want to estimate use values only or both use values and NUVs, they need to decide how to define non-use and non-users in order to distinguish them from use (and therefore users).

Traditionally, the literature has identified two approaches to determining NUVs (Marre et al. 2015; Johnston et al. 2003). The first is to target a population that will certainly never use fresh water, cultural services, etc. (e.g., because of distance) and then ask them about their willingness to pay (WTP). The second is to consider users and non-users in the sample and estimate values for both groups. Both approaches raise definitional issues (Marre et al. 2015; Johnston et al. 2005). In general, the literature defines non-users as individuals who have not used a resource in a defined historical period, and do not expect to use it in a similar way in a defined future period (Johnston et al. 2003). Users, on the other hand, are typically defined in terms of their participation in (recreational) activities at the site of interest during a defined period of time: There is no consensus on the time period to be considered: Moore et al. (2018) conducted a DCE in the Chesapeake Bay estuary in the United States, estimating the WTP for improvements in five environmental attributes for a sample of users and non-users. The former was defined as individuals who participated in recreational activities at the Bay within the last five years. Amiri et al. (2022) considered the same time lag in their DCE study specific to recreational use values, while Farber and Griner (2000) considered the last two years. Finally, Tu and Abildtrup (2016) focused on the last 12 months. Alternatively, in a DCE on salt marsh restoration efforts in Rhode Island, Johnston et al. (2005) distinguished between recreational non-users (who did not visit the site for recreational purposes) and complete non-users (who did not use the site for recreational purposes and also did not drive by (regularly) or live within sight of the Rhode Island salt marsh). Respondents who did not fall into either of these categories were considered users. In this study, we identify non-users by excluding local residents (potential recreational users) and the population that consumes drinking water from the catchment.

Numerous applications of stated preference methods have been used to assess non-market values of watersheds or river basins (Loomis, 1997; Duberstein and de Steiguer, 2003 and Thurston et al. 2009). If contingent valuation has been widely used in the past (Duberstein and de Steiguer, 2003) and is still

being used (Abebe et al. 2019), the DCE method has become popular for conducting such valuations. Case studies of DCE assessing preferences for watershed/river basin ES can be found all over the world (Kaval, 2019): in Europe (Garcia Llorente et al. 2012; Hernandez and da Costa, 2022; Amiri et al. 2022), in the United States (Shrestha and Alavalapati, 2004; Chaikaew et al. 2017; Aguilar et al. 2018) or in Asia (Cheng et al. 2021; Khan et al. 2021, 2019).

Most of this literature investigated local population preferences for ES or land use management (Amiri et al. 2022; Cheng et al. 2021; Hernandez and da Costa, 2022; Chaikaew et al. 2017; Garcia Llorente et al. 2012). However, some authors used a different strategy: Aguilar et al. (2018) conducted a national survey on ES from forested watersheds and attitudes towards payment for environmental services (PES) programmes. Moore et al. (2018) conducted a DCE on water quality improvements in the Chesapeake Bay, surveying residents of the 17 eastern states and the District of Columbia to enable NUV assessment: about 70% of respondents were non-users of the Chesapeake Bay or watershed lakes. These papers analyse the heterogeneity of preferences and WTP, in particular heterogeneity based on the residential location, heterogeneity related to water quality improvements, and observed individual heterogeneity. It is now widely recognised that the major limitation of conditional logit models is that they assume that preferences are identical for all individuals. The ability to account for individual-specific effects make it possible to overcome this limitation by allowing for variation between individuals using mixed logit, or variation between groups of individuals using latent class logit models. Some research goes further in exploring issues of heterogeneity: Zhao et al. (2015) evaluate ES in the context of watershed restoration and highlight the issue of heterogeneity in valuation, which could be due to differences in natural context and socio-economic characteristics. Based on data from a DCE and a mixed logit estimation of preferences, they estimate individual-specific WTP as a regression of several individual variables to analyse the sources of potential preference heterogeneity. Indeed, many studies estimate interaction terms between attribute variables and individual characteristics to capture systematic preference heterogeneity and still directly interpret the associated coefficient as an interaction effect. However, in nonlinear models such as logit or probit models, the marginal effect on choice probabilities of a change in both interacted variables is not the coefficient of the interaction term (Ai and Norton, 2003), except in some specific cases where the interactions are with the status quo constant (Garcia et al. 2024).

The existence of distance decay in NUVs, where the value decreases with distance to the environmental good being valued, has been widely discussed in the literature (Glenk et al. 2020; Johnston et al. 2015), with mixed empirical results (Johnston et al. 2015, Schaafsma et al. 2013). Farber and Griner (2000) tested the existence of a distance effect for both users and non-users in a study of watershed quality improvements for two streams in western Pennsylvania. They found that non-users placed low and statistically insignificant values on stream improvements, and that these values were unrelated to

distance from the streams. They interpreted this as consistent with a 'purist' interpretation of NUVs, which suggests that NUVs must be spatially independent to be clearly distinguished from use values. Hanley et al. (2003) tested whether the distance decay effect is different for a single environmental good (the Mimram River) than for a larger set of goods (all rivers in the Thames region). Specifically, they estimate Tobit regressions where the dependent variables are positive WTP as a function of individual characteristics and distance to the environmental good, depending on use values and NUVs. Moore et al. (2018) found no distance decay in WTP.

Our study aims to assess preferences and in particular NUVs for environmental improvement projects in a specific watershed using a DCE. We would like to know whether these values exist and what their amplitude is for each of the following water and biodiversity protection measures implemented by Agrivair, the Nestlé Waters subsidiary responsible for protecting the water quality of the Vittel impluvium: reduction of pesticide and fertiliser use, protection and planting of hedgerows, restoration of watercourses and sustainable forest management. Therefore, a major contribution of our study is to assess the non-use values of catchment restoration and protection measures. These non-use values are in addition to the use values of local residents documented in Amiri et al. (2022). Another focus is the existence of a distance effect on environmental preferences, by interviewing people living either near or far from the watershed. In this way our study also contributes to the unresolved debate on the existence of distance decay for non-use values. Finally, assessing WTP is useful for public decision-makers to know which protection measures to target. However, the analysis of preference heterogeneity leading to WTP heterogeneity could help to guide and calibrate more efficient public taxes or subsidies. Thus, another contribution of this paper is to identify the sources of heterogeneity and the factors influencing the estimated WTP.

The rest of the paper is structured as follows: In the next section, we present our methodology by describing the literature on NUVs in the context of watershed water and biodiversity protection policies, the study area and the DCE design. Section 3 describes the econometric models used for the empirical analysis and the descriptive statistics of the sample. We then present the estimation results and provide an in-depth analysis of the heterogeneity of preferences in section 4. Finally, we discuss our findings and conclude the paper.

