Economic valuation of ecosystem services provided by irrigation of meadows and pastures: evidence from Aosta Valley, Italy

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Abstract

This study examines affordability issues related to EU water pricing policies in mountain areas, where irrigation entails costs but also provides valuable ecosystem services. Focusing on Italy's Aosta Valley, we use a discrete choice experiment to assess residents' willingness to pay (WTP) for ecosystem services from irrigated meadows and pastures, specifically: maintaining active livestock farms, reducing landslide risk, attracting summer tourism, and preserving the traditional landscape. Respondents valued *the traditional landscape at €126/year, each livestock farm at €0.5/year, and each landslide avoided at €3.4/year; summer tourism was not statistically significant. Total WTP estimated is €633.5/year per household, or approximately €36 million/year for the region. Results support recognising traditional mountain irrigation as a provider of ecosystem services and inform the integration of their value into EU water policy.*

Keywords: ecosystem services; irrigation; livestock farms; mountain areas; Discrete Choice Experiment

JEL Codes: Q25, Q57; H41

1. INTRODUCTION

Facing growing pressure on water resources, the European Union (EU) has promoted more sustainable water management through the Water Framework Directive 2000/60 (WFD), which aims to establish overarching principles for sustainable water management across sectors. In agriculture, this approach is primarily economic and based on the "polluter pays principle". According to this principle, those who pollute or exploit natural resources are obliged to cover the associated costs, incentivizing more efficient and conscious use (Buttinelli et al., 2024; Zucaro et al., 2015). To this end, Article 9 of the WFD introduced a water-pricing policy for irrigation water, aimed to "provide an incentive for users to use water resources efficiently, and thereby contribute to the environmental objectives of the Directive". The European Commission (2000) specified that users should recover three cost components: financial costs, environmental costs, and resource costs.

Estimating these components has proved difficult across Member States, especially in marginal agricultural areas where higher water charges raise affordability concerns (Zucaro et al., 2015).

In Italy, irrigation water services are managed by regional administrations and implemented by Water User Associations (WUAs). Implementing the Directive has been particularly challenging in areas with environmental and socio-economic constraints, such as mountain regions. In the Aosta Valley, the EU has criticised the Region for the absence of a coherent irrigation water pricing system. Here, deeply rooted traditional practices, further complicate the picture: WUA members contribute voluntary labour to the regular maintenance of irrigation networks, effectively constituting a non-monetary form of cost recovery not recognised as compliant under EU guidelines.

The situation was further compounded when the EU made implementation of the WFD pricing policy a condition for accessing European funds, including Rural Development funds (Regulation (EU) 1303/2013). In response, the regional administration argues that irrigation water use for mountain meadows and pastures entails not only costs, but also external benefits in the form of public goods and services.

Particularly in inland and marginal areas, dairy livestock farming is a vital activity that provides and maintains various ecosystem services (ES), including biodiversity, water flow regulation, landscape, recreation, and cultural benefits (Pauler et al., 2025; Herzog & Seidl, 2018; Orlandi et al., 2016; Battaglini et al., 2014). To implement a comprehensive compensation criterion, the value of these ES should be estimated. Assigning a monetary value to these services allows them to be recognised at the European level and to be compared with the recovery costs established by the water pricing policy.

A growing body of literature has explored the social preferences for agricultural ES across European countries (Alcon et al., 2020; Bernués et al., 2019; Tienhaara et al., 2019; Novikova et al., 2017; Chatzinikolaou et al., 2015).

Many studies have also focused on the economic valuation of irrigation-related ES, highlighting their role in promoting societal well-being and estimating willingness to pay (WTP) for improvements in water quality, drought mitigation and landscape conservation (Khan et al., 2019; Vivithkeyoonvong, 2017). These services are increasingly recognised for their non-market value (Kourtis & Tsihrintzis, 2017). Stated preference studies reveal that people show WTP for the protection and restoration of water ecosystems, especially where agricultural practices or infrastructure improvements can enhance local ecological conditions (Kourtis & Tsihrintzis, 2017; Lee et al., 2017). These ES also generate broader societal benefits, including biodiversity conservation, climate regulation, and cultural heritage preservation (Khan et al., 2019). Overall, integrating their value into policy could better balance environmental protection with agricultural and water management practices, supporting more sustainable outcomes (Khan et al., 2019; Vivithkeyoonvong, 2017).

