Agricultural Water Management 278 (2023) 108168

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Dairy farmers' willingness to adopt cleaner production practices for water conservation: A discrete choice experiment in Mejia, Ecuador

Cristhian A. Ortiz [a], Jorge J. Avila-Santamaría [a,*], Adan L. Martinez-Cruz [b,c]

[a] School of Economics, Universidad San Francisco de Quito USFQ, Diego de Robles s/n y Vía Interoceánica, Quito, 170901 Ecuador
[b] Department of Forest Economics, and Centre for Environmental and Resource Economics (CERE), Swedish University of Agricultural Sciences (SLU), 90183, Umea, Sweden
[c] Department of Economics, Centro de Investigacion y Docencia Economicas (CIDE), 20213 Aguascalientes, Mexico

ARTICLE INFO

Handling Editor - Dr. B.E. Clothier

Keywords:
Water conservation practices
Discrete choice experiment
Irrigation technology
Dairy production
Manure and solid waste management
Water governance

ABSTRACT

Worldwide, farming practices directly impact the quality and quantity of both underground and surface water resources. In Mejia, the leading milk-producing region of Ecuador, the adoption rate of conservation practices among farmers is low despite price incentives established by the Agricultural Ministry. Our discrete choice experiment documents stated preferences for water conservation practices of Mejia's dairy farmers by facing respondents to alternatives described in terms of water-efficient technologies, management of manure and solid waste, and training to resolve conflicts over water use. Estimates derived from our preferred random parameter logit specification imply that the average willingness to pay (WTP) for a solid rain irrigation system is US\$147 ha^{-1}; and US\$212 ha^{-1} for training to resolve conflicts. In addition, we report heterogeneity in WTP estimates. These findings can assist in the resolution of current issues in Mejia, including inefficient water irrigation and weak water governance system. Based on our results and the context of our study area, we suggest, first, the adoption of a cost-sharing scheme (given that the WTP for these practices does not cover their implementation cost), and second, the participation of academic institutions to help these water users resolve conflicts, establish their own rules, and improve water governance.

1. Introduction

Water is an essential component of global animal production (e.g., for feeding and drinking), which requires 2422 Gm^3 on an annual basis.[1] Of this volume, 19% is used for dairy production (Mekonnen and Hoekstra, 2012). Forage crops account for 50–86% of the total blue water dedicated to milk production (Sultana et al., 2014). The water consumption of a single cow is between 68 and 155 liters per day (see Drastig et al., 2021), equivalent to 20–50 times the liquid demand of a typical human. Thus, dairy production exerts pressure on stocks of freshwater even in regions where water is relatively abundant such as Latin America (Mekonnen et al., 2015).

A non-exhaustive list of issues that livestock farming must tackle to improve water management includes i) inefficient use of water, ii) deficient management of solid and animal waste, and iii) conflicts over water (FAO, 2018; LEAD and FAO, 2006; Ostrom and Gardner, 1993; Zhang et al., 2022). In general, inefficient surface irrigation is the primary irrigation method used in South America, requiring the application of strategies and innovations to achieve sustainable water use (de Oliveira et al., 2009). Dairy farm water pollution arises from animal and solid waste mismanagement (FAO and IWMI, 2017; FAO and WHO, 2008; Xu et al., 2021), affecting the environment and animals alike. Inadequate water provision and arbitrary water appropriation are two constants in cow milk production zones, generating conflicts among water users (Bardhan, 1993; Sheikh et al., 2006).

The Agricultural Ministry of Ecuador has established a minimum raw milk price of \$0.42 per liter, and a premium that rewards the adoption of Best Management Practices (BMPs) (MAGAP, 2013). However, adoption rate of conservation practices among farmers is low despite such price incentives: only 29 livestock farms in the province of Pichincha hold a BMP certification (MAG, 2020). The milk price including the premium can at most be \$0.44. In comparison, the average production cost is

* Corresponding author.
E-mail addresses: cortiz1@alumni.usfq.edu.ec (C.A. Ortiz), javilas@usfq.edu.ec (J.J. Avila-Santamaría), adan.martinez.cruz@slu.se (A.L. Martinez-Cruz).

[1] To put this number into perspective, a typical Latin American family (e.g., four members) has a water endowment of 112,000 m^3 per year (United Nations, 2021), which is equivalent to 1.12E-22 Gm^3.

https://doi.org/10.1016/j.agwat.2023.108168
Received 27 September 2022; Received in revised form 10 January 2023; Accepted 14 January 2023
Available online 18 January 2023
0378-3774/

$0.43 per liter (Cevallos Polanco et al., 2021). Thus, the premium from adopting BMPs seems insufficient, as in other cases of agricultural conservation program in Ecuador (see Barrowclough et al., 2016; Raes et al., 2016).

The canton of Mejia is our case study because, in addition to being the leading Ecuadorian milk-producing region, it suffers from inefficient water management (Cachipuendo et al., 2017; GAD Provincia de Pichincha, 2015; Nieto et al., 2018), water pollution by solid and animal waste (Andrango and Sandoval, 2021; Bonifaz, 2018; Vinueza et al., 2021), and conflicts among water users (GAD Provincia de Pichincha, 2015). For instance, the primary irrigation systems in Pichincha are overhead sprinkler systems or flood irrigation techniques, resulting in only 60% of the water being purposively used (GAD Provincia de Pichincha, 2015). Case studies have also identified excess levels of *E. coli* in various dairy farms' drainage systems in Mejia (Andrango and Sandoval, 2021; Bonifaz, 2018). Similarly, livestock production produces solid contaminants (e.g., vaccine syringes or chemical containers). Mejia's per-capita plastic waste is 33.22 kg a year (14% of total solid rubbish), and only 0.73% of this waste is recovered for recycling.[2] Finally, water conflicts result from appropriation and provision issues due to growing water demand from urban and rural areas, inefficient administration of water, lack of farmer organization, and other factors (Chiriboga, 2015; Lloret, 2009).

We conducted a discrete choice experiment (DCE) to explore whether Mejia's farmers are willing to adopt cost-saving conservation practices for both the quantity and the quality of their water resources. We have examined the literature to identify research strategies and lessons regarding the economic value of water and BMPs. We concluded that few or no DCE studies have been performed to assess water conservation practices within the context of livestock or dairy production in Latin America (see Olum et al., 2020).[3] Our DCE explores preferences for four attributes. The first attribute refers to water efficient irrigation practices—micro-sprinklers and solid rain. The second attribute involves composting as a manure management. The third attribute refers to the private or municipal management of plastics waste. The fourth attribute describes the availability of training in water conflict resolution and cooperation. Finally, the monetary attribute has been described as the percentage of costs that a respondent would pay him/herself. In November 2020, our DCE presented 98 dairy farmers – i.e., 3.08% of Meija's dairy units— with water conservation practices in terms of the above five attributed.

Our research contributes to the literature by documenting dairy farmers' preferences, decision-making processes, and potential transitions toward incentivized water preservation practices, with an eye towards achieving sustainable development goals. To the best of our knowledge, the academic literature has largely overlooked preferences of dairy farmers in Latin America. We estimate the economic value Ecuadorian dairy farmers assign to production practices that preserve water. Also, we illustrate how DCE can be used to gather policy-relevant information when designing incentive-based interventions to encourage movement toward a cleaner production regime in Latin American countries.

2. Context, data, and methods

2.1. Study zone description

Mejia is a canton in the southeastern part of the province of Pichincha, Ecuador (see Fig. 1). Mejia is surrounded by natural elevations such as Atacazo, La Viudita, El Corazón, Los Ilinizas, Pasochoa, Ninahilca, Sincholagua, Rumiñahui and Cotopaxi (GAD Municipio de Mejía, 2015); this is why this canton is called *"The Valley of the Nine Volcanoes"*. As this Andean zone enjoys a unique biodiversity within their montane rain forests and paramos, it has a protected natural reserve with more than 30,000 ha, where Los Ilinizas mountain is the biggest protected area (63% of total protected area) (see GAD Municipio de Mejía, 2020). Also, there exist 14 different types of terrestrial ecosystems in Mejia, where the most prevailing is "*herbazal del paramo*," which is usually located between 2900–3900 m.a.s.l., consists of dense vegetal formation, and faces high variability of humidity and temperature.[4]

In terms of climate conditions, Mejia shows a great variability across its territory, with an annual precipitation between 500 and 2000 mm in some places and more than 2000 mm in others (GAD Municipio de Mejía, 2020). Also, it presents an annual average temperature between 10 °C and 24 °C. Although this canton has "low probability of drought events", agriculture is the land use more exposed to this occurrence.[5]

Mejia benefits from the two main sub-basins in Pichincha, the Guayallabamba and Blanco rivers, which generate approximately 384 rivers and streams. San Pedro and Pita rivers are also important water bodies (GAD Municipio de Mejía, 2020), supplying water for both human consumption and agricultural irrigation. Despite these abundant water resources, Mejia suffers from water deficits, particularly during the summer (GAD Provincia de Pichincha, 2015).

Thus, Mejia is suitable for agricultural activities. It has a total area of 1410.82 km^2, of which 36,078.91 ha are used for livestock production (GAD Municipio de Mejía, 2020). Around 21% of its labor force participates in agricultural activities, specifically in dairy production. Pichincha is the leading milk province in Ecuador, with 15.9% of the national milk output. Mejia supplies 34% of Pichincha's production, with an average productivity of 13.5 liters per day per cow (Banco Central del Ecuador, 2020; GAD Municipio de Mejía, 2020). This productivity is above the national and Pichincha average of 6 and 11.27 liters, respectively (dataset INEC, 2022).

2.2. Data collection and discrete choice experiment

Our study was conducted primarily within the communities of Machachi, Tambillo, Aloasi, and Uyumbicho. Sampled dairy farms were located along the San Pedro River. Although dairy production is the main farm activity in our study area, farmers also grow crops such as potatoes, maize, broad beans, etc.