## **2. Methodology**

### **2.1 DCE and watershed management**

Our study assesses preferences for NUVs of watershed water and biodiversity protection measures by targeting non-users. We use a stated preference approach, i.e. DCE, in which respondents reveal their preferences by choosing between different alternatives. According to Holmes et al. (2017), “there has

been an explosion of interest” in DCE during the past two decades. The method began to be applied in the early 80s (Hernandez and da Costa, 2022) with the works of Louviere and Hensher (1983) and Louviere and Woodworth (1983). DCE gradually became more popular than all other environmental valuation methods (Guijarro and Tsinaslanidis, 2020), including contingent valuation (Mahieu et al. 2014; Guijarro and Tsinaslanidis, 2020). The paper that “generated attention in the environmental economics community” (Carson and Czajkowski, 2014) was that of Adamowicz et al. (1998), who used both a DCE and revealed preference data on recreational destinations to value environmental amenities.

As written previously, DCE investigated preferences for watershed/river basin ES in a variety of contexts and countries (Kaval, 2019): in Europe (Garcia Llorente et al. 2012; Hernandez and da Costa, 2022; Amiri et al. 2022), in The United States (Shrestha and Alavalapati, 2004; Chaikaew et al. 2017; Aguilar et al. 2018) or in Asia (Cheng et al. 2021; Khan et al. 2021, 2019). Even if these watersheds/river basins might share some characteristics, every site is unique and different factors, such as land use/ land cover features, may influence ES provision (Postel et Thompson, 2005; Smith et al. 2006; FAO, 2006).

## 2.2 Study area and experimental design

We designed the DCE to estimate the economic value of protecting water quality and biodiversity in a particular watershed, focusing on the NUVs. However, groundwater protection has direct use values for water consumers, and biodiversity protection may increase recreational value for local landscape users. Therefore, to estimate the NUVs, we identified a specific watershed in a rural area with low population density and clearly defined water users. To make our scenarios as realistic as possible, we specified hypothetical measures for the Rupt de Mad watershed located in the Rhin-Meuse Basin (Figure 1), which is currently part of a project to improve biodiversity and water quality. Residents consuming drinking water from this watershed were then excluded from the sample (residents of Metz and surrounding municipalities). Although one of the objectives of the study is to test the environmental characteristics corresponding to specific measures implemented by Agrivair on the Vittel impluvium, we have preferred not to use the impluvium as a study area in order to avoid any bias that might be associated with the reputation of the site (including feelings for or against Nestlé Waters).



a)



b)




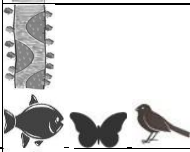

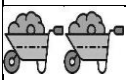

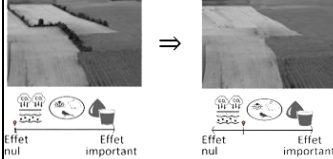


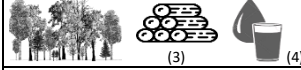

**Figure 1: a) Outline of the Rhine-Meuse Basin (BRM) in black (source: Bassins hydrographiques – Métropole 2019 - BD Topage® IGN) and b) the Rupt de Mad watershed in black (source: Agreste Grand Est, fiche territoriale)**

We surveyed a representative sample of residents in the area covered by the Rhin-Meuse water agency. Water agencies (*Agence de l'eau*) are French public institutions created in 1964 to manage and preserve water resources and the aquatic environment. Inspired by foreign initiatives (Brun, 2012; Barraqué et Laigneau, 2017), French water policy remains somewhat unique (Feuillette et al. 2015): in fact, the 1964 law is also the origin of other governance structures, such as the basin committee (Brun, 2012, Feuillette et al. 2015, 2016). The French territory is divided into six river basins, and each of them has a consultative structure (*Comités de bassin*) and an executive structure (*Agence de l'eau*). According to the "polluter-pays principle", the agencies receive royalties from water users (companies, households, etc.) depending on the level of water pollution and the extraction of resources (Brun, 2012, Feuillette et al. 2015). These fees are then used to finance projects to improve water management and quality at the level of the river basin. This reciprocity is referred to as the "water-pay-water" principle (Brun, 2012; Barraqué and Laigneau, 2017). Such projects are selected according to criteria defined in a multiannual programme and validated by a basin committee (Brun, 2012, Feuillette et al. 2015). The water agency therefore has a credible framework for introducing hypothetical protection scenarios.

In our questionnaire, we first presented the context of the watershed improvement projects to the respondents, i.e. the role of the Rhin-Meuse water agency in the protection of water resources and biodiversity. We explained that they participate in the financing of projects to promote practices that are more favourable to water quality (less intensive use of pesticides, etc.) and the protection of biodiversity. The respondents are informed that such measures contribute to improving the quality of the raw water, thus reducing the cost of water treatment, which benefits consumers in Metz and the surrounding communes. As these residents are excluded from the analyses, our sample only includes respondents who do not directly benefit from improved water quality.

The attributes included in the DCE were selected through a literature review and discussion with stakeholders and agricultural scientists (Table 1). These included five attributes related to agricultural and forest land use, the dominant land uses in the catchment: pesticide use, watercourse restoration, type of fertiliser used on agricultural land, hedgerows and forest management. The sixth attribute, the means of payment, was an increase in the annual water bill (corresponding to the current practice of financing environmental measures) between 1 and 55 €. The levels of the different attributes refer to environmental measures that the project plans to implement or not: for example, watercourse restoration (narrowing of streams to allow faster water flow, planting of trees, etc.) may or may not be included in the project. The number of levels considered depends on the attribute: attributes related to pesticides, renaturation and forest management have only two levels each, while hedgerows management and fertiliser application have three levels. Including an additional level for these attributes allowed us to consider a variety of possible management practices.

**Table 1. Description of the attributes of the DCE**

Characteristics	Levels	Meaning
Pesticides		The project plans to ban the use of pesticides.
	 (1)	The project does not plan to ban the use of pesticides.
Renaturation of watercourses		The project does not involve the restoration of a watercourse.
		The project involves the renaturation of a watercourse (narrowing the stream to allow water to flow more quickly, planting trees, etc.). This will encourage the development of aquatic and terrestrial biodiversity.
Type of fertiliser	 (2)	Organic fertiliser is applied at low rates to all agricultural land (100%). No negative impacts on biodiversity and water quality are observed.
		Significant application of organic fertiliser to part of agricultural land. Local negative impacts on water quality and biodiversity.
		Maximum amount of organic and chemical fertiliser allowed by law. Overall negative impact on water quality.
Hedgerows		Without the project, hedgerow clearance will continue. Negative impact on landscape, carbon sequestration, biodiversity (birds, insects, etc.) and water quality.
		Maintain hedgerows to avoid negative impacts on water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species.
		Planting hedges. Significant positive impact on landscape, water quality, carbon sequestration and biodiversity (birds, insects, etc.) and plant species.
Forest management	 (3) (4)	Forest management for timber production and protection of water resources.
		Forest management with the aim of producing timber, protecting water resources, and preserving biodiversity.
Increase in annual water bill	Increase between €1 and €55 1, 5, 10, ..., 55€ (12 values) if no project: 0€	Increase in the annual water bill to fund the project.