The value of agricultural ES, including water quality, biodiversity, landscape preservation and hydrogeological regulation, has also been explored in northern Italian regions (Blasi et al., 2023; Mazzocchi & Sali, 2022; Tempesta & Vecchiato, 2018; Faccioni et al., 2019), where mountain agricultural practices help sustain fragile ecosystems and provide public goods beyond economic output, and where citizens have shown a clear preference for agricultural practices that prioritise environmental services over intensification.

In particular, Ruberto et al. (2022) analysed traditional irrigation systems in Lombardy, highlighting their role in providing ES such as water regulation and biodiversity conservation, and found a significant WTP for higher levels of these services, suggesting that their inclusion in water pricing policies under the WFD could encourage more sustainable agricultural water use. Similarly, Tempesta and Vecchiato (2013) assessed residents' preferences for policies aimed at reducing nitrate concentrations in groundwater and improving riverscape quality along the Serio River in northern Italy, finding that residents valued both groundwater quality, due to its health implications, and broader riverscape improvements linked to recreation and biodiversity. More broadly, the literature stresses the need to better recognise ES within EU sectoral policies, as current instruments still struggle to integrate their value into effective territorial strategies (Winkler et al., 2025; Viaggi, 2018).

Although research on agricultural ES is expanding, the valuation of services provided by water use in marginal and mountainous areas remains poorly explored. This study addresses this gap through a context-specific analysis of the ES provided by traditional irrigation practices in the extensive mountain pastures of Aosta Valley, estimating regional residents' WTP as direct beneficiaries of these services, and contributing to more informed water management policies that account for both the environmental benefits and the socio-economic challenges of mountain areas.

To this end, the estimation relied on a Discrete Choice Experiment (DCE), a widely-used method in environmental economics that allows for the monetary evaluation of non-market goods by presenting respondents with hypothetical scenarios involving choices among alternative policies (Aizaki, 2010; Alriksson & Öberg 2008; Holmes et al, 2017).

2. SURVEY DESIGN AND DATA

2.1 Experiment setting

DCEs simulate real-life decision-making by presenting respondents with multiple choice sets, each combining different attribute levels of the good or scenario being valued. By including a monetary attribute, it is possible to elicit WTP for different attribute level combinations (Louvriere, 2001; Louviere et al., 2010). The method is grounded in the Lancastarian utility theory (Lancaster, 1966) and the Random Utility Theory (McFadden, 2001).

In analytical term, the utility that individual *i* derives from alternative *j* is expressed as:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

where V_{ij} denotes the systematic component of utility, typically specified as a function of the attributes and their associated parameters, and ε_{ij} represents the stochastic component (McFadden, 2001). As a consequence of this unobservable component, utility cannot be directly observed, and choices are therefore modelled probabilistically. Individuals are assumed to select the alternative that yields the highest utility (Revelt & Train, 1998).

Our experiment was designed to assess the value of ES provided by irrigation of meadows and pastures in the Aosta Valley. A detailed description of the study area is provided in the Supplementary Materials.

Respondents were presented with a hypothetical scenario in which the regional administration implements a water pricing policy in line with the WFD. As a result, local farmers may not be able to afford the higher irrigation costs, with negative effects on production and the loss of some irrigation ES. To limit such loss of benefits, respondents were asked to support farmers by contributing to their irrigation water costs. The ES considered in the analysis were those identified in a study conducted in the same area by Novelli et al. (2022).

Focus group discussions have been used to identify and prioritise the benefits that irrigation provides in the Region. Local stakeholders identified four main benefits: i) maintaining the economic and social vitality of mountain areas through the presence of livestock, ii) preventing hydrogeological instability by maintaining irrigation networks, iii) attracting summer tourists for hiking and excursions in a well-maintained environment, and iv) preserving the traditional agricultural landscape.

Following the ES framework adopted in a DCE by Faccioni et al. (2019) and consistent with established classification systems (Millennium Ecosystem Assessment, 2005; Haines-Young, 2023), the benefits considered in this study belong to different ES categories and contribute to distinct components of the Total Economic Value (TEV). The presence of livestock farms represents a socio-economic benefit derived from agroecosystem functioning. Cultivated crops (including those providing fodder for livestock) and animals reared for nutritional purposes are classified as *provisioning ecosystem services* and correspond to a consumptive direct use value (Haines-Young, 2023; FAO, 2025). The prevention of hydrogeological instability constitutes a *regulating ecosystem service*, generating an indirect use value by reducing environmental risks and safeguarding public safety and infrastructure. Landscape and tourism are a *cultural ecosystem services* that provide non-consumptive direct use value, reflecting their aesthetic and recreational benefits. Although mass tourism in fragile areas can have negative environmental impacts (Pueyo-Ros, 2018), stakeholders emphasised that summer tourism in the Aosta Valley largely takes the form of nature-based ecotourism and can therefore be regarded as a cultural benefit (Viddaller & Dutoit, 2022).

