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Discrete Choice Experiment for Water Conservation Practices in Mejia, Ecuador

Proyecto de Investigación

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Discrete Choice Experiment for Water Conservation Practices in Mejia, Ecuador

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DEDICATORIA

A mi familia, pilar fundamental en mi vida.

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RESUMEN

Nuestro caso de estudio se centra en la comprensión de las preferencias de los agricultores y las prácticas ganaderas en Mejía, principal cantón de la industria láctea ecuatoriana. Los ganaderos son los potenciales proveedores de una mejor calidad del agua y los beneficiarios son los mismos ganaderos y las comunidades a su alrededor. A pesar de los beneficios económicos que país otorga, los agricultores prefieren aplicar actividades no amigables con el medio ambiente. Se ha utilizado un experimento de elección discreta (DCE) para estimar la disposición a pagar (DAP) de los agricultores para introducir las mejores prácticas de gestión. Para ello, se ha realizado una encuesta a productores de leche de Mejía. El objetivo de determinar sus preferencias es averiguar cuál es la forma preferida para abordar el problema de la contaminación por residuos sólidos y animales, la ineficiencia y los conflictos sobre su uso del agua. Nuestros resultados muestran que un típico productor está dispuesto a pagar una media del 12% del coste de implantación para adoptar la lluvia sólida (137,28 dólares por hectárea), un 6% para utilizar el servicio de los centros de recogida de residuos sólidos (68,64 dólares por hectárea) y un 12% para asistir a seminarios de formación sobre resolución de conflictos y recursos de manejo del agua (137,28 dólares por hectárea). Si se tiene en cuenta la disposición de los agricultores a adoptar prácticas más respetuosas con la naturaleza, se promoverían los objetivos medioambientales a largo plazo.

Palabras clave: experimento de elección discreta, sistema de riego, ganadería, preferencias, logit condicional, logit mixto, recursos hídricos, Mejía.

ABSTRACT

Our case study is centered on the understanding of farmers' preferences and livestock practices in Mejia, which is the Ecuadorian milk industry's leading canton. Farmers are the potential providers of better water quality and beneficiaries are the same farmers and communities around them. In spite of the country's financial benefits, farmers prefer to apply environmentally unfavorable activities. A discrete choice experiment (DCE) has been used to estimate farmers' willingness to pay (WTP) to introduce best management practices. This was done through a survey administered to Mejia's dairy farmers. The aim behind determining their preferences is to find out which is the preferred way to tackle the issue of animal and solid waste pollution, water inefficiency, and conflicts over water use. Our findings show that a typical producer is willing to pay on average 12% of implementation cost to adopt solid rain (USD 137.28 per ha), 6% to utilize the service of collection centers for solid waste (USD 68.64 per ha), and 12% to attend training seminars on conflict resolution and water management resources (USD 137.28 per ha). By taking into consideration farmers' willingness to adopt more nature-friendly practices, long-term environmental objectives would be promoted.

Key words: discrete choice experiment, irrigation system, livestock, preferences, conditional logit, mixed logit, water resources, Mejia.

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INTRODUCTION

Currently, in Mejia, there are only 6 farms with the best management practices (BMPs) certification from 5372 milk production units (Agrocalidad, 2019). Although the ministerial agreement 394 (2013) of MAGAP establishes incentives for adopting good environmental and livestock practices in Ecuador, efforts mainly focused on the preservation of environmental resources, farms do not adopt them. MAGAP in 2013, through Ministerial Agreement 394, Art. 7 established a minimum support price for raw milk at 0.42 USD per liter, to which is added one cent more for the certification of a farm free of brucellosis and tuberculosis and one cent more for being certified with Best Management Practices (Acuerdo Ministerial No 394, 2010). Thus, the milk price depending on the quality and certifications can range from approximately $0.43 to $0.53 per liter. The public entities responsible for verifying and controlling the payment of this surplus and the farm conditions are MAGAP and AGROCALIDAD.

Our primary reason for this research is to understand better how farmers form preferences and what practices they will follow and value in Mejia. Despite the economic benefits MAGAP registers low adoption practices by farmers (MAGAP, 2015). According to Tempesta et al. (2019), a discrete choice experiment (DCE) works for estimating the willingness to pay (WTP) to adopt environment-friendly livestock practices. Our DCE's attributes and levels tackle water quality issues, animal and solid waste pollution, inefficient use of water, and water use disputes. The monetary attribute in this DCE is the implementation costs of the improved practices.

Using a sample of 98 livestock producers, we estimate a mixed logit model (ML), which shows that a typical producer is willing to pay on average 12% of implementation cost to adopt solid rain (USD 137.28 per ha). 6% to utilize the service of collection centers for solid waste (USD 68.64 per ha), and 12% to attend training seminars on conflict resolution and water management resources (USD 137.28 per ha). We also calculated the numerical cost of each related water management practice. In that sense, our findings provide a good case for differentiating incentives to promote environmentally sustainable activities, identifying key components of the dairy production process. The implicit price estimated indicates that producers are motivated to practice eco-sustainable activities. These findings in collaboration with the government could help to establish special practices based on farmers' preferences. A policy based on monetary benefit could be developed to promote this form of activity, thus reducing pollution of the water supply in Mejia Canton.