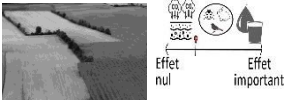


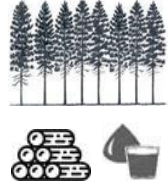
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Researchers use an experimental design “to map attributes and levels into sets of alternatives from which respondents indicate their choices” (Johnson et al. 2013). The design aims to isolate the effects of individual attributes on choices (Hanley et al. 1998). In our case, we generated 24 choice sets, which were divided into three blocks of eight choice sets to reduce the number of choices per respondent. An efficient statistical design was estimated using NGENE (ChoiceMetrics 2014). The design was estimated using priors based on a previous study in the same region (Amiri et al. 2022) and discussions with stakeholders.

Table 2 shows an example of a choice card: respondents are given three alternatives. The status quo is based on the absence of an environmental project. Including a status quo alternative in the DCE is generally recommended (Penn et al. 2019; Marsh et al. 2011; Hensher, 2010) for various reasons, such as making choice tasks more realistic or avoiding forced choices that can lead to biased welfare estimates.

**Table 2. Choice set example**

Please choose one of the three options below:

Characteristics	Absence of project	Project A	Project B
Pesticides			
Renaturation of watercourses			
Type of fertiliser			
Hedgerows			
Forest management			
Increase of annual water bill	0€	50€	20€

Your choice:



### 3. Empirical Analysis

DCE has its theoretical foundation in the new Lancaster's Theory of Value (Lancaster, 1966), and its econometric basis is the Random Utility Model (RUM, McFadden, 1973, 1981, 2001): RUM aims to model the choices of individuals among discrete sets of alternatives  $j$ . It assumes that preferences for the different alternatives can be described by a utility function. In a given sample of  $N$  respondents, each respondent  $n$  faces  $T$  choice situations. Each choice situation has a choice set of  $J$  alternatives. The total utility for respondent  $n$  choosing alternative  $j$  in the choice set in situation  $t$  is  $U_{njt}$ . This utility depends on a component that the researcher can observe, called the deterministic part of the utility attributes ( $V_{njt}$ ) and a random component that cannot be observed ( $\varepsilon_{nj}$ ):

$$U_{njt} = V_{njt} + \varepsilon_{njt}, \quad n = 1, \dots, N, \quad j = 1, \dots, J \quad t = 1, \dots, T \quad (1)$$

The deterministic part  $V_{njt}$  is a function of  $X_{njt}$ , the vector of attributes relating to alternative  $j$ , and other observed factors such as individual characteristics  $Z_n$ :

$$V_{njt} = V(X_{njt}, Z_n) \quad (2)$$

The random error term  $\varepsilon_{njt}$  is i.i.d. as a Gumbel law (or type I extreme value).<sup>1</sup> The relative contribution of each attribute  $X_{knt}$  to the total utility  $U_{njt}$  can be represented by a parameter  $\beta_{kn}$ , while the parameters  $\gamma_l$  are associated with the  $l$  individual characteristics  $Z_n$ . From here on, we consider that the utility parameters to be estimated are embedded in a vector of parameters  $\theta_n$ , associated with the regressors  $R_{njt} = (X_{njt}, Z_n)$ .

The individual chooses the alternative  $i$  in each alternative in each choice set that provides the highest utility:

$$U_{nit} \geq U_{njt}, \quad \forall i, j \in t, \quad i \neq j. \quad (3)$$

In contrast to utilities, only the choice preferred by individual  $n$  is observed. Therefore, we want to estimate the probability that individual  $n$  chooses alternative  $i$  for each set of choices  $t$ :

$$p_{nit} = \Pr(U_{nit} \geq U_{njt}) = \Pr(\varepsilon_{njt} - \varepsilon_{nit} \leq V_{nit} - V_{njt}), \quad (4)$$

where the new error term  $\varepsilon_{nit} = \varepsilon_{njt} - \varepsilon_{nit}$  follows a logistic distribution, giving the choice

probabilities:  $p_{nit} = \frac{\exp(\varepsilon_{nit})}{\sum_{j=1}^J \exp(\varepsilon_{njt})}$ .

### 3.1 Econometric models

According to Train (2009), various econometric models can be used to explain respondents' choices and to interpret the results. The conditional (multinomial) logit (CL), the most commonly used model to explain discrete choices, can be described by the probability that an individual  $n$  chooses alternative  $i$  in choice situation  $t$ :

$$P_{nt}(i) = \frac{\exp(R_{nit}\theta)}{\sum_{j=1}^J \exp(R_{njt}\theta)} \quad (5)$$

---

<sup>1</sup> The Gumbel density of the error term of utility is  $\exp(-\varepsilon_{njt})\exp[-\exp(-\varepsilon_{njt})]$  and the cumulative distribution is  $\exp[-\exp(-\varepsilon_{njt})]$ , with a variance of  $\pi^2/6$ .

However, the CL model assumes independence of irrelevant alternatives (IIA) and that respondents' utility functions are identical, implying that preferences must be homogeneous, so that the parameters associated with the regressors are constant:  $\theta$ .