Although some ES in the DCE, particularly provisioning services and tourism-related activities, are linked to market revenues, the experiment does not estimate their market value. Instead, it assesses the marginal economic value and welfare effects of changes in ES provision, expressed through individuals' WTP.

Therefore, four attributes were identified: i) number of active livestock farms, ii) landslides and debris flows avoided/year, iii) summer tourists/year, and iv) landscape appearance - each measuring changes in the provision level of the selected ES. Respondents were presented with a future scenario in which WFD implementation would threaten the supply of these benefits over 30 years. Drawing on an approach used for endangered species valuation, where respondents are asked to value the avoidance of further decline (Bartczak & Meyerhoff, 2013; Wallmo & Lew, 2016; Imamura et al., 2020), participants were asked to state their WTP to prevent ES deterioration. In our experimental design, the *status quo* reflects the current situation with fully operational irrigation systems and maximum ES provision for all non-cost attributes. The non-intervention scenario assumes that, in the absence of financial support to farmers, WFD-induced cost increases progressively reduce irrigation activities, leading to ES deterioration over the 30-year horizon and corresponding to the worst projected levels of non-cost attributes.

For each attribute, three levels were defined: (i) the current situation, corresponding to the full maintenance of ES through a complete offset of the additional irrigation costs arising from the implementation of the WFD pricing policy; (ii) an intermediate level, reflecting a partial offset of these additional irrigation costs and, consequently, a partial mitigation of the associated negative impacts; and (iii) a non-intervention scenario, representing the maximum projected deterioration of ES in the absence of financial support. All attributes were quantitative, except for the landscape. Landscape appearance was depicted with photos showing three alternative attribute levels based on irrigation practices: green meadows with cows grazing (no-change scenario), yellowed pastures, and yellowed pastures with invasive tree species (non-intervention scenario). While the ES included in the DCE are interrelated through irrigation, attribute levels were varied independently in the experimental design to enable the estimation of marginal utilities, with each level reflecting realistic and plausible changes in the provision of the corresponding service (Bateman, 2002).

The payment vehicle and the cost attribute levels (bid vector) were defined through a pilot study administered in person to 50 respondents. The bid vector was explored with an open-ended question covering the 15th, 50th, and 85th percentiles; as for the payment vehicle, two methods were tested: a levy on the domestic water bill and an annual donation to a voluntary contribution fund. The majority of respondents preferred the mandatory levy, considered to be fairer because the cost would be evenly distributed among all citizens benefiting from the proposed policy. Monetary contributions would be allocated to a public compensation scheme supporting mountain farmers facing increased irrigation costs under the WFD pricing policy, aiming to ensure the continuation of traditional irrigation practices and the ES they sustain.

Table 1 shows the final set of attributes and levels used in the experiment.

Table 1. Attributes and levels used in the experiment.

Attributes	Description	Levels (potential changes within the next 30 years)
Number of active livestock farms	Maintaining a viable agricultural sector to preserve the economic and social vitality of mountain areas and prevent depopulation	– 1,000 (current number of livestock farms)[1] – 800 (20% loss of livestock farms) – 600 (40% loss of livestock farms), non-intervention scenario
Number of landslides and debris flows/year	Contributing to the prevention of hydrogeological instability through the maintenance of the existing irrigation network, linked to irrigation management activities	– 75 (current number of landslides and debris flows/year)[2] – 100 (+25 events/year) – 125 (+50 events/year), non-intervention scenario
Number of summer tourists/year	Attracting tourists during the summer season, the green landscape enhances the presence of visitors engaged in hiking and outings	– 600,000 (current number of summer tourists/year)[3] – 480,000 (20% loss) – 360,000 (40% loss), non-intervention scenario
Landscape appearance	Preserving the aesthetic value of the landscape through the maintenance of pastoral activities based on currently existing irrigated pastures and grassland	  *  * non-intervention scenario
Domestic water bill increase (euro/year)	Willingness to pay for the described level of external benefits	– 20 – 50 – 80 – 0 (non-intervention scenario)

[1] Regional farm archive, year 2020.
[2] Regional archive of hydrogeological disturbance, mean data of the years 2017-2018-2019 (http://catastodissesti.partout.it/).
[3] Regional archive of tourism, number of tourists from June to September, mean data of the years 2017-2018 -2019 (https://www.regione.vda.it/asstur/statistiche/default_i.asp).