In November 2020, we implemented a face-to-face survey[6] on 98 dairy farmers. While this sample represents 3.08% of Mejia's dairy units (GAD Municipio de Mejía, 2015),[7] it falls short of 187 – the sample size according to Orme (2010)'s rule of thumb.[8] Due to COVID-19-related challenges, we have not been able to gather data from a larger sample size. In this respect, we would like to highlight that previous DCE studies

[2] Data obtained from dataset INEC, 2020) to infer these numbers.

[3] We mainly looked for published stated preference literature describing (livestock or dairy) farmers' WTP/WTA for water conservation practices.

[4] See Terán et al. (2019) for more details of the definition of these forest ecosystems in Ecuador.

[5] In Ecuador, average annual precipitation is 2159.33 mm, and mean temperature depends on the months, where from December to May is rainy season with temperature between 25 °C and 26 °C, and from June to November is dry season with temperature between 21 °C and 22 °C (see World Bank Group, 2021).

[6] Approval from Human Research Ethics Committee at the Universidad San Francisco de Quito.

[7] Data collection by Perspectiva Consultores Estrategicos CIA Ltd.–Management Consulting Services. Our budget was for 100 surveys initially, where two of them were incomplete and excluded from our analysis. We do not have the number of farmers who did not want to participate in this in-person survey.

[8] Orme (2010)'s rule of thumb states that $n \geq 500c/ta$, where n is the number of respondents; t is the number of choice tasks per respondent; a is the number of alternatives in each choice set (excluding the status quo alternative); and c is the largest number of levels for any one attribute when considering only main effects –which is the case here. In our case, t is 4, a is 2, and c is 3.

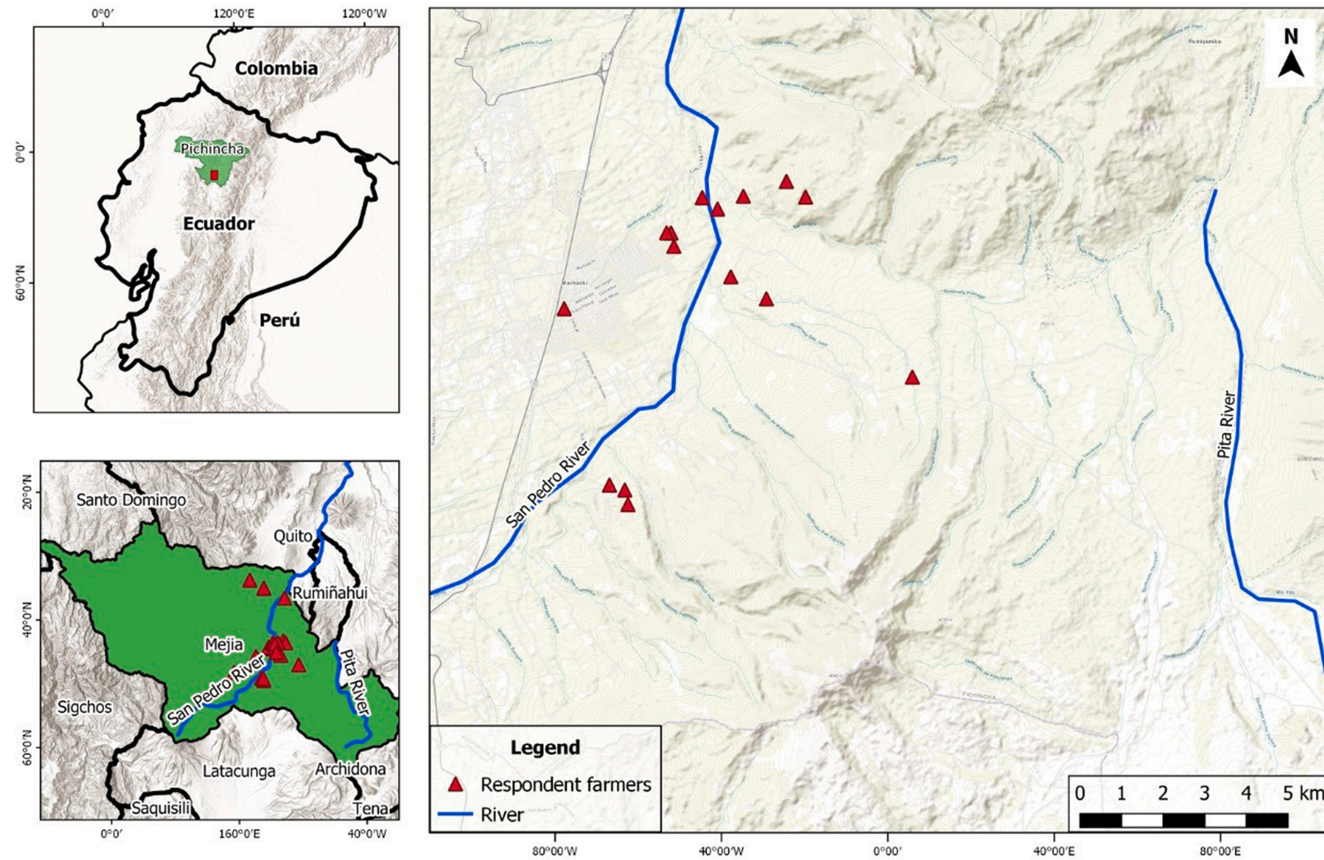

Fig. 1. Water resources, and locations of sampled farms in Mejia.

have analyzed samples of similar size (e.g., Ngoc et al., 2016; Sauthoff et al., 2016; Schreiner and Latacz-Lohmann, 2015; Vassalos et al., 2015).

Two filter questions ensured that respondents were milk producers and made decisions about their farms. At the farms, experienced enumerators carefully described the experiment, the practices, and the average implementation cost of US$1144 to respondents –details on how these costs are in Appendix D of Ortiz (2021) and in Domínguez (2020).

The survey comprised eight sections (see Appendix A). Section 1 identifies the respondents. Section 2 collects agricultural production information. Section 3 asks financial literacy questions. Section 4 introduces our DCE. Section 5 collected demographic data. Section 6 asks intrahousehold decision-making questions for married respondents. Section 7 obtains respondents' family information, including premarriage information. Finally, section 8 asks about respondent's household composition.

DCE is one of the foremost stated preferences methods (Johnston et al., 2017; Petrolia et al., 2021). DCE allows to estimate WTP for different hypothetical alternatives. This is an advantage over contingent valuation (CV), which only gives the economic value of a particular scenario (Perman et al., 2003). In addition, DCE infers WTP to each attribute level or characteristic of a prospective scenario, while CV method estimates a global value. DCE welfare estimates also have smaller variance than those from CV (Adamowicz et al., 1998). Finally, DCE is preferred over Conjoint Analysis because it is based on the Random Utility Theory (RUT) that is more consistent with the demand theory (Louviere et al., 2010). One disadvantage of DCE is that it imposes a tedious mental exercise to respondents who are asked to select different alternatives from different choice sets. This opens the doors for choosing with no careful consideration (Perman et al., 2003). To reduce this fatigue of respondents, we employ a blocking strategy on a fractional factorial design with a D-efficiency of 1.[9] Our design contained 12 choice sets divided into three blocks. Each respondent answered one block of four choice sets. Each set included two plans and the status quo (see Appendix B).

We conducted interviews with local experts (agronomists, veterinarians, and biologists) and dairy farmers, and identified twenty water conservation practices. Based on economic feasibility, we chose four attributes related to improved irrigation systems, appropriate animal manure and solid waste management, and strong water governance. In Table 1, we describe the attributes and levels of our DCE.

Precision irrigation is an alternative to the widespread use of inefficient flood irrigation (Brar et al., 2022). Thus, our first attribute has two irrigation technology levels—micro-sprinkler systems, and the superabsorbent polymers known as “solid rain.” Micro-sprinkler systems distribute water to cultivated plants via a low-pressure piping system, resulting in greater water efficiency, decreased irrigation time, and deterrence of soil erosion (Chen et al., 2002; El-Hafez et al., 2020; FAO, 2008). In 2020, the estimated implementation cost for this irrigation system is US$1200 ha^{-1}, which includes the suction pump, sprinklers, valves, and couplings for installation(see Riego Ecuador, 2020). Solid rain is a polymer that retains water. It can be applied to the soil to moisturize plant roots. Once the water held by the polymer is totally absorbed, the polymer can be charged again, for up to 10 years. Polymer application has resulted in increases in crop production, absorption of agrochemicals (avoiding leaching and runoff), and prevention of soil

[9] Our design was implemented with R-packages Idefix and Radiant (see Ortiz, 2021).

Table 1
Description of attributes and levels.

Attributes	Levels	Description
Irrigation system	Micro-sprinklers	Water saving, soil erosion prevention, suitable for uneven and sloped terrain. Higher installation time and costs, demands more (skilled) labor. Estimated implementation costs: $1200 ha^{-1}.
	Solid rain	Water saving, lower frequency-time, and easy to implement. Demands more (skilled) labor. Estimated implementation cost: $650 ha^{-1}.
Manure management	Composting	Better soil texture and structure, favoring fertility and permeability, and reduction of fertilization cost. Water pollution prevention. Demands more labor and space for a compost bin Estimated implementation costs: $438 ha^{-1}.
Solid waste management	Private	Water pollution prevention. Private collection centers manage solid waste. Farmers must transport and drop off the waste at the collection centers.
	Municipal	Water pollution prevention. Municipality manages solid waste. Farmers must submit this proposal. Service cost is 2% of the electricity bill. No implementation cost.
Water governance	Training	An academic institution could provide this training as part of the social involvement or professional practices of final-year students. Regular attendance during the year. No implementation cost.
Cost-share payment (%)	30%, 60%, 70%	Based on government subsidies; for example, the 30% subsidy within the cattle repopulation and genetic improvement program (MAG, 2016); the 80% subsidy for certified seeds and fertilizers, among other commodities (ElTelegrafo, 2017); or the 50%, 70%, or 90% subsidy for operating costs in forest conservation (MAE, 2013).