Other models, such as mixed logit (MXL) models, attempt to address these issues by allowing parameters to vary randomly across individuals ( $\theta_n$ ). It is generally assumed that preferences vary between respondents, but not between choices made by the same respondent. Therefore, "a clustered specification is applied that allows for repeated choices for each individual" (Revelt and Train, 1998). The conditional probability of the MXL model can be written as following:

$$P_{nt}(i|\theta_n) = \frac{\exp(R_{nit}\theta_n)}{\sum_{j=1}^J \exp(R_{njt}\theta_n)} \quad (6)$$

In the case of multiple choices for each respondent, the logit probability refers to the probability that the individual  $n$  makes a sequence of  $T$  choices specified as  $t = \{1, \dots, T\}$ . Knowing the probability of each choice as presented by equation (6), the logit probability of the observed sequence of  $T$  choices conditioned on  $\theta_n$  is given by:

$$P_n(j_{n1}, \dots, j_{nT_n}|\theta_n) = \prod_{t=1}^{T_n} P_{nt}(j_{nt}|\theta_n) \quad (7)$$

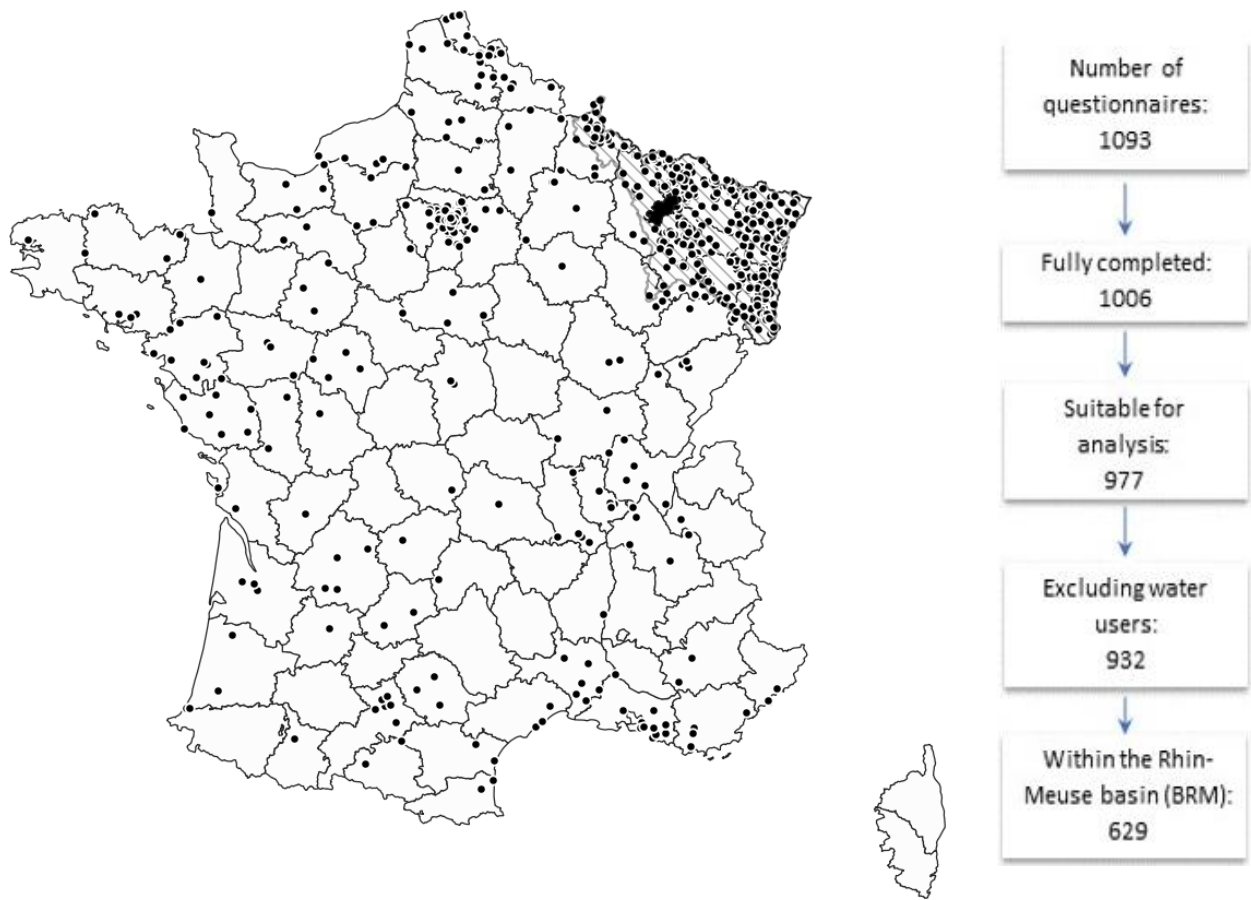
In our paper we used the statistical software STATA MP 18 and the the mixlogit package (Hole, 2007) and the clogit command. All of these commands handle fixed effects and are therefore well suited to our dataset, where individuals make a sequence of  $T$  choices.

The application of the MXL allows to compute estimates of individual-specific preferences by deriving the conditional distribution based (within the sample) on their known sequence of choices (Train, 2009 chapter 11; Hensher et al., 2006). In our study, we regress the estimated individual-specific marginal WTP on respondent characteristics to better understand preference heterogeneity (see also Abildtrup et al., 2013, and Neves do Prado and Abildtrup, 2022). It should be noted that, strictly speaking, these conditional parameter estimates are not a unique set of estimates for the individual, but rather a mean and standard deviation estimate of the subpopulation making the same choices given the same choice sets (Hensher et al., 2006). The individual-specific parameter estimates are obtained using Bayes' theorem, which estimates the conditional density for the random parameters.

### 3.2 Descriptive statistics

The descriptive statistics on individual characteristics presented in Table 3 are based on the 977 questionnaires that were suitable for analysis. Figure 2 shows the step of managing the responses to the questionnaires and summarises the choices made by the respondents in the DCE. Out of 1093

questionnaires, 1006 were fully completed. We also removed people who didn't understand the DCE exercise, based on their self-reports on follow-up questions to the DCE.



**Figure 2. Sample, observations and geographical distribution**

Initially, the survey and the DCE were only intended for people living in the Rhine-Meuse Basin (BRM), where everyone pays the same charges directly on their water bill, which is collected by the water authority. However, people outside the BRM were also interviewed. This allows us to test whether the latter have understood the lack of credibility of the payment method, since they are not affected by the BRM agency taxes, but by those of their water agency.

Because we focused on NUVs, we removed from the sample individuals who were identified as water users.<sup>2</sup> 47 respondents, from 13 different municipalities were in this case. We also separated people who are not located in the BRM, because they are not likely to pay for environmental projects through a water bill increases.

<sup>2</sup> See <https://www.regie-eau-mm.fr/espace-usagers/communes-desservies-2250.html>

Table 3. Demographic and socio-economic statistics (674 indiv.)