By repeated choices between bundles of attribute levels (choice sets), respondents evaluated trade-offs among alternatives. In a full factorial design with four attributes at two levels each and one attribute at three levels, the total number of possible profiles is $2^4 \times 3=48$. When constructing choice sets composed of two alternatives plus a fixed status quo (non-intervention scenario), the total number of unique unordered choice sets would be $(48 \times 47)/2=1,128$. Given that this number is prohibitively large to present to our sample, the attribute level combinations were generated using an efficient experimental design. We first constructed a D-optimal design under zero priors, assuming no prior information on the sign or magnitude of the parameters[1]. After collecting data from the first 50 respondents, we estimated a preliminary model and used the resulting parameter estimates as informative priors. We then re-optimised the design to improve its statistical efficiency, while preserving the same attribute space and level balance. The final experimental design comprised 12 choice tasks, organised into three blocks of four tasks each; respondents were randomly assigned to one of these blocks. Each choice task presented three mutually exclusive irrigation scenarios: two policy alternatives whose attribute levels varied across tasks according to the experimental design, and a *no-intervention* alternative. The *no-intervention* scenario was kept constant across all choice cards.

2.2 Questionnaire design and administration

The survey questionnaire was divided into three sections. The introductory section provided a brief overview of the research objectives and information about the study area. In the second section, the hypothetical scenario was presented, along with a description of the ES provided by irrigation of meadows and pastures, followed by the choice experiment. The final section was dedicated to collecting sociodemographic data relevant to individuals' WTP.

In line with the experimental design, each of the three blocks featured four choice tasks. Each task presented participants with two alternatives, as well as a *no-intervention* option at zero cost. Figure 1 provides an example of one of these choice tasks.

[1] The design was generated in Stata using the dcreate module, which implements a modified Fedorov algorithm (Cook and Nachtsheim, 1980; Zwerina et al., 1996; Carlsson and Martinsson, 2003) to maximize D-efficiency of the design using the covariance matrix of the conditional logit model as input.

Figure 1. Example of choice task.

The following table shows three alternative scenarios for the Aosta Valley over the next 30 years, after the implementation of the EU water pricing policy. Scenario 1 and Scenario 2 display the benefits of irrigation maintained through citizens monetary contributions, and the resulting increase in domestic water bill per household/year. The third scenario shows the situation without any contribution, at zero costs for the citizens.

Which scenario would you prefer?

	Scenario 1 (in 30 years)	**Scenario 2** (in 30 years)	**Scenario 3** (in 30 years)
Number of active livestock farms	1,000	800	600
Number of landslides and debris flows/year	100	75	125
Number of summer tourists	600,000	480,000	360,000
Landscape			
Domestic water bill increase (euro/year per household)	20	80	0
Which do you prefer?	☐	☐	☐

Respondents who consistently selected the non-intervention scenario were asked to state their reasons, to distinguish between *genuine zeros* and *protest zeros* (Meyerhoff and Liebe, 2006). *Genuine zeros* identify respondents unconcerned about changes projected 30 years ahead or who believe reduced irrigation-related ES would not affect residents' well-being. *Protest zeros* refer to those rejecting aspects of the survey, often perceived as unfair (Jørgensen et al., 2020). In this study, the most common motivations were that existing public funds were deemed sufficient, that farmers already receive adequate EU subsidies, or that respondents preferred voluntary one-off contributions.

Data collection was outsourced to an external professional survey agency. The questionnaire was administered online in January 2022 using a CAWI (Computer Aided Web Interviewing) method. The target population consisted of residents of the Aosta Valley aged 18 to 65, with stratified sampling by age and gender applied to reflect the regional population structure. The final dataset consists of 150 respondents whose main sociodemographic characteristics are reported in Table 2. Sample data show some discrepancies with regional data on education and income, which should be interpreted with caution given their imperfect comparability. With these caveats in mind, the sample appears to include a higher share of lower-income and more highly educated households than the regional population.