Note: for details of estimated costs, see Ortiz (2021).
Source: own elaboration

erosion (Ai et al., 2021; Chang et al., 2021; Cisneros et al., 2020; Shock and Iida, 2009). Studies in Ecuador have experimented with this practice in potato, broccoli, and lettuce production (Caizapasto, 2019; Toctaguano, 2019; Valera, 2018), and the return per dollar invested increased in all cases. Solid rain technology incurs in an initial cost of US $650 ha^{-1}, considering recommended amount per hectare along with the cost of labor for the installation process (Cosecha de Lluvia Sólida, 2015).

The second one-level attribute, manure composting, can help to prevent water pollution caused by untreated manure and agrochemicals (Bekchanov and Mirzabaev, 2018; Lim et al., 2016). Animal manure is a valuable resource that, when properly managed, can i) increase income from livestock, ii) improve animal nutrition, and iii) minimize financial risk. Integrated manure management entails the storage, processing, and subsequent application of the excreta on crops (Hristov et al., 2013; Jiménez-Trujillo, 2007). Its estimated initial cost is US$438, which implies the building of the concrete block, the metal structure, and the plastic cover. This cost also includes the necessary piping to ensure proper functioning (see Paredes, 2018).

The third attribute has two levels related to the management of plastic solid waste generated by dairy production, in accordance with guidelines on container disposal (FAO and WHO, 2008). The first level is private management, where farmers themselves collect plastic waste and transport it to private collection centers. Various reverse logistics programs for the management of plastic containers exist in countries such as Australia, Brazil, Canada, and Chile (FAO and WHO, 2008). The second level is a public waste management system, where municipal dumpsters visit accessible areas. Farmers would not incur any implementation cost other than a monthly payment of 2% of the electricity bill for two collections a month, as in Gualichicomín (2018).10

The fourth attribute aims to capture preferences for features that strengthen water governance through conflict resolution and water user cooperative training courses. These can be seen as instruments for the promotion of cooperation and self-governance, aiming to decrease in conflicts over water resources (Amirova et al., 2019; Bardhan, 1993; Cardenas et al., 2011; Cox et al., 2010; McGinnis and Ostrom, 1992; Mirzaei et al., 2019; Ostrom and Gardner, 1993). The Fondo para la Protección del Agua (FONAG) develops similar initiatives in the north-eastern part of Quito (FONAG, 2020).[11] The idea of this attribute is to have a constant community engagement between academic institutions and water users. Last-year students (e.g., from law schools) can provide these training sessions as part of their final examination (i.e., internships). Working with the irrigation board in each community, this training may be a requirement for farmers to be irrigation beneficiaries. The producer will incur no costs. Every training session will provide communication strategies, negotiation skills, cooperation initiatives, and free counsel to resolve problems related to water management.

The fifth attribute is the farmers' implementation cost-share payments for irrigation systems and manure management. The other practices have no initial cost. We present three cost-share levels—30%, 60%, and 70%—selected from a review of assistance and subsidies available from various government agencies. Table 2 provides an example of one of our choice sets.

2.3. Conceptual framework

The empirical design of discrete choice experiments relies on the idea that utility is derived from the attributes of a good (Lancaster, 1966). Also, DCE is based on RUT, in which conceptual and empirical probabilistic models intersect based on the assumption of a utility function containing deterministic and stochastic factors (Marschak, 1974; McFadden, 1986). Thus, assume the following utility ($U_{ij}$of agent i for alternative j):

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta_j + \Sigma_s \beta_s X_{ijs} + \beta_c C_{ij} + \varepsilon_{ij} \tag{1}$$

where V_{ij} and $\varepsilon_{ij}$are the deterministic and random elements, respectively. X_{ijs} is an observable attribute "s" with its preference parameter β_s. C_{ij} is a cost attribute with its coefficient β_c. Lastly, $\beta_j$is the alternative-specific utility. We excluded agent's characteristics for simplicity. Using Eq. (1), we calculate WTP for attribute "*s*" —i.e., the Marginal

Table 2
Example of a choice set.

Attributes	Plan A	Plan B	
Irrigation system	Micro-sprinklers	Solid rain	
Manure management	None	Manure composting	Prefer status quo
Solid waste management	Private	Municipal	
Water governance	Training	None	
Farmer's cost-share payment (%)	60%	30%	
Preferred Plan:	☐	☐	☐

Source: own elaboration

[10] Mejia's government charges 10% of electricity bills (kWh/month) for garbage collection services, where the average cost per kWh is US$0.1031 and US$0.1041 for residential and commercial areas, respectively.

[11] FONAG is a water conservation fund financed by public and private organizations to protect the water resources in Ecuador.

Rate of Substitution, or the respondent's subjective value of attribute "*s*" in terms of the cost attribute— as follows:

$$WTP_s = \frac{-\frac{\partial U_{ij}}{\partial X_{ijs}}}{\frac{\partial U_{ij}}{\partial C_{ij}}} = \frac{-\beta_s}{\beta_C} \quad (2)$$

2.4. Econometric strategy

Based on Eq. (1), an agent i will choose, among all possible alternatives $j = 1, 2, \ldots, J$, the alternative j over k using the following criteria:

$$U_{ij} > U_{ik} \Longrightarrow \varepsilon > V_{ik} - V_{ij} \forall_{j \neq k} \quad (3)$$

where $\varepsilon = \varepsilon_{ij} - \varepsilon_{ik}$. As utility levels are not observable, the probability of choosing an alternative is computed as follows:

$$Prob(Chosej) = Prob(\varepsilon > V_{ik} - V_{ij}), \forall_{j \neq k} \quad (4)$$

Then, assuming ε is independent and identically distributed (IID) as a Gumbel (a type 1 extreme value), Eq. (4) is mathematically specified as follows (see Greene, 2008):

$$Prob(Chosej) = \frac{e^{V_{ij}}}{\sum_{j=1}^{J} e^{\Sigma_s V_{ij}}} = \frac{e^{\beta_j + \Sigma_s \beta_s X_{ijs} + \beta_c C_{ij}}}{\sum_{j=1}^{J} e^{\beta_j + \Sigma_s \beta_s X_{ijs} + \beta_c C_{ij}}} \quad (5)$$

Eq. (5) is the Conditional Logit (CL) model, which holds two important assumptions: i) independence of irrelevant alternative (IIA), and ii) preference homogeneity. We relax these restrictive assumptions by employing the Random Parameter Logit (RPL) model (see Train, 2009). Thus, the probability of choosing j is:

$$Prob(Chosej) = \int \frac{e^{\beta_j + \Sigma_s \beta_s X_{ijs} + \beta_c C_{ij}}}{\sum_{j=1}^{J} e^{\beta_j + \Sigma_s \beta_s X_{ijs} + \beta_c C_{ij}}} f(\beta|\theta, \Omega) d\beta \quad (6)$$

where $f(\beta|\theta, \Omega)$ is a density function for a vector of the attribute's coefficients with expected value θ and variance-covariance matrix Ω. This model abandons the IIA assumption and incorporates unobserved preference heterogeneity (Boxall and Adamowicz, 2002).

3. Results

3.1. Descriptive statistics

Table 3 compares the descriptive statistics of our sample and official data for Pichincha in 2021.[12] Based on this comparison, we believe that our sample closely approximates a representative sample of dairy farmers in Mejia. Regarding the sampled respondents' socioeconomic characteristics, most farmers are male (74%), with an average age of 55.3 years, which is statistically similar to official statistics. Our respondents, however, seem to be less educated than individuals from the official data. While the official data report 68% of respondents holding no higher qualification than a high school diploma, this number is 91% in our sample.

Our sampled farmers hold 7.36 ha on average, statistically equal to official numbers (11.17 ha). Our respondents on average own 5.50 head of cattle ha^{-1}, produce 101.37 liters of milk per day, and sell that milk for a price of US\$ 0.35 L^{-1}. These numbers are statistically equal to their equivalents in the official data. Only 23% of our respondents reported a decrease in sales due to COVID-19 conditions, which is lower than the official number (39%).

Of the sampled respondents, 35% do not irrigate, whereas 39% of participants in the official data do not irrigate. Within irrigators, 97% utilize sprinkler/surface system in our sample, similar to the official rate

Table 3
Descriptive statistics (Mean): Sample (N = 98) versus Pichincha's official data for 2021.

Variable	Sample	Official	Differences
Farmers' characteristics			
Age (years)	55.30 (12.20)	56.54 (14.85)	-1.24
Male	0.74 (0.44)	0.74 (0.44)	0
High school diploma or less	0.91 (0.28)	0.68 (0.47)	0.23***
Dairy production			
Farm size (ha)	7.36 (17.81)	11.17 (67.36)	-3.81
Head of cattle per ha	5.50 (10.78)	4.99 (8.47)	0.51
Milk price (US\$ L^{-1})	0.35 (0.05)	0.40[a]	-0.05
Milk production (L)	101.37 (207.91)	68.50 (280.01)	32.87
Sales decreased due to COVID-19	0.29 (0.19)	0.39 (0.49)[b]	-0.10**
Monthly income between 0 and 1000 (US\$)	0.83 (0.37)	-	-
Irrigation system[c]			
None	0.35 (0.48)	0.39 (0.49)	-0.04
Sprinkler/surface	0.97 (0.17)	0.98 (0.10)	-0.01
Micro-sprinkler	0.03 (0.17)	0.01 (0.09)	0.02**
Other[d]	0.02 (0.12)	0.003 (0.05)	0.017***
Fertilization			
None	0.03 (0.17)	0.50 (0.50)	-0.47***
Organic	0.50 (0.50)	0.46 (0.50)	0.04
Chemical	0.86 (0.34)	0.71 (0.46)	0.15***
Manure management			
None	0.16 (0.37)	0.54 (0.50)[e]	-0.36***
Dispersion	0.94 (0.24)	0.86 (0.34)[e]	0.08**
Composting	0.07 (0.26)	0.12 (0.32)[e]	-0.05
Solid waste management			
Common trash/burn/bury	0.88 (0.33)	-	

Note:
[a] From Banco Central del Ecuador (2020).
[b] Specific question: were agricultural activities affected by COVID-19?
[c] Farmers can choose more than one option.
[d] Drip, manual, and unidentified systems.
[e] We used the fertilization section and expansion factors of ESPAC (2021) to infer these numbers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$.
Source: own elaboration.

of 98%, while only 2% employ micro-sprinkler systems, statistically different from the official rate of 0.3%. In our sample, 86% of farmers use chemical fertilizers for grassland cultivation and 50% use organic fertilizers—this latter number is equal to the official statistic. Concerning manure management, most farmers practice manure dispersion (94% in our sample and 86% in the official data), while only a few practice composting (7% in our sample and 12% in the official data). Finally, 88% of our respondents burn, bury, or dump their solid waste alongside common trash –there are no official data on solid waste disposal methods.