Variable	Modality	%
Gender	Men	47.63
	Women	52.37
Age	[18-24 years old]	9.94
	[25-29 years old]	4.19
	[30-34 years old]	8.01
	[35-39 years old]	7.27
	[40-44 years old]	9.05
	[45-49 years old]	10.39
	[50-54 years old]	8.31
	[55-59 years old]	8.61
	[60-64 years old]	11.42
	[65-69 years old]	13.20
	[70-75 years old]	7.12
[>75 years old]	1.48	
Education	General certificate of secondary education	22.55
	High school diploma	29.23
	High school diploma + 2 years	24.04
	High school diploma + 3 years	9.35
	High school diploma + 4 and +5 years	6.08
		7.57
	Doctorate	1.19
Occupation	Farmer	0
	Independent	1.78
	Manager	8.31
	Retired	28.04
	Worker	6.53
	Employee	27.75
	Intermediary	11.87
	No activity	15.73
Percentage of bottled water drinkers	Never	17.36
	Occasionally	45.10
	Mostly	22.85
	Always:	14.69

The survey provided us with information on the socio-economic profile of the respondents: A slight majority of respondents were women (53.12%). People aged between 65 and 69 were the most represented in the sample (12.18%). Just over half of the respondents (51.17%) did not have a high level of education (high school diploma or less). Looking at the sample without excluding water users (from Metz and the surrounding area) and people living outside the Rhin-Meuse basin, the proportion of "mixed" water drinkers (people who drink both bottled water and tap water) is somewhat comparable to that observed at national level (67.04% in our study versus 74% at the national level<sup>3</sup>).

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<sup>3</sup> See CIE (2022).

After excluding the inhabitants of Metz and surrounding areas whose tap water comes from the Rupt de Mad catchment area (45 respondents), we can analyse the results of the DCE. Some statistics on their choices are given in Table 4.

Table 4. Descriptive summary of DCE results (629 indiv.)

Variable		
Choice (in %)	No Project	15.62
	Project A	45.47
	Project B	38.91
Average payment for a project (in €)	No Project	0
	Project A	24.35
	Project B	23.60
Attribute non-attendance (in %)	Did you consider all the attributes when choosing between the different projects?	86.80
Non-attendance, which attribute? (in %)	Price	5.25
	Pesticide	3.02
	Watercourse restoration	2.23
	Fertilisers	4.93
	Hedgerows	4.45
	Forest management	2.86
Reasons of systematic SQ (in number of choices)	Water quality and biodiversity protection are not important to me	16
	The characteristics of projects A and B did not suit me	24

Respondent giving the following reasons for always choosing the status quo were excluded from the sample: (i) Protest responses: “These projects should not be financed by increasing water bills”, “These costs must be borne by the landowner”, “I already pay too much for my water”, or (ii) misunderstanding: “The number of attributes to be compared was too large”, “I didn't understand what was being asked of me”. The analysis of non-attendance in attributes showed that a large majority of respondents took all characteristics into account when answering the DCE, regardless of whether they lived in the BRM or not.

## 4. Estimation results

### 4.1 CL and MXL models

As a preliminary test, we took advantage of having data from respondents outside the BRM to test whether they would view the DCE differently, in particular knowing that the tax on the water bill was only introduced for people inside the BRM. To do this, we introduced the interaction term (water bill  $\times$  BRM) in the CL model and found a significantly negative parameter. Together with the negative parameter of the water bill, this indicates that respondents inside the BRM are more sensitive to the price and will therefore have a lower WTP than respondents outside the BRM.<sup>4</sup>

<sup>4</sup> Estimation results are available on request from the authors.

Based on the responses to the DCE for the sub-sample of respondents within the BRM used for all the results below, we report the estimation results of the CL and MXL models in Table 5. After excluding two respondents living in proximity to the watershed, the main econometric estimates concern 627 individuals.<sup>5</sup> Comparing the CL and MXL results, the first thing to note is that although the signs of the parameters are the same, the values are quite different. However, the most notable difference is that the CL model shows that people strongly prefer hedgerow planting to hedgerow clearing or hedgerow conservation, whereas the MXL model shows that the preference goes towards hedgerow conservation.

**Table 5. Estimation results of the CL and MXL models**

VARIABLES	(1)	(2)	
	CL choice	Mean	SD
Water bill	-0.0132*** (0.000946)	-0.0201*** (0.00151)	
ASC	-0.745*** (0.0673)	-0.847*** (0.0870)	
Pesticide ban	0.446*** (0.0328)	0.596*** (0.0737)	1.418*** (0.0792)
Watercourse restoration	0.301*** (0.0329)	0.385*** (0.0619)	0.981*** (0.0715)
No negative effect of fertiliser	0.109** (0.0446)	0.188*** (0.0662)	0.388*** (0.150)
Local negative effect of fertiliser	0.0351 (0.0448)	0.0357 (0.0666)	-0.527*** (0.106)
Hedgerow planting	0.112** (0.0449)	0.122 (0.0758)	1.068*** (0.0903)
Hedgerow conservation	0.0681 (0.0457)	0.120* (0.0620)	-0.252 (0.192)
Forest management for water and biodiversity	0.148*** (0.0328)	0.171*** (0.0594)	0.874*** (0.0715)
Log likelihood	-4858	-4489	
Chi-squared	1305	738.8	
Prob > chi2	0.000	0.000	

Notes. Obs. = 15,048. Individuals = 627. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Number of draws used to simulate of the MXL model = 10,000.

Focusing now on the MXL results (in column 2), we can first note that all the standard deviations associated with the mean coefficients of the random variables are significantly different from zero, except for hedgerow conservation, indicating the existence of a strong heterogeneity of preferences for the different environmental attributes.

The parameter ASC associated with the SQ, i.e., the 'no project' alternative, is significantly negative, implying that respondents preferred to choose a project rather than the SQ. As expected, the coefficients

<sup>5</sup> The total number of observations for the multinomial logit analysis is 15,048, i.e., 627 individuals × 3 alternatives × 8 choice sets.

associated with the attributes "ban on pesticides", "restoration of watercourse" and "no negative effect of fertiliser" are positive (all highly significantly different from zero). The overall negative effect on water quality resulting from the use of both organic and chemical fertilisers is rejected by individuals. Hedgerow conservation is preferred to hedgerow clearing without the project, but only significantly at the 10% level, while there is no significant preference for hedgerow planting over hedgerow clearing. Finally, forest management that favours biodiversity (in addition to timber production and water conservation) is valued by the respondents.

## 4.2 Heterogeneity in preferences

In this section we want to explore the extent and nature of heterogeneity in preferences for water and biodiversity conservation measures. To do this, the distributions of the attribute parameters (excluding distance variables) reported in column 2 of Table 5 are plotted in Figure 3. As explained above, it is possible to compute estimates of individuals' specific preferences from the MXL by deriving the conditional distribution based (within the sample) on their known sequence of choices (Train, 2009 Chapter 11; Hensher et al., 2006).

We have overlaid a histogram of the frequencies of the different continuous variables along a scaled normal density and a kernel density estimate of the density. We can better see the strong heterogeneity of preferences for several attributes, especially for pesticide ban, watercourse restoration, hedgerow planting and forest management for water and biodiversity, and to a lesser extent, for no negative effect and only local effect of fertiliser. For example, we see that although the mean parameter for pesticide ban is positive and highly significant, there is also a certain number of respondents with negative preferences for pesticide ban. We can also see that the normal distribution is quite appropriate for each attribute, except for the attributes 'local negative effect of fertiliser' and 'hedgerow planting', where the distribution has two peaks, but the estimated mean parameters are not significantly different from zero.