Table 2. Descriptive statistics of the sample compared with the Aosta Valley population.

	Sample	**Aosta Valley population**
	Frequency %	Frequency %
Gender (female)*	50.0	51.0
Age bracket*		
19-36	28.7	28.5
37-51	33.3	33.5
52-66	38.0	38.0
Education**		
None	-	-
Primary school	0.7	3.0
Secondary school	28.7	34.9
High school diploma	58.0	42.4
Academic degree	12.7	19.7
Members of environmental association	27.3	N/A
Household net income/month (€)		
< 1,200	19.1	N/A
1,200 - 2,000	38.2	N/A
2,000 - 3,000	30.9	N/A
> 3,000	11.8	N/A
Household yearly net income		
Mean *	N/A	39,461 €
Median *	N/A	32,900 €

Note: *ISTAT data refer to 2022 **ISTAT data refer to 2020 for individual aged 25-64

2.3. Method

To estimate the utility associated with alternative irrigation scenarios, we adopt a random-parameter (mixed) logit model in the random utility maximisation tradition (McFadden, 2001; Hensher et al., 2015). The indirect utility that respondent *n* derives from choosing irrigation policy alternative *j* in choice situations *t* specified as:

$$U_{njt} = \beta_n' x_{njt} + e_{njt}\ ,$$

Where $\mathbf{x}_{njt}$ is a vector of observed attributes describing alternative *j* (number of livestock farms maintained, number of landslide events avoided, number of summer tourists, landscape quality, and annual increase in the household water bill), β_n is a vector of individual-specific parameters, and e_{njt} is an unobserved error term independently and identically distributed extreme-value type I. Utility is specified as additive in attributes and linear in parameters. Continuous attributes enter the utility function in their natural units, without nonlinear transformations or interaction terms. This implies constant marginal utility over the DCE attribute ranges; therefore, coefficients for active livestock farms, landslides and debris flows, and summer tourists should be interpreted as average marginal effects within the experimentally defined intervals.

In the mixed logit specification, preference heterogeneity is captured by allowing the elements of β_n to vary across individuals according to continuous probability distributions. In our baseline model, all non-cost parameters are treated as random and assumed to follow a normal distribution, thereby allowing for continuous preference heterogeneity across individuals, whereas the cost parameter is kept fixed.

$$\boldsymbol{\beta}_n = \boldsymbol{\beta} + \eta_n\ ,\ \eta_n \sim N(0, \Sigma), \qquad \text{eq.1}$$

Where $\boldsymbol{\beta}$ is the vector of mean coefficients and Σ is the variance–covariance matrix of the random parameters. Under this specification, the marginal utilities of the non-cost attributes, and therefore the implied willingness-to-pay measures, are allowed to vary across respondents.

The model parameters are estimated by simulated maximum likelihood. We use Stata 18 (StataCorp LLC, College Station, TX) and approximate the integrals over the random parameters with 500 Halton draws per respondent. From the estimated coefficients, we derive marginal WTP for each attribute as the ratio between the attribute coefficient and the (negative) cost coefficient, and then compute scenario-specific WTP as appropriate linear combinations of the marginal WTPs.

$$WTP_k = -\frac{K}{\mathrm{cost}}, \qquad \text{eq. 2}$$

For attributes measured on a continuous scale (e.g. number of livestock farms, number of landslides avoided), WTP_k represents the amount that respondents are willing to pay per year for a one-unit increase in attribute *k*. For categorical attributes modelled with dummy variables (e.g. landscape quality), the corresponding coefficient and WTP measure the change relative to the *non-intervention* scenario.

In addition to marginal WTPs, we derive each respondent's total WTP for a policy scenario that maintains the current provision of irrigation-related benefits over the next 30 years. Let x0 denote the vector of attribute levels (including the non-intervention dummy and zero cost) describing this non-intervention scenario, and x1 the vector of attribute levels describing the scenario in which the current provision of irrigation benefits is maintained in 30 years. Using the individual-specific coefficients n, we compute the respondent-specific compensating surplus (i.e. total WTP) associated with the current provision of irrigation-related benefits for respondent n as (Mariel et al., 2025):

$$\mathrm{WTP}_{\mathrm{n,maint}} = -\frac{1}{cost}\beta_n'(x^1 - x^0), \qquad \text{eq.3}$$

This expression represents the monetary equivalent of the utility change between the non-intervention and maintenance scenarios, obtained as the sum of the marginal willingness-to-pay values for each attribute multiplied by the corresponding attribute change. This yields an empirical distribution of total WTP across respondents. Aggregate regional values are obtained by multiplying the 25th, 50th (median), and 75th percentiles of this per-household WTP by the number of households in the Aosta Valley.