3.2. Econometric models

Table 4 reports estimates from four RPL and one CL specifications.[13] Panel A reports the mean point estimates of coefficients. The first and second columns report RPL assuming normally distributed parameters, including the price parameter, but show uncorrelated (RPL1) and correlated RPL (RPL2), respectively. The third and fourth columns report RPL assuming fixed price parameter and normal distribution of the rest of the parameters: uncorrelated (RPL3) and correlated (RPL4) RPL, respectively. The fifth column displays CL estimate.

Regarding sign direction and the statistical significance of mean estimates, Table 4 shows that the utility parameter associated with the status quo is negative in all four RPLs, but statistically significant for

[12] Encuesta de Superficie y Produccion Agropercuaria Continua (dataset INEC, 2022). Official data are representative at province level; only farm size, head of cattle ha^{-1}, milk price, and milk production are specific to dairy farms.

[13] Find our dataset in Ortiz et al. (2022). We used Stata Statistical Software to estimate our models.

Table 4
RPL and CL specifications.

Attribute	(RPL1)	(RPL2)	(RPL3)	(RPL4)	(CL)
Panel A: Mean estimates					
Status quo	-1.320**	-8.813***	-0.369	-0.959	0.057
	(0.653)	(2.727)	(0.551)	(0.661)	(0.315)
Solid rain	0.864**	4.479***	0.684**	0.646*	0.657***
	(0.280)	(1.480)	(0.254)	(0.378)	(0.178)
Manure composting	-0.335	-2.671**	-0.389	-0.546	-0.192
	(0.274)	(1.248)	(0.257)	(0.355)	(0.161)
Municipal management	-0.315	-2.459***	-0.343	0.170	-0.245
	(0.249)	(0.919)	(0.233)	(0.351)	(0.160)
Training	1.245***	1.690*	0.983***	0.628*	0.779***
	(0.296)	(0.952)	(0.249)	(0.364)	(0.173)
Farmer's cost-share payment (US $ ha^{-1})[a]	-0.006***	-0.032***	-0.004***	-0.005***	-0.002***
	(0.001)	(0.008)	(0.001)	(0.001)	(0.000)
Panel B: Standard deviation of parameters					
Status quo	3.697***		3.242***		
	(0.740)		(0.567)		
Solid rain	1.118**		1.123**		
	(0.374)		(0.455)		
Manure composting	0.869**		0.985**		
	(0.383)		(0.435)		
Municipal management	0.647		0.103		
	(0.409)		(0.930)		
Training	0.879**		0.531		
	(0.419)		(0.382)		
Farmer's cost-share payment (US $ ha^{-1})	0.005***				
	(0.001)				
	Panel C: Total observations and goodness of fit.				
Observations	1176	1176	1176	1176	1176
Log-Likelihood	-295.2	-285.2	-302.4	-291.7	-367.1
AIC	614.5	624.5	626.8	625.5	746.3
BIC	675.3	761.25	682.6	732	776.7

Note: Standard errors in parentheses. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.001$. Ignore signs on the standard deviation coefficients.
[a] Using the average plan's implementation cost.
Source: own elaboration.

Table 5
Elements of the lower-triangular covariance matrix of random coefficients.

	(RPL2)	(RPL4)
Status quo	-13.931***	-2.929***
	(3.894)	(0.753)
Solid rain – status quo	-2.447***	0.863
	(0.874)	(0.651)
Manure composting – status quo	0.451	0.102
	(0.696)	(0.449)
Municipal management – status quo	-0.683	-1.469***
	(0.751)	(0.499)
Training – status quo	-3.345***	1.234**
	(1.217)	(0.569)
Solid rain	-14.770***	-0.975***
	(4.037)	(0.359)
Manure composting – solid rain	2.462**	1.151***
	(1.204)	(0.372)
Municipal management – solid rain	6.231***	0.726**
	(1.879)	(0.369)
Training – solid rain	-7.771***	0.354
	(2.198)	(0.345)
Manure composting	0.052	0.0354
	(0.771)	(0.587)
Municipal management – manure composting	8.870***	-0.293
	(2.463)	(0.429)
Training – manure composting	1.198	-0.714
	(0.773)	(0.621)
Municipal management	-2.993***	-0.458
	(1.070]	(0.439)
Training – municipal management	-3.769***	0.0213
	(1.188)	(0.437)
Continued.		
	(RPL2)	(RPL4)
Training	-10.237***	0.461
	(2.798)	(0.473)
Cost-share payment – status quo	-0.028***	
	(0.007)	
Cost-share payment – solid rain	0.003	
	(0.002)	
Cost-share payment – manure composting	-0.019***	
	(0.005)	
Cost-share payment – municipal management	-0.006**	
	(0.002)	
Cost-share payment – training	-0.009***	
	(0.003)	
Cost-share payment	-0.011***	
	(0.003)	

Note: Standard errors in parentheses. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.001$. Ignore signs on the standard deviation coefficients.
Source: own elaboration.

RPL1 and RPL2. The CL specification yields a positive but insignificant estimate for the status quo. In addition, all four RPLs and the CL yield positive and statistically significant preferences for solid rain and training. Preferences for manure composting are negative in all five models but statistically significant only in RPL2, and a similar pattern is evident for municipal management. Consistent with economic theory, the price coefficient is negative and statistically significant at 99% confidence across all models.

In Table 4, panel B reports the standard deviation of utility parameters for RLP1 and RPL3. The statistical significance and the magnitude of the standard deviation coefficients of status quo, solid rain, and manure composting indicate the presence of high levels of unobserved preference heterogeneity. Table 5 reports the elements of the lower-triangular covariance matrix of utility parameters for RPL2 and RPL4. The significance of these Cholesky elements confirms unobserved preference heterogeneity. We do not compute correlations directly, but the signs of these elements indicate the direction of these correlations. For instance, using RPL2 specification, we observe that status quo has a negative correlation with solid rain, training, and cost-share payment. While solid rain is positively correlated with manure composting and municipal plastic waste management. Finally, we also see that cost-share payment has a negative correlation with manure composting, municipal and training.

Given the magnitude and statistical significance of variance and Cholesky parameters documenting unobserved heterogeneity in preferences, it is not surprising that all four RPLs outperform CL, as reflected by both AIC and BIC (see panel C in Table 4). Among the four RPLs, RPL1 has the highest performance concerning AIC and BIC. Of the two empirical models that align with economic theory by keeping the price parameter fixed (i.e., RPL3 and RPL4), RPL3 outperforms RPL4 regarding BIC, and performs only slightly worse than RPL4 in terms of AIC. Comparison of the statistical fitness of the RPLs thus suggests that a lack of correlation among the parameters is empirically preferred in our data, as assumed in RPL1 and RPL3.

3.3. Willingness to pay estimates

Table 6 displays estimates of WTP arising from the five specifications reported in Table 4. We mostly focus on WTP arising from RPL1 and RPL3. Statistically significant and positive WTPs for solid rain adoption and training for conflict resolution and cooperation are consistent across models. For instance, findings from RPL3 indicate that farmers are willing to pay US$170 ha^{-1} for the adoption of solid rain, which represents 26.15% of its implementation cost (or, 14.86% of average implementation cost), and US$244 ha^{-1} for training.

Table 7 reports WTP by subsamples based on heads of cattle (<10, and >=10) and farm size (<4 ha, and >=4 ha) that reflect the size of

Table 6
WTP estimates and 95% confidence interval (US$ ha^{-1}).

WTP	(RPL1)	(RPL2)	(RPL3)	(RPL4)	(CL)
Status quo	-224.36	-273.42	-91.88	-194.62	22.69
Mean					
Lower	-392.85	-337.55	-344.65	-417.57	-230.40
Upper	-55.86	-209.28	160.89	28.32	275.79
Solid rain					
Mean	146.90	138.97	169.86	131.00	263.68
Lower	46.53	80.41	33.87	-24.11	103.82
Upper	247.26	197.53	305.85	286.10	423.54
Manure composting					
Mean	-56.99	-82.86	-96.69	-110.71	-77.22
Lower	-147.91	-143.57	-215.73	-248.87	-201.52
Upper	33.91	-22.15	22.35	27.46	47.09
Municipal management					
Mean	-53.49	-76.28	-85.31	34.45	-98.39
Lower	-138.69	-117.51	-197.13	-106.10	-232.24
Upper	31.70	-35.05	26.52	175.00	35.47
Training					
Mean	211.61	52.43	244.22	127.42	312.3
Lower	110.83	-2.37	121.47	-14.83	152.02
Upper	312.39	107.23	366.97	269.66	472.58

Source: own elaboration.

Table 7
WTP and 95% confidence interval (US$ ha^{-1}) from RPL1, by size of production unit.

	Head of cattle		Farm size	
WTP	< 10	> =10	< 4 ha	> =4 ha
Status quo				
Mean	-199.278	-223.638	-226.358	-230.668
Lower	-546.661	-349.528	-452.804	-275.170
Upper	148.106	-97.748	0.087	-186.166
Solid rain				
Mean	115.891	137.015	151.530	98.040
Lower	-42.420	38.239	-0.430	62.784
Upper	274.202	235.790	303.490	133.297
Manure composting				
Mean	-17.957	-83.763	-134.651	-24.507
Lower	-163.629	-170.011	-265.432	-56.480
Upper	127.715	2.484	-3.870	7.466
Municipal management				
Mean	21.916	-116.959	-16.955	-103.454
Lower	-114.876	-208.531	-141.418	-126.608
Upper	158.708	-25.387	107.508	-80.301
Training				
Mean	195.198	161.671	188.966	138.195
Lower	30.667	74.366	63.911	109.852
Upper	359.728	248.976	314.021	166.537

Source: own elaboration.

each production unit. We chose RPL1 following goodness-of-fit tests (see Ghosh et al., 2013). The findings are consistent across both subsamples. While smaller farmers have an insignificant negative WTP for the status quo, larger farmers have a significantly negative WTP for the status quo—ranging from US$230 to US$224 ha^{-1}. This finding reflects a greater disutility among the larger farmers. Similarly, while a positive WTP for solid rain exits for all subsamples, it is only among bigger farmers that this WTP is statistically significant, ranging from US$98 to US$137 ha^{-1}. In contrast, the results demonstrate a significant and positive WTP for training in all subsamples.