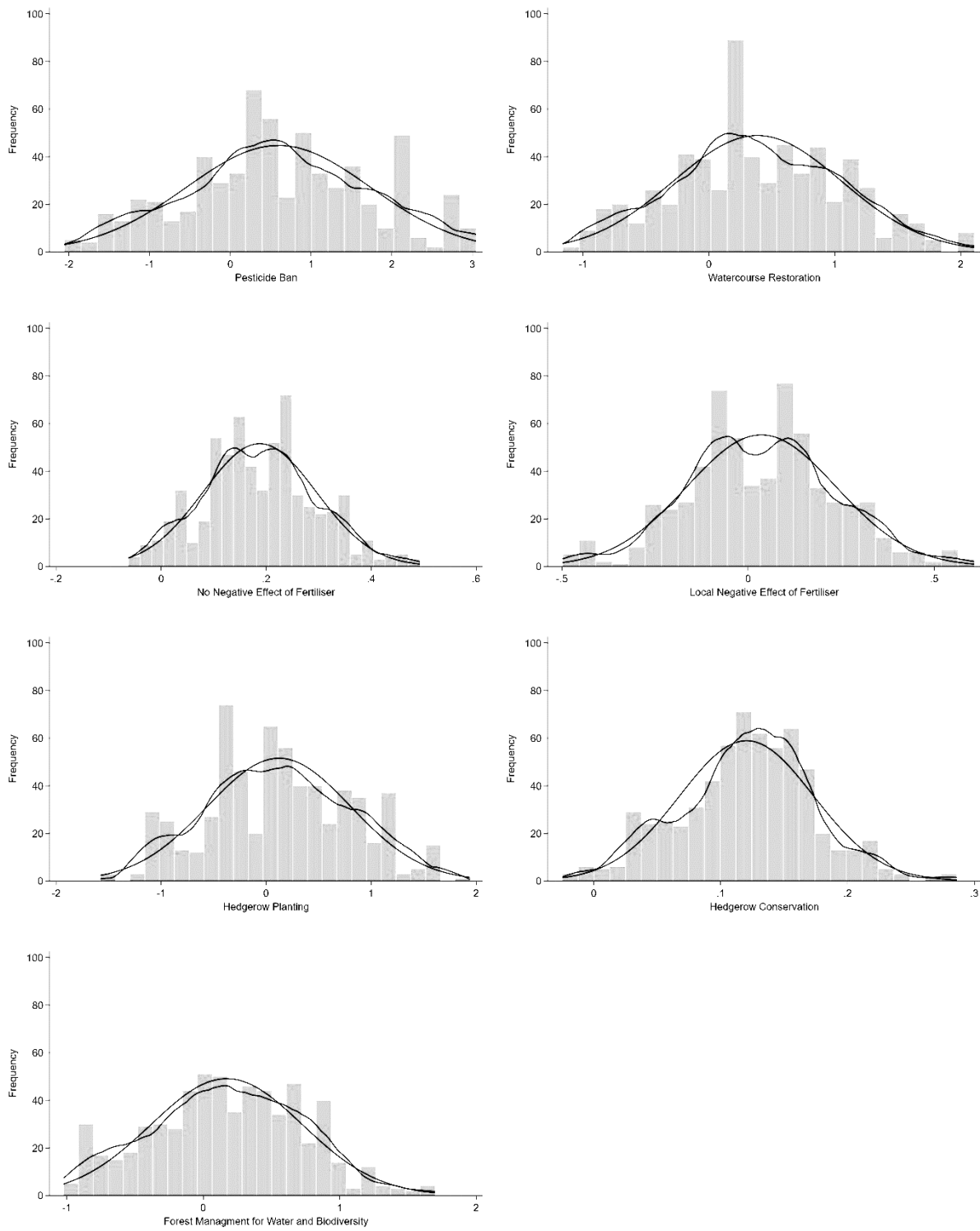


Figure 3. Distribution of preference parameters for the different environmental attributes

**Table 6. Estimation results of the MXL model with individual variables**

VARIABLES	Mean	SD	Mean	SD	
Water bill	-0.0196*** (0.00147)		Pesticide ban	0.581*** (0.0713)	1.362*** (0.0769)
ASC	-0.524 (0.385)		Watercourse restoration	0.379*** (0.0593)	0.913*** (0.0699)
ASC × Dist	-0.00161 (0.00106)		No negative effect of fertiliser	0.198*** (0.0640)	-0.265 (0.200)
ASC × Male	-0.313*** (0.120)		Local negative effect of fertiliser	0.0499 (0.0649)	-0.461*** (0.113)
ASC × Age	0.0242 (0.0266)		Hedgerow planting	0.118 (0.0737)	1.023*** (0.0876)
ASC × Degree	-0.174*** (0.0450)		Hedgerow conservation	0.121** (0.0600)	0.115 (0.308)
			Forest management for water and biodiversity	0.171*** (0.0574)	0.831*** (0.0702)
<b>Occupation (Ref. = Manager, independent)</b>					
ASC × Retired	0.525* (0.277)				
ASC × Worker	0.264 (0.327)				
ASC × Employee	0.906*** (0.258)				
ASC × Intermediary	0.567** (0.277)				
ASC × No activity	0.881*** (0.281)				
<b>Bottled water drinkers (Ref. Always drink)</b>					
ASC × Never drink	-0.133 (0.184)				
ASC × Occasionally drink	-0.606*** (0.159)				
ASC × Mostly drink	-0.425** (0.176)				
Log likelihood	-4442				
chi-squared	675.4				
Prob > chi2	0.000				

Notes. Obs. = 15,048. Individuals = 627. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Number of draws = 10,000.

Second, we attempted to identify any observed heterogeneity by interacting individual characteristics with the status quo (SQ, i.e., the choice of no environmental project). The estimation results of the MXL logit with individual variables are presented in Table 6. We make an initial investigation into the existence of a distance decay effect on SQ. One hypothesis to be tested was that the further individuals are from the Rupt de Mad watershed, the less concerned they are about improving environmental quality. We calculated distances (denoted Dist) using the centroid of the respondent's municipality of residence (Farber and Griner, 2000; Campbell et al. 2008, 2009; Rolfe and Windle, 2012) and considered straight line distances to the nearest point of the Rupt de Mad watershed (we use the closest point to the boundary of the watershed to calculate the distance), as this may be appropriate for assessing NUVs

where access to the site of interest is not required (De Valck et al. 2017; Holland and Johnston 2017). We can see that the variable Dist has no significant effect on the status quo.