3. RESULTS

Nineteen respondents out of 150 (12.6%) chose the non-intervention scenario across all choice sets. All these zero values were classified as protest zeros, with respondents citing feelings of unfairness about contributing to irrigation costs, as farmers already receive significant public subsidies. These protest zeros were excluded from the sample, as they do not represent respondents' "true" valuations of the benefits provided by irrigation.

Results of the econometric analysis conducted on the 131 valid questionnaires are reported in Table 3. The analysis is based on 524 choice situations (corresponding to 1,572 alternatives).

Most of the estimates from the random parameter (mixed) logit analysis were significant ($p < 0.05$), indicating that the attribute had a substantial impact on the respondents' choices. The only attribute that seems to not significantly influence respondents' choices is the number of summer tourists. For the continuous variables, the sign of the estimates indicated a negative (-) or a positive (+) relationship between the respondents' utility and the marginal increase in attribute level. As expected, the respondents' utility increased with an increase in active livestock farms, while it decreased with an increase in landslides and debris flows, as well as with an increase in the domestic water bill. For landscape appearance, respondents derive higher utility from green irrigated meadows compared to degraded landscapes. While the "green landscape" level has a strong and significant positive effect, the "yellow landscape" level is not statistically significant.

The WTP values reported in Table 3 correspond to marginal WTP. For continuous attributes, these values represent the WTP for a one-unit change in the attribute; for categorical attributes, they represent the WTP for moving from the reference level (non-intervention/status quo) to the level described in the alternative.

Respondents' marginal WTP for each livestock farm maintained is about 0.5 €/year, while the marginal WTP for each avoided landslide is about 3.4 €/year. The marginal WTP to maintain the grazed green meadows instead of the landscape described non-intervention scenario is about 126€/year.

The positive and significant coefficient associated with the no-intervention (opt-out) alternative suggests that, all else equal, respondents display a baseline preference for the opt-out alternative. When the intervention scenario preserves multiple ES at their current level, their combined utility outweighs the baseline preference for the opt-out alternative.

Table 3. Mixed logit estimates

Attribute	Coef.	Std.err	*p*-value	Marginal WTP (€/year)
Number of active livestock farms	0.009***	0.00	<0.001	0.50
Number of landslides and debris flows/year	-0.062***	0.01	<0.001	-3.38
Number of summer tourists (thousands)/year	-0.003	0.00	0.15	-0.15
Landscape appearance (green landscape)	2.312***	0.39	<0.001	126.34
Landscape appearance (yellow landscape)	0.011	0.01	0.366	0.61
Domestic water bill increase (euro/year)	-0.018**	0.00	0.019	
No- intervention (opt-out)	3.184***	1.14	0.006	173.99
σ(Number of active livestock farms)	0.007***	0.002	0.004	
σ(Number of landslides and debris flows)	0.058***	0.009	<0.001	
σ(Number of summer tourists)	0.016***	0.004	<0.001	
σ(Landscape appearance - green)	2.388***	0.436	<0.001	
σ(Landscape appearance - yellow)	0.261	0.287	0.363	

Note: σ indicates the standard deviation of the random parameters distribution. Random parameters are assumed to be normally distributed. (*$p < 0.10$; **$p < 0.05$; *** $p < 0.01$); Log-likelihood = -448.6; McFadden's pseudo-R^2 = 0.32; AIC =933.2; BIC =1032.2; Observations (choice cards analyzed) = 524; Respondents = 131.

Beyond marginal values, we also calculated the total WTP associated with a scenario that preserves the current provision of irrigation-related benefits over the next 30 years. Specifically, the WTP values were: €126.34/year for maintaining grazed green meadows, €200/year to preserve the current number of 400 livestock farms, €169/year to prevent an increase of 50 landslides, -€36/year for preserving the current number of summer tourists, and €173.99/year for the opt-out scenario. The calculations are specified in Appendix A.

The median value calculated per household is about 633.5 €/year (Table 4). Based on this value and the number of households living in the Region, we estimated a total benefit of almost 36 million €/year for the regional population.

Table 4. Willingness to pay for the best scenario (€/year).