Finally, farmers have provided their preferences for which financial institutions should share the cost of implementation. Public financial institutions such as BanEcuador (57.14%) and CFN (12.25%) are the most preferred, followed by private banks (14.29%), and other entities such as saving and credit cooperative (19.39%).[14]

4. Discussion

Our findings illustrate that the status quo –low adoption rate of water conservation practices— does not necessarily imply disutility, particularly among smaller farmers. We offer two reasons for this finding: 1) given financial barriers and uncertainties, exacerbated by the current pandemic, producers may be avoiding the addition of new practices and costs to their production process; and 2) some of the practices are not well known, and farmers may not have completely understood our explanation of these hypothetical alternatives. In this case, the status quo would become the best option. This second reason will lead to forthcoming research in which we will attempt to empirically measure the relationship between farmers' choices and financial literacy. We use financial literacy as a proxy of farmers' understanding of complex scenarios.

Our findings strongly suggest that farmers are interested in two practices: solid rain and training courses for water governance improvement. First, given the inefficient use of water in Mejia, farmers demand improved irrigation systems. Although solid rain is not yet well known in our study area, farmers, especially larger farmers, showed strong interest in experimenting with this technique. In fact, the literature discusses how farmers assign intrinsic values to water that exceed irrigation water prices (Alcon et al., 2014; Mu et al., 2019; Rigby et al., 2010; Salman and Al-Karablieh, 2004), providing insights into the potential for incentive-based mechanisms to increase farmers' adoption of efficient irrigation technologies.[15]

Second, water governance is weak in our study area, which opens the door to water conflicts. Thus, our producers seem to be interested in strategies that would help them establish rules and form cooperation initiatives. The existing literature supports preferences over cooperative behavior among farmers. For example, this behavior occurs in a collaborative insurance scheme in Central Mexico (Colin-Castillo et al., 2022), in collective participation in an agri-environmental scheme in Spain (Villanueva et al., 2015), or in the local management of an irrigation system in South Africa (Saldías et al., 2016). In addition, local communities are willing to associate with external agencies to improve governance, for instance, in the implementation of climate change adaptation schemes (Nthambi et al., 2021). This also supports our proposal that external agencies could offer training courses.

In this context –i.e. given that our respondents are interested in efficient irrigation technologies and open to improve their water governance—, we see an opportunity to build a water governance that prevents the undesirable rebound effect. This effect refers to the potential that adoption of efficient technologies does not necessarily bring lower use of resources because adopters may end up using such efficient technologies at higher rates to the point that efficiency is overcompensated and resources en up used at higher rates than before adoption of efficient technologies. In this respect, Sainz-Santamaria and Martinez-Cruz (2019) document that experts in agronomy and hydrology do not expect that widespread adoption of efficient irrigation (sprinkler or drip technologies) would substantially reduce aquifer overdraft in Aguascalientes, Mexico. The authors point out that these expectations are coherent with previous economic studies documenting that adopters increase irrigated area after technology adoption, and switch to crops that use water more intensively. Thus, findings in this paper open the possibility of further researcher aiming to take

[14] Shares of agricultural loans are 49.36% for public institutions and 50.64% for private banks (MAG, 2020).

[15] Prior research also reports preferences for improved irrigation technologies such as drip, gravity, soil moisture monitoring, drainage management, among others (Abebe et al., 2020; Aydogdu and Bilgic, 2016; Houessionon et al., 2017; Khachatryan et al., 2019; Ogonna Olive and Kingsley David, 2021).

advantage of dairy farmers' interest on improvement of water governance to foresee mechanisms preventing rebound effects from adoption of efficient technologies –this topic deserves further exploration both for academic purposes and for public policy relevance.

Two practices were not preferred, and farmers would even demand payment for their adoption. The first, manure composting, implies additional costs and the construction of a composting site, which reduces space for other farming activities (some of these farms cover less than 1 ha). Potential increases in labor cost, and low prices for fertilizers such as urea and diammonium phosphate in previous years (Baffes and Chian Koh, 2019), may provoke farmers' unwillingness to adopt manure composting even when it yields monthly savings. Our finding differs from the conclusion drawn by Tur-Cardona et al. (2018) that livestock producers in seven EU countries are willing to pay prices for manure composting of up to 41.3% more than the cost of chemical fertilization.

The second non-preferred practice, municipal management, does not involve an implementation cost, but Mejia's municipality would charge an additional fee for managing solid waste. One reason for a negative preference is that as bigger electricity consumers, larger farmers might observe a higher increase in their bill than smaller farmers. Another reason is an option not explored in our DCE, the public-private management. For instance, study cases show farmers' willingness to pay for a public-private management between US$1,68 and US$4.22 per month (see Omotesho et al., 2016; Rahji and Oloruntoba, 2009). Thus, our sampled farmers did not see this option as an attribute level and then, status quo became their desired alternative. Indeed, we may need more research on other levels of this attribute.

Differences between our findings and previous findings may reflect context-specific preferences –e.g., preferences of farmers in developed countries versus preferences of farmers in a developing country. However, we cannot exclude the possibility that the lack of attribute's statistical significance that we are interpreting as lack of farmers' preferences is due to the size of our sample. Orme (2010)'s rule of thumb has suggested a sample size of 187 but we have collected data from 98 respondents due to COVID-19-related challenges. Thus, it is plausible that an increase in data yields statistically significant parameters for the attributes that we are documented as of no interest for our respondents.

Indeed, WTP estimates in this paper have been obtained amid the COVID-19 pandemic. Whether and by how much these estimates may differ from those obtained in post-pandemic times become relevant research questions –relevant from a public policy perspective but also from a purely scientific perspective. In this respect, we plan to explore potential differences in the near future. In addition, we wish to direct the reader's attention to previous evidence suggesting that estimates of stated WTP remain stable in context of economic recessions –which is how the pandemic can be translated into a macroeconomic event (Krugman, 2020). Keeping in mind that goods under valuation and contexts are different in comparison to our study, Martínez-Cruz and Núñez (2021) have reported that stated WTP for renewable energies have change only slightly once an economic recession has occurred in developed countries –research on this issue has yet to be carried out in developing countries.

5. Conclusions

Our findings are relevant for policymakers and researchers interested in promoting water conservation practices among dairy farmers in Ecuador and other developing countries, particularly in Latin America. The first finding that we highlight is the disutility that Mejia's larger farmers report for the status quo. This result implies that a change in current management practices would deliver an increase in utility among larger farmers. In this sense, solid rain and training courses for conflict resolution and cooperation would deliver an improvement in the welfare of larger producers. It is also consistent in our case study that manure composting is not in demand among our farmers.

The story is less straightforward in the case of solid rain and municipal waste management. While smaller farmers seem to have zero WTP for municipal management, larger farmers report disutility, a result which holds across all sizes of production units. Overall, WTP for solid rain is positive and significant across model specifications, but smaller farmers are not interested in this irrigation technique, while larger farmers report positive preferences. Thus, field experimentation is required for the adoption of this improved irrigation system.

Such heterogeneity in preference is intuitive. Larger farmers would likely benefit more from solid rain than smaller farmers, which translates into a higher WTP. Simultaneously, the relatively homogeneous preferences for the status quo and training on conflict resolution and cooperation are informative. Farmers–of all farm sizes–demanding a change in status quo conditions is consistent with their demand for assistance in handling likely conflicts in the current context. These results are expected, given the inefficient water use in our study area and the risk of water conflict due to weak water administration. Local universities or NGOs through community engagement programs can play an essential role in helping water users develop cooperative behaviors and resolve conflicts (Handayani et al., 2022; McKinney and Thorson, 2015; Wingfield et al., 2021). In fact, Ecuadorian universities require internships in some of their academic programs. For instance, last-year law school students, supervised by their professors, can impart training courses or legal advice on cooperation and conflict resolution strategies. For this policy action, we can learn from FONAG's projects that address legal framework, technical assistances, governance, conflict resolution, and son on (FONAG, 2020, 2007). Finally, environmental law clinics would allow students to offer counsel to facilitate the resolution of problems between water users.

Our results show that farmers are interested in solid rain. However, their WTP only covers a portion of its implementation cost. Consequently, cost-sharing schemes could facilitate the adoption of this technology or other conservation practices that satisfy the Ecuadorian government's guidelines for livestock BMPs (Agrocalidad, 2012). In fact, there are different cases of cost-sharing programs in Ecuador such as 30% subsidy within the cattle repopulation and genetic improvement program (MAG, 2016), the 80% subsidy for certified seeds and fertilizers, among other commodities (ElTelegrafo, 2017), or the 50%, 70%, or 90% subsidy for operating costs in forest conservation (MAE, 2013). Farmers with financial aid could overcome implementation risks and current financial barriers, and where cost-sharing schemes can have long-lasting effects on farmers' livelihood (Hossain et al., 2022). Policymakers should devise cost-sharing plans, based primarily on the farmers' profiles and needs, to reduce high implementation costs. DCE is a tool that can provide ex-ante information about farmers' preferences for different sustainable practices, and thus help agricultural authorities make informed decisions when implementing agricultural adoption programs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Our DOI is already active on Mendeley Data. DOI: 10.17632/ncj6ws6hbj.1.