We can then see that several individual characteristics seem to explain the preference for the status quo. Women are more likely to choose the status quo than men. According to their occupation, respondents are more likely to choose the status quo than others. This is the case for retired people, employees, intermediaries and the economically inactive compared to for managers and professionals (the reference group). Finally, people who always drink bottled water seem to prefer the status quo as the coefficients of the less frequent drinkers are all negative. We then calculated individual marginal WTP (MWTP) for environmental attributes using the individual-specific parameters corresponding to the attribute variables and the (constant) monetary attribute parameter from the MXL results (Table 5, column 2) and from the MXL results with individual variables (Table 7). The MWTPs are based on the monetary attribute included in the DCE, i.e., the increase in the annual water bill used to finance environmental projects.

**Table 7. Marginal willingness to pay (MWTP) for project attributes**

	MXL Attributes only	MXL With individual variables
Pesticide ban	29.61 [22.00 ; 38.51]	29.64 [22.06 ; 38.51]
Watercourse restoration	19.12 [13.18 ; 25.53]	19.33 [13.48 ; 25.69]
No negative effect of fertiliser	9.31 [2.87 ; 15.80]	10.10 [3.71 ; 16.56]
Local negative effect of fertiliser	1.77 [-4.92 ; 8.36]	2.55 [-4.11 ; 9.15]
Hedgerow planting	6.04 [-1.22 ; 13.93]	6.03 [-1.23 ; 13.89]
Hedgerow conservation	5.98 [0.13 ; 12.19]	6.16 [0.34 ; 12.34]
Forest management for water and biodiversity	8.51 [2.82 ; 14.45]	8.74 [3.11 ; 14.64]

Notes. 95% confidence intervals and mean MWTP between brackets are estimated using the Krinsky-Robb method (parametric bootstrap) with 10,000 draws, see Hole (2007).

As a final exercise, we try to explain the heterogeneity of the MWTPs by individual characteristics, including the distance from the watershed. From the estimates of individual-specific parameters, we calculate individual-specific MWTP.

Table 8 shows the mean MWTP for each attribute as a function of different distance categories. From these statistics we can see that there is no particular trend in MWTP.

**Table 8. Mean MWTP for each attribute by distance category**

Distance category (in km)	Nb of individuals	% of the sample	Mean MWTP						
			Pesticide ban	Watercourse restoration	No negative effect of fertiliser	Local negative effect of fertiliser	Hedgerow planting	Hedgerow conservation	Forest management for water and biodiversity
]0 ; 20]	57	9.09	21.67	13.83	8.68	1.85	4.92	5.78	7.01
]20 ; 30]	93	14.83	31.51	16.57	8.81	1.21	5.58	6.08	7.00
]30 ; 50]	73	11.64	21.67	24.54	9.82	0.60	7.93	5.74	6.05
]50 ; 70]	49	7.81	51.41	17.72	10.87	2.45	9.09	6.00	10.24
]70 ; 100]	106	16.91	37.83	17.65	10.40	2.92	6.20	5.86	11.11
]100 ; 130]	102	16.27	22.96	15.46	8.46	1.95	0.91	5.95	8.88
]130 ; 150]	132	21.05	34.66	22.66	9.37	1.55	7.76	6.31	6.97
]150 ; 200]	64	10.21	29.84	22.54	9.65	2.14	10.25	5.82	13.42

Notes. Number of individuals = 627. The mean distance is 86.46 with a minimum of 1.26 and a maximum of 186.53.

Finally, we regress the individual-specific MWTP for the different environmental attributes on the sociodemographic and other characteristics of the respondents, using attribute-wise linear regression models. This allows us to test different hypotheses, such as the existence of distance decay (see Table 8) and the effect of individual characteristics. Table 9 shows the regression results based on the MWTPs calculated from the MXL results in Table 5, column 2. Leaving aside the regression of MWTP for the local negative effect of fertiliser and hedgerow planting, whose mean parameters were not found to be significantly different from zero, we can show important results. First, we show that distance has no effect on MWTP. Second, MWTP increases with education and is higher for older people. We show some differences in preferences according to occupation. For example, managers have a higher MWTP for restoring watercourses and maintaining hedgerows. We also find that compared to the 'always' bottled water drinkers, the occasional drinkers seem to have a higher WTP for banning pesticides, restoring watercourses and not having negative impacts from fertilisers.

**Table 9. Determinants of individuals WTP for each attribute**

Variables	(1) Pesticide ban	(2) Watercourse restoration	(3) No negative effect of fertiliser	(4) Local negative effect of fertiliser	(5) Hedgerow planting	(6) Hedgerow conservation	(7) Forest management for water and biodiversity
Distance	-0.00472 (0.0440)	0.0163 (0.0258)	-0.00122 (0.00420)	0.00353 (0.00768)	-0.00339 (0.0269)	0.00155 (0.00200)	0.0125 (0.0217)
Degree	5.277*** (1.449)	2.046** (0.971)	0.304** (0.153)	0.159 (0.258)	0.404 (0.969)	0.0721 (0.0738)	1.817*** (0.693)
<b>Age category</b>							
Young adult	--	--	--	--	--	--	7.446*** (2.739)
Middle-aged	--	--	--	--	-5.710* (3.287)	-0.222 (0.229)	--
Older	18.00** (9.058)	5.802* (3.176)	0.991** (0.478)	4.533*** (1.497)	9.399* (5.528)	0.824** (0.405)	5.790** (2.578)
<b>Occupation</b>							
No activity	--	--	--	--	-8.510* (4.664)	--	--
Retired	--	--	--	--	-9.536** (4.816)	--	--
Employee	4.641 (5.353)	--	--	--	-6.319 (4.143)	--	--
Worker	10.05 (9.511)	--	1.665* (0.900)	--	-5.679 (6.612)	--	--
Intermediary	13.18* (7.014)	--	--	--	--	--	--
Manager	--	10.59** (5.250)	--	--	--	1.321*** (0.379)	--
Independent	--	--	--	--	--	1.181* (0.679)	--
<b>Bottled water drinkers</b>							
Never drink	2.644 (6.373)	2.621 (4.812)	1.100 (0.761)	--	--	--	--
Occasionally drink	10.47** (5.032)	7.796* (4.032)	1.918*** (0.644)	--	--	--	--
Mostly drink	--	7.528* (4.260)	0.796 (0.721)	--	--	--	--
Always drink	--	--	--	--	--	--	--
Constant	5.569 (7.100)	4.434 (4.598)	6.938*** (0.764)	0.687 (1.034)	12.27** (5.451)	5.530*** (0.298)	-1.073 (3.165)
R-squared	0.039	0.035	0.031	0.016	0.018	0.037	0.026

Notes: Individual obs. = 627. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

For age, occupation and bottled water drinker categories, the reference is different depending on the attribute MWTP.