	WTP (25% percentile)	WTP (50% percentile)	WTP (75% percentile)
Total value per household (€)	564.26	633.35	705.18
Aggregated regional value (€) (56,562 households[1])	30,897,558	35,823,542	39,886,391

[1] https://demo.istat.it/previsionifamiliari/index.php?lingua=ita

Finally, following Weituschat et al., (2023), the heterogeneity of attribute preferences among respondents was analysed, testing the relationship between the marginal WTPs obtained from the mixed logit model and the socioeconomic characteristics of the sample. Table 5 shows the results of a seemingly unrelated regression model, where the individual marginal WTPs for the four attributes (dependent variables) are regressed on the individual socioeconomic characteristics (explanatory variables). The sign of the coefficients indicates whether there is a direct or inverse relationship between attributes' marginal WTPs and either the marginal increase of continuous explanatory variables (age, educational qualification, income bracket) or, in the case of dummy variables, the belonging to a specific category (female, membership in an environmental association).

According to the results, gender does not seem to influence the respondents' WTP, as the estimated coefficients are not significant for any of the considered attributes. Younger respondents place a higher value on the presence of summer tourists than older respondents. The opposite holds true for the benefits from landslides reduction, livestock farms maintenance and agricultural landscape maintenance, which seem to be more appreciated as the age of respondents increases. The value placed on landslides reduction and landscape maintenance is lower for higher educated individuals. As the income bracket increases, the WTP for all the ES increases, except for the number of livestock farms. Members of environmental associations show a lower-than-average WTP for both landslide reduction and agricultural landscape maintenance.

Furthermore, it should be noted that the constants in Table 5 are large and statistically significant for all attributes, indicating that a substantial share of the heterogeneity in marginal WTPs is not captured by the socioeconomic variables included in the model. This suggests that factors other than the observed demographics, play a major role in shaping respondents' valuations.

Table 5. Seemingly unrelated regression results.

	Active livestock farms	Landslides and debris flow	Summer tourists	Landscape appearance
Age (years)	0.001*	-0.013**	-0.004***	0.448***
Gender (male)	0.01	-0.081	-0.029	-0.841
Education (level)	-0.001	0.131**	0.021	-7.995***
Income (bracket)	-0.027***	-0.194***	0.024*	20.275***
Member of env. ass. (yes)	0.013	0.192**	0.008	-15.261***
Constant	0.536**	-3.344***	-0.171*	114.521***

Note: (*p < 0.10; **p < 0.05; *** p < 0.01)

4. DISCUSSION

Our results provide insights into the perceptions of the citizens of the Aosta Valley regarding the ES provided by the irrigation of meadows and pastures.

Although European citizens generally support public aid to farmers (Mata & Dos-Santos, 2024; Schüler & Noack, 2019; European Commission, 2016), more than one in ten respondents in our survey protested against further support for local farmers. This may be partly explained by the Aosta Valley's special statute status, where substantial regional funds complement EU support. The same context may also underlie the baseline preference for the no-intervention option, suggesting reluctance to support additional financial contributions despite recognising the value of the ES provided.

Yet, citizens with a positive WTP expressed a significant appreciation for the external benefits of irrigation, probably due to their strong identification with the distinctive features that define the region (Novelli et al., 2022).

This finding aligns with evidence from other EU regions, where agriculture and forestry are broadly perceived as providers of public goods and payments for ES are considered a relevant policy response (Targetti et al., 2022). Positive WTP for agri-environmental, landscape and irrigation-related ES has similarly been documented across other EU contexts, including Flanders, Ireland, the Po Valley and Lombardy (Fockaert et al., 2023; Howley et al., 2012; Blasi et al., 2023; Ruberto et al., 2022).

Tourism is the only non-significant attribute, likely reflecting heterogeneous preferences for visitors across socioeconomic groups (Muresan et al., 2021; Șorcaru et al., 2022; Brida et al., 2011). In the Aosta Valley context, this heterogeneity is mainly explained by a generational tension: older respondents are possibly more concerned about cultural disruption, while younger ones focus on the expected economic benefits of tourism.

Respondents valued livestock farm maintenance, confirming that citizens recognise the ES provided by traditional agricultural practices, including food security, water regulation and cultural heritage (Faccioni et al., 2019; García-Llorente et al., 2012; Tempesta & Vecchiato 2018). WTP for this attribute is negatively correlated with family income, suggesting that livestock maintenance may be perceived as an 'inferior good' (Ebert, 2003): lower-income respondents may fear that fewer farms would reduce market competition and raise prices, or value the direct economic benefits of livestock activities, such as employment and access to local products.