Dataset for: Dairy farmers' willingness to adopt cleaner production practices for water conservation: A discrete choice experiment in Mejia, Ecuador (Original data) (Mendeley Data)

Acknowledgements

Our research was supported by the School of Economics at the

Universidad San Francisco de Quito USFQ (Economia Grants 2019-2020 - H16908). We are also grateful to Dr. Kelly Grogan and Dr. Pilar Useche, who shared ideas for our methodology. We appreciate the suggestions from Dr. Julio Acuña. Special thanks to all professors from Universidad San Francisco de Quito USFQ, experts, and farmers for their participation in the design of our experiment. Finally, we thank to the anonymous reviewers and the associate editor for their valuable comments and suggestions.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.agwat.2023.108168.

References

Abebe, F., Zuo, A., Ann Wheeler, S., Bjornlund, H., van Rooyen, A., Pittock, J., Mdemu, M., Chilundo, M., 2020. Irrigators' willingness to pay for the adoption of soil moisture monitoring tools in South-Eastern Africa. Int. J. Water Resour. Dev. 36, 1–22. https://doi.org/10.1080/07900627.2020.1755956.

Adamowicz, W., Boxall, P., Williams, M., Louviere, J., 1998. Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. Am. J. Agric. Econ. 80, 64–75.

Agrocalidad, 2012. Guía de buenas prácticas pecuarias de producción de leche. Resolución técnica No. 0217 R.O. No. 842. Inocuidad del los alimentos. Quito. 〈https://www.agrocalidad.gob.ec/wp-content/uploads/2020/05/pecu3.pdf〉.

Ai, F., Yin, X., Hu, R., Ma, H., Liu, W., 2021. Research into the super-absorbent polymers on agricultural water. Agric. Water Manag 245, 106513. https://doi.org/10.1016/j.agwat.2020.106513.

Alcon, F., Tapsuwan, S., Brouwer, R., de Miguel, M.D., 2014. Adoption of irrigation water policies to guarantee water supply: a choice experiment. Environ. Sci. Policy 44, 226–236. https://doi.org/10.1016/j.envsci.2014.08.012.

Amirova, I., Petrick, M., Djanibekov, N., 2019. Long- and short-term determinants of water user cooperation: experimental evidence from Central Asia. World Dev. 113, 10–25. https://doi.org/10.1016/j.worlddev.2018.08.014.

Andrango, J., Sandoval, A., 2021. Plan de manejo de efluentes en la actividad de ordeño en 4 tambos pequeños del canton Mejia, Universidad Politecnica Salesiana. 〈https://dspace.ups.edu.ec/bitstream/123456789/19928/1/UPS-TTS300.pdf〉.

Aydogdu, M.H., Bilgic, A., 2016. An evaluation of farmers' willingness to pay for efficient irrigation for sustainable usage of resources: the GAP-Harran Plain case, Turkey. J. Integr. Environ. Sci. 13, 175–186. https://doi.org/10.1080/1943815X.2016.1241808.

Baffes, J., Chian Koh, W., 2019. Fertilizer market outlook: potash prices to rise in 2019 but urea and phosphates remain subdued, World Bank Blog: Let's Talk Development. 〈https://blogs.worldbank.org/developmenttalk/fertilizer-market-outlook-potash-prices-rise-2019-urea-and-phosphates-remain〉. (Accessed 13 January 2022).

Banco Central del Ecuador, 2020. Reporte de coyuntura sector agropecuario II trimestre. 〈https://contenido.bce.fin.ec/documentos/PublicacionesNotas/Catalogo/Encuestas/Coyuntura/Integradas/etc202002.pdf〉.

Bardhan, P., 1993. Symposium on management of local commons. J. Econ. Perspect. 7, 87–92.

Barrowclough, M., Stehouwer, R., Alwang, J., Gallagher, R., Barrera Mosquera, V.H., Domínguez, J.M., 2016. Conservation agriculture on steep slopes in the Andes: promise and obstacles. J. Soil Water Conserv 71, 91–102. https://doi.org/10.2489/jswc.71.2.91.

Bekchanov, M., Mirzabaev, A., 2018. Circular economy of composting in Sri Lanka: opportunities and challenges for reducing waste related pollution and improving soil health. J. Clean. Prod. 202, 1107–1119. https://doi.org/10.1016/j.jclepro.2018.08.186.

Bonifaz, E.A., 2018. Evaluación de la contaminación fecal de origen humano y animal en la cuenta alta del río Guayllabamba mediante indicadores virales, Universidad de la Americas-UDLA. 〈https://www.researchgate.net/profile/Edison-Bonifaz-2/publication/326550288_UDLA-EC-TIB-2018–16/links/5b5552940f7e9b240ffd7132/UDLA-EC-TIB-2018–16.pdf〉.

Boxall, P.C., Adamowicz, W., 2002. Understanding heterogenous preferences in random utility models: a latent class approach. Environ. Resour. Econ. 23, 421–446. https://doi.org/10.1023/A:1021351721619.

Brar, A.S., Kaur, K., Sindhu, V.K., Tsolakis, N., Srai, J.S., 2022. Sustainable water use through multiple cropping systems and precision irrigation. J. Clean. Prod., 130117 https://doi.org/10.1016/j.jclepro.2021.130117.

Cachipuendo, C., Requelme, N., Gualavisí, O., Sandoval, C., Sandoval, J., 2017. Community use of water and land for sustainable production of pasture. La Granja Rev. Cienc. la Vida 26, 142–154.

Caizapasto, G., 2019. Evaluación del rendimiento del cultivo de lechuga (Lactuca sativa l.) variedad crespa salad con retenedores de agua en Tocachi – Pichincha y San José de Chaltura - Imbabura, Universidad Técnica del Norte. 〈http://repositorio.utn.edu.ec/bitstream/123456789/9780/2/03〉 EIA 486 TRABAJO GRADO.pdf.

Cardenas, J.C., Rodriguez, L.A., Johnson, N., 2011. Collective action for watershed management: field experiments in Colombia and Kenya. Environ. Dev. Econ. 16, 275–303. https://doi.org/10.1017/S1355770X10000392.

Cevallos Polanco, A., Taipe Taipe, M.V., Caiza de la Cueva, F.I., 2021. Costo real de producción del litro de leche, en pequeños ganaderos de la comunidad de Sivicusig, cantón Sigchos, Ecuador. Cienc. Lat. Rev. Científica Multidiscip. 5, 4474–4489. https://doi.org/10.37811/cl_rcm.v5i4.632.

Chang, L., Xu, L., Liu, Y., Qiu, D., 2021. Superabsorbent polymers used for agricultural water retention. Polym. Test. 94, 107021 https://doi.org/10.1016/j.polymertesting.2020.107021.

Chen, C., Roseberg, R.J., Selker, J.S., 2002. Using microsprinkler irrigation to reduce leaching in a shrink/swell clay soil. Agric. Water Manag 54, 159–171. https://doi.org/10.1016/S0378-3774(01)00150-0.

Chiriboga, J.L., 2015. Cambio climático, agua y conflicto: disputas sociales, crisis hídrica y oportunidades de adaptación en la Sierra Centro-Norte de Ecuador Estudio de caso: conflicto por el uso del agua entre la ciudad de Quito y la cuenca agropecuaria de GÜITIG. Universidad Andina Simón Bolívar. 〈https://repositorio.uasb.edu.ec/handle/10644/4738〉.

Cisneros, E., Zayas, R., Cun, G., Herrera, J., González, F., 2020. Efecto de los polímeros súper absorbentes en la economía del agua para uso agrícola. Rev. Iberoam. Polímeros 21, 1–13.

Colin-Castillo, S., Manriquez Garcia, N., Martinez-Cruz, A.L., 2022. Farmers ' willingness to adopt chemical -free inputs and engage in collaborative arrangements: a discrete choice experiment in Mexico. Econoquantum in press,.

Cosecha de Lluvia Sólida, 2015. ¿ Qué es cosecha de lluvia sólida? (WWW Document). 〈https://www.cosechadelluvia.com/〉. (Accessed 6 October 2020).

Cox, M., Arnold, G., Villamayor Tomás, S., 2010. A review of design principles for community-based natural resource management. Ecol. Soc. 15. https://doi.org/10.5751/ES-03704-150438.

[dataset] INEC, 2020. Gestión integral de residuos sólidos, Estadísticas de información ambiental económica en gobiernos autónomos descentralizados. 〈https://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_agropecuarias/espac/espac-2018/Boletintecnico.pdf〉. (Accessed 20 May 2022).

[dataset] INEC, 2022. Encuesta de superficie y producción agropecuaria continua ESPAC 2021, Estadísticas agropecuaria. 〈https://www.ecuadorencifras.gob.ec/estadisticas-agropecuarias-2/〉. (Accessed 19 February 2022).

Domínguez, C., 2020. Designing a Choice Experiment: Water Resources and Best Management Practices for livestock production in Mejía, Universidad San Francisco de Quito USFQ. 〈https://repositorio.usfq.edu.ec/bitstream/23000/9134/1/130666.pdf〉.

Drastig, K., Vellenga, L., Qualitz, G., Singh, R., Pfister, S., Boulay, A.-M., Wiedemann, S., Prochnow, A., Chapagain, A., De Camillis, C., Opio, C., Mottet, A., 2021. Accounting for livestock water productivity: how and why? L. Water Discuss. Pap. https://doi.org/10.4060/ca7565en.

El-Hafez, S.A., Mahmoud, M.A., El-Bably, A.Z., 2020. Micro-sprinkler irrigation of orchard. In: Omran, E., Negm, A. (Eds.), Technological and Modern Irrigation Environment in Egypt. Springer Water, pp. 257–274.

ElTelegrafo, 2017. El Gobierno proporciona tres tipos de kits agrícolas subsidiados. 〈https://www.eltelegrafo.com.ec/noticias/economia/1/el-gobierno-proporciona-tres-tipos-de-kits-agricolas-subsidiados〉. (Accessed 9 August 2021).

FAO, 2008. Factores que se deben considerar para seleccionar el sistema de riego más adecuado, Roma. 〈https://www.fao.org/3/aj470s/aj470s02.pdf〉.

FAO, 2018. Los contaminantes agrícolas: una grave amenaza para el agua del planeta, Agronoticias: Actualidad agropecuaria de América Latina y el Caribe. 〈https://www.fao.org/in-action/agronoticias/detail/es/c/1141955/〉. (Accessed 14 January 2022).