## 5. Discussion and conclusion

This paper analyses the non-use value of water and biodiversity protection in a watershed in eastern France. While measures to protect or improve water quality are usually considered to generate direct use values for water consumers, we show that non-users may also have positive preferences for measures that have positive impacts on water quality and biodiversity.

Our results highlight several key points about individual preferences for the environment and the factors that influence these preferences. First, the results of the mixed logit estimation indicate that individuals have significantly positive preferences for policies that have a positive impact on water quality and biodiversity. This suggests the existence of non-use values attached to the protection of these environmental resources. However, it is also shown that there is strong heterogeneity in preferences for different environmental attributes. This heterogeneity of preferences underlines the importance of recognising the complexity of individual attitudes towards the environment.

The results show strong individual opposition to the status quo, suggesting a widespread desire to improve the environment. However, despite this opposition to the status quo, some trends in status quo choice are observed based on individual characteristics such as education level and bottled water consumption habits. For example, individuals with lower levels of education may be more likely to prefer the status quo, highlighting a potential need for environmental awareness and education. Similarly, people who are used to drinking bottled water may have different attitudes towards measures to improve water quality. Furthermore, by analysing preferences for each environmental attribute on the basis of individual variables, we are able to better understand the underlying mechanisms that influence environmental choices. This approach helps to identify specific demographic groups or individual characteristics that may require particular attention in the design and implementation of environmental policies. These findings highlight the importance of taking into account the diversity of individual preferences and demographic characteristics when planning environmental policies.

Although our results show a great deal of heterogeneity between people in terms of their WTP for the proposed measures, it is possible to compare them with previous studies found in the literature. In France, several studies have investigated WTP for the preservation of groundwater quality (Hérivaux and Rinaudo, 2016; Rinaudo and Aulong, 2014; Hérivaux, 2011; Rinaudo, 2008; Grappey, 1999, Stenger and Willinger, 1995; Rozan et al. 1996). For example, Stenger and Willinger (1995) used CVM to calculate water users' conservation values for the Alsatian aquifer threatened by various pollutants (nitrates, herbicides, mercury). They found that the average conservation value was about 700FF/household/year (about €110 at the time). This estimate was extended to non-users (Rozan et al., 1996). These non-users were potential future users as they were located close to the aquifer and the quality of their current

water resource was also threatened by pollution. This second study showed that the WTP of the nonusers was 60% of the conservation value of the users).

Hérivaux (2011) investigated public perception and WTP for groundwater quality improvement in a part of the Meuse alluvial aquifer near Liège (Belgium). Even though the proportion of water users was close to zero (1.5%), the author emphasised that people living above the aquifer were more likely to contribute to groundwater quality improvement (72% compared to 62% for the others), and WTP amounts were likely to be higher for households living closer to the Meuse. Nevertheless, the main motivation for contributing to the protection measures was the possibility of passing on a better quality groundwater body to future generations. In monetary terms, the average WTP is 46.9 €/household/year if only positive WT are considered and 40.1 €/household/year if real zeros are included.

Interestingly, some studies focused on areas close to our area of interest: Hérivaux and Rinaudo (2016) and Rinaudo (2008), conducted a study in eastern France (Meurthe et Moselle and Vosges), where the Lower Triassic sandstone aquifer is located. In contrast to other studies presented here, the aquifer was facing over-exploitation rather than pollution. Nevertheless, the study provides interesting information: firstly, if most respondents used this water for recreational or other purposes, the main motivation to pay was related to non-use (transfer of quality drinking water to future generations), confirming Rinaudo and Aulong (2014). In this case, respondents had a higher WTP than others. In addition, the binary variable indicating respondents' agreement with the statement "I am willing to pay for this aquifer as I would be willing to pay for any other aquifer in France" was significant. The average WTP was 39.5€/household/year if true zeros were included and 45€/household/year if they were not.

We also investigated a possible distance decay effect on non-users' preferences for environmental attributes. We could not statistically reject that there was no effect of distance on WTP. Therefore, we cannot confirm the distance decay for non-use values. In this way, the results contribute to the ongoing debate about the existence of distance decay for non-use values. Our results are consistent with the fact that the benefits of the measures are not consumed by the respondent, i.e. there is no need for transport. This also indicates that the way we identified our sample of non-users is valid. If our sample had included users, we would have expected a significant decline in distance.

We hypothesised that the respondents' water consumption habits would influence the results, i.e., if people buy bottled water, they may be very concerned about water quality and therefore have strong preferences for water conservation measures, even if they do not consume the protected groundwater. We did not find a clear effect of consuming bottled water. This could be due to different effects. For example, some people may consume bottled water for convenience and not because they are concerned about water quality, or some respondents may choose not to consume bottled water to reduce resource use because they are concerned about the environment, which may correlate with preferences for water

conservation measures. Future studies should look more closely at the factors that determine preferences for water quality and protection.

The fact that drinking water protection measures can have significant NUVs has important implications for the regulation of water resources. In particular, it could justify the French delegation of water and biodiversity protection to the regional water agencies, as it allows for a more comprehensive spatial consideration and the integration of water and biodiversity concerns in the regulation, although not all measures have the same value. In fact, water protection measures include NUVs that are not only related to the quality of water for consumption, and we find that it is not only local residents who benefit from protection measures. Some inhabitants living far from the Rupt de Mad water catchment area (even more than 100 km) have a positive WTP for some protection measures, although this is mostly limited to the ban on pesticides and the restoration of watercourses.

We found that all respondents considered a pesticide ban to be an important environmental measure, complementing the findings of Amiri et al. (2022) who found an important utility value of pesticide ban in recreational areas. Therefore, French water authorities should prioritise pesticide bans as a measure to protect water and biodiversity, in order to be in line with public preferences.

In this paper, we have assumed that the WTP for water protection of individuals who do not consume water from the protected catchment area in the scenarios proposed in the DCE reflect NUVs. This is based on the assumption that respondents did not consider that they would one day benefit from the improved water quality, for example by moving to the area served by the protected resources. However, we believe that this assumption will generally not be violated as very few will have this perception. Furthermore, even if the assumption is violated, our results still show that the value of water protection does not only benefit current drinking water consumers. Similarly, we assume that the respondents are not (future) recreational users of the watershed. However, the lack of a strong distance decay effect suggests that respondents did not consider the catchment as a potential recreational site.

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