Respondents showed considerable concerns about landslide risk, reflected in the high WTP estimated for this attribute, consistent with findings from similar studies (Alcon et al., 2020; Owuor et al., 2019). WTP for landslide reduction is higher among younger respondents and members of environmental organisations, likely reflecting greater awareness of current environmental risks, particularly in mountainous areas considered most vulnerable to climate change (Palomo-Campesino et al., 2018).

The value placed on maintaining the traditional agricultural landscape was significant and positive, consistent with similar studies (Targetti et al. 2020; Faccioni et al., 2019; Notaro et al. 2019; Novikova et al., 2019; Dupras et al., 2018; Tempesta & Vecchiato 2018). Interestingly, WTP decreases with higher education and membership of environmental organisations, possibly reflecting a preference for wilderness and renaturation over traditional heritage landscapes, and greater sensitivity to water scarcity.

Direct comparisons of WTP estimates from stated-preference methods are limited by differences in context, scale, beneficiaries, and valuation design. Against this backdrop, our estimated median WTP of about 630 €/year per household for the current provision scenario lies in the upper range of comparable

European studies. Ruberto et al. (2022) report WTP values of approximately 30-40 €/month for preserving ES from traditional irrigation systems in Lombardy (corresponding to roughly 360-480 €/year per household). Our estimate reflects the aggregation of multiple benefits within a single policy scenario, which partly explains its higher magnitude. A comparable DCE by Faccioni et al. (2019), estimated a total economic value of 159.30 €/year per person for four ES (landscape, biodiversity, water quality, and quality local products) in the Alpine agroecosystem of Trento Province, broadly comparable to our figure once differences in aggregation level are accounted for. It is also worth noting that the higher total WTP may also reflect both the 30-year time horizon and the Alpine context, characterized by strong landscape identity and sensitivity to hydrogeological risks, which likely reinforce stated WTP compared to shorter-term or less risk-exposed settings.

5. CONCLUSION

The WFD requires water pricing across all sectors, including agriculture, where farmers should cover the financial, environmental and resource costs of irrigation. In Italy, the Aosta Valley has been criticised for lacking a compliant pricing system, raising concerns about affordability for local livestock farmers (Borsotto et al., 2021). However, irrigation in mountain areas also generates ecosystem services and environmental benefits that create a socially derived demand for water and justify internalising these amenities through water allocation policies (Thiene & Tsur, 2013). Monetising them is therefore necessary for their recognition at EU level and for comparison with irrigation costs.

The total annual benefit of irrigation for regional residents was estimated at around €36 million, a substantial figure given that only four ES were valued. Irrigation, in fact, generate a broader range of benefits not captured here, including water quality maintenance, firefighting infrastructure, and professional role creation (Novelli et al., 2022).

Despite differences in context, scale and methods, the findings accord with European evidence of positive WTP for landscape preservation, hydrogeological risk reduction and traditional mountain farming (Faccioni et al., 2019; Bernués et al., 2019; Novikova et al., 2017; Dupras et al., 2018). Tourism was the only exception, with conflicting preferences that require careful management.

These findings should nonetheless be interpreted with caution. Partial interdependence among attributes - which reflects real-world irrigation dynamics -means that additive WTP may overstate the value of the whole package, as respondents may have valued certain combinations as a bundle rather than as independent goods. The small sample (131 after excluding protest zeros), though comparable to other regional DCE studies (Blasi et al., 2023; García-Llorente et al., 2012), limits statistical power and generalisability.

These results are therefore indicative and context-specific, yet they offer a contribution to the broader debate on balancing agricultural practices with sustainable resource use, particularly in informing the design of socially sustainable agri-environmental policies.

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Appendix A. Calculation of individual willingness to pay for the policy scenario

Attribute	Marginal WTP (€/year)	Δ (policy scenario – baseline)	Total (€/year) (Marginal WTP × Δ)
Number of active livestock farms	0.50	400	200
Number of landslides and debris flows/year	-3.38	-50	169
Number of summer tourists (thousands)/year	-0.15	240	-36
Landscape appearance (green landscape)	126.34		126.36
No- intervention (opt-out)	173.99		173.99
Total			**633.35**