FAO, IWMI, 2017. Water pollution from agriculture: a global review. Executive Summary. 〈https://www.fao.org/3/i7754e/i7754e.pdf〉.

FAO, WHO, 2008. International Code of Conduct on the Distribution and Use of Pesticides: Guidelines on Management Options for Empty Pesticide Containers, Rome. 〈https://apps.who.int/iris/bitstream/handle/10665/195648/9789241509671_eng.pdf?sequence=1〉.

FONAG, 2007. En busca de la realidad hídrica de Quito. Agua Fondo 8–9.

FONAG, 2020. Informe de cumplimiento de metas, Quito. 〈www.fonag.org.ec/web/wp-content/uploads/2021/04/INFORME-DE-CUMPLIMIENTO-DE-METAS-FONAG-2020.pdf〉.

GAD Municipio de Mejía, 2015. Actualización del plan de desarrollo y ordenamiento territorial. Mejia. 〈http://app.sni.gob.ec/sni-link/sni/PORTAL_SNI/data_sigad_plus/sigadplusdocumentofinal/1760003760001_DOCUMENTO%20FINAL%20ACTUALIZACION%20PDyOT%20GAD%20MEJIA_09–04-2015_10–38-44.PDF〉.

GAD Municipio de Mejía, 2020. Diagnóstico Estratégico. 〈https://municipiodemejia.gob.ec/assets/PDOT_GADMCM.pdf〉.

GAD Provincia de Pichincha, 2015. Diagnóstico de riego y drenaje de la provincia de Pichincha. Imprenta Gobierno de Pichincha. 〈http://sitp.pichincha.gob.ec/repositorio/diseno_paginas/archivos/Diagn%C3%B3stico%20de%20Riego%20y%20Drenaje%20de%20la%20provincia%20de%20Pichincha.pdf〉.

Ghosh, S., Maitra, B., Das, S.S., 2013. Effect of distributional assumption of random parameters of mixed logit model on willingness-to-pay values. Procedia Soc. Behav. Sci. 104, 601–610. https://doi.org/10.1016/j.sbspro.2013.11.154.

Greene, W.H., 2008. Models for discrete choice. Econ. Anal. 770–859.

Gualichicomín, D., 2018. Plan de gestión integral de residuos sólidos no peligrosos para el cantón mejía, basado en el cálculo de rutas óptimas, ESPE. 〈http://repositorio.espe.edu.ec/xmlui/bitstream/handle/21000/14016/T-ESPE-057605.pdf?sequence=1&isAllowed=y〉.

Handayani, W., Dewi, S.P., Septiarani, B., 2022. Toward adaptive water governance: an examination on stakeholders engagement and interactions in Semarang City, Indonesia. Environ. Dev. Sustain. https://doi.org/10.1007/s10668-022-02124-w.

Hossain, M., Mabiso, A., Garbero, A., 2022. Matching grants and economic activities among horticultural entrepreneurs: long-term evidence from Rwanda. World Dev. 150, 105712 https://doi.org/10.1016/j.worlddev.2021.105712.

Houessionon, P., Fonta, W.M., Bossa, A.Y., Sanfo, S., Thiombiano, N., Zahonogo, P., Yameogo, T.B., Balana, B., 2017. Economic valuation of ecosystem services from small-scale agricultural management interventions in Burkina Faso: a discrete choice experiment approach. Sustainability 9, 1–16. https://doi.org/10.3390/su9091672.
Hristov, A.N., Oh, J., Lee, C., Meinen, R., Montes, F., Ott, T., Firkins, J., Rotz, A., Dell, C., Adesogan, A., Yang, W., Tricarico, J., Kebreab, E., Waghorn, G., Dijkstra, J., Oosting, S., 2013. Mitigación de las emisiones de gases de efecto invernadero en la producción ganadera — Una revisión de las opciones técnicas para la reducción de las emisiones de gases diferentes al CO2, Fao, FAO, Roma. ⟨www.biopasos.com/biblioteca/mitigacion%20GEI%20ganaderia%20FAO.pdf⟩.
Jiménez-Trujillo, J.A., 2007. Diseño de sistemas de producción ganaderos sostenibles con base a los sistemas silvopastoriles (SSP) para mejorar la producción animal y lograr la sostenibilidad ambiental. Centro Agronómico Tropical de Investigación y Enseñanza. ⟨https://repositorio.bibliotecaorton.catie.ac.cr/bitstream/11554/4751/1/Diseno_de_sistemas_de_Produccion.pdf⟩.
Johnston, R.J., Boyle, K.J., Adamowicz, W., (Vic), Bennett, J., Brouwer, R., Cameron, T. A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C. A., 2017. Contemporary guidance for stated preference studies. J. Assoc. Environ. Resour. Econ. 4, 319–405. https://doi.org/10.1086/691697.
Khachatryan, H., Suh, D.H., Xu, W., Useche, P., Dukes, M.D., 2019. Towards sustainable water management: preferences and willingness to pay for smart landscape irrigation technologies. Land Use Policy 85, 33–41. https://doi.org/10.1016/j.landusepol.2019.03.014.
Krugman, P., 2020. Opinion | Coming next: The greater recession (WWW Document), New York Times. ⟨https://www.nytimes.com/2020/08/06/opinion/coronavirus-us-recession.html⟩.
Lancaster, K.J., 1966. A new approach to consumer theory. J. Polit. Econ. 74, 132–157.
LEAD, FAO, 2006. Chapter 4 Livestock's role in water depletion and pollution. Livestock's Long. Shad. Environ. Issues Options 125–176. https://doi.org/10.1177/0030727020915206.
Lim, S.L., Lee, L.H., Wu, T.Y., 2016. Sustainability of using composting and vermicomposting technologies for organic solid waste biotransformation: recent overview, greenhouse gases emissions and economic analysis. J. Clean. Prod. 111, 262–278. https://doi.org/10.1016/j.jclepro.2015.08.083.
Lloret, P., 2009. La gestión del agua y la nueva Ley de Aguas. Let. Verdes, Rev. Latinoam. Estud. Socio 19–20. https://doi.org/10.17141/letrasverdes.4.2009.842.
Louviere, J.J., Flynn, T.N., Carson, R.T., 2010. Discrete choice experiments are not conjoint analysis. J. Choice Model. 3, 57–72. https://doi.org/10.1016/S1755-5345(13)70014-9.
MAE, 2013. Socio Bosque. Programa de protección de bosques. Quito. ⟨https://www.ambiente.gob.ec/wp-content/uploads/downloads/2015/07/SOCIO-BOSQUE.pdf⟩.
MAG, 2016. Ganaderos adquieren reses con un subsidio del 30%. ⟨https://www.agricultura.gob.ec/ganaderos-adquieren-reses-con-un-subsidio-del-30/⟩. (Accessed 28 February 2022).
MAG, 2020. Diagnósticos territoriales del sector agrario. Resumen ejecutivo, Quito. ⟨https://www.agricultura.gob.ec/wp-content/uploads/2020/08/Resumen-Ejecutivo-Diagnósticos-Territoriales-del-Sector-Agrario_14–08-2020–1_compressed.pdf⟩.
MAGAP, 2013. Acuerdo No. 394. Regular y controlar el precio del litro de leche cruda pagado en finca y/o centro de acopio al productor y promover la calidad. Ecuador. ⟨https://www.agricultura.gob.ec/wp-content/uploads/2018/11/acuerdo-394–2.pdf⟩.
Marschak, J., 1974. Binary choice constraints on random utility indications (1960). Econ. Inf., Decis. Predict. Theory Decis. Libr. (Int. Ser. Philos. Methodol. Soc. Behav. Sci. 7–1, 312–329.
Martínez-Cruz, A.L., Núñez, H.M., 2021. Tension in Mexico's energy transition: are urban residential consumers in Aguascalientes willing to pay for renewable energy and green jobs. Energy Policy 150. https://doi.org/10.1016/j.enpol.2021.112145.
McFadden, D., 1986. The choice theory approach to market rsearch. Mark. Sci. 5, 275–297.
McGinnis, M., Ostrom, E., 1992. Design principles for local and global commons. Link. Local Glob. Commons 50 (Cambridge, Massachusetts). ⟨http://dlc.dlib.indiana.edu/dlc/bitstream/hand⟩.
McKinney, M., Thorson, J.E., 2015. Resolving water conflicts in the American West. Water Policy 17, 679–706. https://doi.org/10.2166/wp.2015.146.
Mekonnen, M.M., Hoekstra, A.Y., 2012. A global assessment of the water footprint of farm animal products. Ecosystems 15, 401–415. https://doi.org/10.1007/s10021-011-9517-8.
Mekonnen, M.M., Pahlow, M., Aldaya, M.M., Zarate, E., Hoekstra, A.Y., 2015. Sustainability, efficiency and equitability of water consumption and pollution in Latin America and the Caribbean. Sustainability 7, 2086–2112. https://doi.org/10.3390/su7022086.
Mirzaei, A., Knierim, A., Fealy Nahavand, S., Shokri, S.A., Mahmoudi, H., 2019. Assessment of policy instruments towards improving the water reservoirs' governance in Northern Iran. Agric. Water Manag 211, 48–58. https://doi.org/10.1016/j.agwat.2018.09.020.
Mu, L., Wang, C., Xue, B., Wang, H., Li, S., 2019. Assessing the impact of water price reform on farmers' willingness to pay for agricultural water in northwest China. J. Clean. Prod. 234, 1072–1081. https://doi.org/10.1016/j.jclepro.2019.06.269.
Ngoc, P.T.A., Meuwissen, M.P.M., Cong, T., Bosma, R.H., Verreth, J., Oude, A., 2016. Adoption of recirculating aquaculture systems in large pangasius farms: a choice experiment. Aquaculture 460, 90–97. https://doi.org/10.1016/j.aquaculture.2016.03.055.
Nieto, C., C., Pazmiño Ch, E., Rosero, S., Quishpe, B., 2018. Estudio del aprovechamiento de agua de riego disponible por unidad de producción agropecuaria, con base en el requerimiento hídrico de cultivos y el área regada, en dos localidades de la Sierra ecuatoriana. Siembra 5, 051–070. https://doi.org/10.29166/siembra.v5i1.1427.
Nthambi, M., Markova-Nenova, N., Wätzold, F., 2021. Quantifying loss of benefits from poor governance of climate change adaptation projects: a discrete choice experiment with farmers in Kenya. Ecol. Econ. 179, 106831 https://doi.org/10.1016/j.ecolecon.2020.106831.
Ogonna Olive, O., Kingsley David, U., 2021. Valuation of rice farmers' preferences and willingness to pay for climate-smart agricultural technologies in Southeast, Nigeria. Asian. J. Econ. Model. 9, 48–57. https://doi.org/10.18488/journal.8.2021.91.48.57.
de Oliveira, A.S., Trezza, R., Holzapfel, E.A., Lorite, I., Paz, V.P.S., 2009. Irrigation water management in Latin America. Chil. J. Agric. Res. 69, 7–16. https://doi.org/10.4067/s0718-58392009000500002.
Olum, S., Gellynck, X., Juvinal, J., Ongeng, D., De Steur, H., 2020. Farmers' adoption of agricultural innovations: a systematic review on willingness to pay studies. Outlook Agric. 49, 187–203. https://doi.org/10.1177/0030727019879453.
Omotesho, O.A., Falola, A., Awolu, S.O., 2016. Assessment of willingness to pay for improved solid waste management by rural farming households in Kwara State, Nigeria. J. Solid Waste Technol. Manag 42, 44–50. https://doi.org/10.5276/JSWTM.2016.44.
Orme, B.K., 2010. Sample size issues for conjoint analysis. In: Getting Started with Conjoint Analysis: Strategies for Product Design and Pricing Research. Research Publishers, Madison, WI, pp. 57–66 c2010.
Ortiz, C., Avila-Santamaria, J., Martinez-Cruz, A.L., 2022. Dataset for: Dairy Farmers' Willingness to Adopt Cleaner Production Practices for Water Conservation: a Discrete Choice Experiment in Mejia, Ecuador, Mendeley Data, V1. https://doi.org/10.17632/ncj6ws6hbj.1.
Ortiz, C.A., 2021. Discrete Choice Experiment for Water Conservation Practices in Mejia, Ecuador, Universidad San Francisco de Quito (USFQ). ⟨https://repositorio.usfq.edu.ec/bitstream/23000/10889/1/207505.pdf⟩.
Ostrom, E., Gardner, R., 1993. Coping with asymmetries in the commons: self-governing irrigation systems can work. J. Econ. Perspect. 7, 93–112. https://doi.org/10.1257/jep.7.4.93.
Paredes, D., 2018. Sostenibilidad económica financiera de las estrategias para el manejo de residuos en sistemas de producción ganaderos en las provincias de Napo, Manabí e Imbabura, Universidad de las Fuerzas Armadas ESPE, Matriz Sangolquí.
Perman, R., Ma, Y., McGilvray, J., Common, J., 2003. Project appraisal. In: In: Natural Resource and Environmental Economics. Pearson Education Limited, p. 689. https://doi.org/10.2174/156802606777323773.
Petrolia, D.R., Guignet, D., Whitehead, J., Kent, C., Caulder, C., Amon, K., 2021. Nonmarket valuation in the environmental protection agency's regulatory process. Appl. Econ. Perspect. Policy 43, 952–969. https://doi.org/10.1002/aepp.13106.
Raes, L., D'Haese, M., Aguirre, N., Knoke, T., 2016. A portfolio analysis of incentive programmes for conservation, restoration and timber plantations in Southern Ecuador. Land Use Policy 51, 244–259. https://doi.org/10.1016/j.landusepol.2015.11.019.
Rahji, M.A.Y., Oloruntoba, E.O., 2009. Determinants of households willingness-to-pay for private solid waste management services in Ibadan, Nigeria. Waste Manag. Res. 27, 961–965. https://doi.org/10.1177/0734242X09103824.
Riego Ecuador, 2020. Sistema de micro aspersores (WWW Document). ⟨https://www.riegoecuador.com/index.php/kits/kit-subfoliar-1-ha–bomba-porten-9hp–valvulas–aspersores⟩. (Accessed 5 March 2020).
Rigby, D., Alcon, F., Burton, M., 2010. Supply uncertainty and the economic value of irrigation water. Eur. Rev. Agric. Econ. 37, 97–117. https://doi.org/10.1093/erae/jbq001.
Sainz-Santamaria, J., Martinez-Cruz, A.L., 2019. How far can investment in efficient irrigation technologies reduce aquifer overdraft? Insights from an expert elicitation in Aguascalientes, Mexico. Water Resour. Econ. 25, 42–55. https://doi.org/10.1016/j.wre.2017.10.003.
Saldías, C., Speelman, S., Huylenbroeck, G., Van, Vink, N., 2016. Understanding farmers ' preferences for wastewater reuse frameworks in agricultural irrigation: lessons from a choice experiment in the Western Cape, South Africa. Water SA 42, 26–38.
Salman, A.Z., Al-Karablieh, E., 2004. Measuring the willingness of farmers to pay for groundwater in the highland areas of Jordan. Agric. Water Manag 68, 61–76. https://doi.org/10.1016/j.agwat.2004.02.009.
Sauthoff, S., Musshoff, O., Danne, M., Anastassiadis, F., 2016. Biomass and bioenergy sugar beet as a biogas substrate ? A discrete choice experiment for the design of substrate supply contracts for German farmers. Biomass Bioenergy 90, 163–172. https://doi.org/10.1016/j.biombioe.2016.04.005.
Schreiner, J.A., Latacz-Lohmann, U., 2015. Farmers' valuation of incentives to produce genetically modified organism-free milk: insights from a discrete choice experiment in Germany. J. Dairy Sci. 98, 7498–7509. https://doi.org/10.3168/jds.2015-9515.
Sheikh, P.A., Merry, F.D., McGrath, D.G., 2006. Water buffalo and cattle ranching in the Lower Amazon Basin: comparisons and conflicts. Agric. Syst. 87, 313–330. https://doi.org/10.1016/j.agsy.2005.02.003.
Shock, C., Iida, C., 2009. La poliacrilamida: Una solución para la erosión, Técnicas para la agricultura sostenible. Oregon State University. ⟨https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em8958-s.pdf⟩.
Sultana, M.N., Uddin, M.M., Ridoutt, B.G., Peters, K.J., 2014. Comparison of water use in global milk production for different typical farms. Agric. Syst. 129, 9–21. https://doi.org/10.1016/j.agsy.2014.05.002.
Terán, A., Pinto, E., Ortiz, E., Salazar, E., Cuesta, F., 2019. Conservación y uso sostenible de los páramos de Tungurahua. Conocer para manejar. Proyecto EcoAndes. CONDESAN, Quito, Ecuador.
Toctaguano, V., 2019. Evaluación del efecto del poliacrilato de potasio sobre la productividad del cultivo de papa chaucha, en suelos del CADER, Universidad Central Del Ecuador. ⟨http://www.dspace.uce.edu.ec/bitstream/25000/17854/1/T-UCE-0004-CAG-072.pdf⟩.

Train, K.E., 2009. Discrete choice methods with simulation, second ed. Cambridge University Press, New York.
Tur-Cardona, J., Bonnichsen, O., Speelman, S., Verspecht, A., Carpentier, L., Debruyne, L., Marchand, F., Jacobsen, B.H., Buysse, J., 2018. Farmers' reasons to accept bio-based fertilizers: a choice experiment in seven different European countries. J. Clean. Prod. 197, 406–416. https://doi.org/10.1016/j.jclepro.2018.06.172.
United Nations, 2021. The United Nations world water development report 2021: valuing water. Facts and Figures. Unesco, p. 12.
Valera, L., 2018. Evaluación del efecto del poliacrilato de potasio sobre la productividad del cultivo de brócoli hibrido Avenger, en suelos del CADER, Universidad central del Ecuador. ⟨http://www.dspace.uce.edu.ec/bitstream/25000/16937/1/T-UCE-0004-CAG-038.pdf⟩.
Vassalos, M., Hu, W., Woods, T., Schieffer, J., Dillon, C., 2015. Risk preferences, transaction costs, and choice of marketing contracts: evidence from a choice. Agribusiness 32, 379–396. https://doi.org/10.1002/agr.
Villanueva, A.J., Gómez-Limón, J.A., Arriaza, M., Rodríguez-Entrena, M., 2015. The design of agri-environmental schemes: farmers' preferences in Southern Spain. Land Use Policy 46, 142–154. https://doi.org/10.1016/j.landusepol.2015.02.009.
Vinueza, D., Ochoa-Herrera, V., Maurice, L., Tamayo, E., Mejía, L., Tejera, E., Machado, A., 2021. Determining the microbial and chemical contamination in Ecuador's main rivers. Sci. Rep. 11, 1–14. https://doi.org/10.1038/s41598-021-96926-z.
Wingfield, S., Martínez-Moscoso, A., Quiroga, D., Ochoa-Herrera, V., 2021. Challenges to water management in ecuador: legal authorization, quality parameters, and socio-political responses. Water (Switz.) 13, 1–17. https://doi.org/10.3390/w13081017.
World Bank Group, 2021. Climate change knowledge portal. For development practitioners and policy makers [WWW Document]. URL ⟨https://climateknowledgeportal.worldbank.org/country/ecuador/climate-data-historical⟩ (accessed 1.12.22).
Xu, X., Zhang, Z., Kuang, Y., Li, C., Sun, M., Zhang, L., Chang, D., 2021. Waste pesticide bottles disposal in rural China: policy constraints and smallholder farmers' behavior. J. Clean. Prod. 316, 128385 https://doi.org/10.1016/j.jclepro.2021.128385.
Zhang, Y., Griffith, B., Granger, S., Sint, H., Collins, A.L., 2022. Tackling unintended consequences of grazing livestock farming: multi-scale assessment of co-benefits and trade-offs for water pollution mitigation scenarios. J. Clean. Prod. 336, 130449 https://doi.org/10.1016/j.jclepro.2022.130449.