BACKGROUND

Global water demand is projected to rise dramatically in the future, by 50% between 1995 and 2025 (UNDESA, 2015). Both developing and developed countries are facing water scarcity due to various human activities, especially in developing countries. Due not only to the increased human population but also to increases in industrial production and wealth (UNEP/GRID, 2008). Water is a critical factor in agricultural production, especially for livestock (OMAFRA, 2015). Water is used in dairy farming, for example, to produce feed crops (which account for most of the water use), give water to the cows, clean and disinfect the barn and machinery, and cool the milk. It is important to consider milk is about 87% liquids and 13% solids as a finished product (USDA, 2016).

Milk production and Water Management in Mejia

Mejia canton is a national symbol of milking production in Ecuador. The area is intensively used for agriculture as well (Vizcarra et al., 2015). Irrigation water is supplied by San Pedro and Pita Rivers, using a network of irrigation canals. Water sources and water quality are under stress because of climate change, population increase, deglaciation, and the rise of the agricultural frontier. All this exacerbates the problems during summer when rivers flow drops and water needs increase, causing shortages and conflicts between farmers who use the water from the irrigation canals (Muñoz, 2012).

The daily milk production in the province of Pichincha has had a favorable evolution from 2009 to 2015. In 7 years, national production has grown because of the expansion of both the cattle herd and the area destined for cattle grazing. The evolution of milk production has maintained a constant growth, where the largest producer continues to be the Mejia canton (38%), followed by the Cayambe canton (23%) and Pedro Moncayo canton (13%) (MAGAP, 2015). Mejia canton is divided into hundreds of farms that currently reach an average production ranging from 17.8 to 25 liters of milk per day per cow (Vizcarra et al., 2015). It represents 7 % of the country's bovine population. It generates daily for Quito about 860 thousand liters of milk (GAD Mejia, 2015). The total land-use area of the canton (105 571.74 ha), the largest percentage, 57.46%, is land for conservation and protection purposes, with a total area of 60 665.68 ha, and it encompasses all-natural vegetation such as forests and scrub. Also, an important part of the territory, 32.85% (34 680.88 ha), is intended for livestock use, where natural pasture can be found. According to GAD Mejía (2015), more than 50% (59,962 ha) of the arable land is destined for livestock production, and around 38% of the land is occupied by agricultural activities.

Mejia canton also has vast water resources, there are 44 micro-basins belonging to the sub-basins of the Guayllabamba, Blanco, Jatunyacu, and Patate rivers. Approximately 384 rivers and streams cross the canton, where the most important are San Pedro, Pita, and Tandapi Rivers (GPP, 2016)**.**

According to III National Agricultural Census, Mejia has unequal access to irrigation water. For example, the largest APUs (Agricultural Production Units) have a significant concentration of irrigation water and land, while the vast majority of APUs, which are small farms, do not have adequate access to irrigation water. As a result of inequality access to freshwater supplies, the productivity of the smallest farms is most affected. Nowadays in the area exists a lack of effective processes to conserve, protect, and distribute the water resources. (Rosales, 2012).

Based on data from the Mejia government (Mejía, 2013), growth exserted among the anthropic activities, causing alterations in water and soil resources, for example, agriculture, livestock, fishing, timber exploitation, and human settlements. According to the local government, agriculture alters the physical and chemical conditions of water and soil significantly. Mainly due to the use of agrochemicals in the soil and the introduction of livestock activities near water sources. Resulting in water contamination with animal feces. In addition, the decrease in water source flow has been mainly caused by the exploitation of natural forests (Mejía, 2015).

The Use of Discrete Choice Experiment for Water Resource Conservation

Many farms are responsible in Romania for environmental problems caused by the production of agricultural products. Most of these farms are family-owned holdings, with limited financial resources. In the agricultural area of Cazanesti in Romania, Toma & Mathijs (2004) conducted an experiment to explore the tradeoffs of farmers between environmental quality, i.e. contamination of the water by farm sources, and environmental effort. The results indicate that farmers tend to favor the status quo, which involves poor environmental conditions (water pollution) and limited environmental investments. Accordingly, agricultural environmental schemes in Romania should provide certain farmers with the financial incentives necessary to enable them to implement agricultural practices. To approximate the importance of surface water quality and quantity, many preference experiments were used. For example, Tentes & Damigos (2015) used a DCE for the groundwater valuation of the Asopos River in Greece. The results reveal that when people choose to remediate groundwater, what matters to them is, primarily, to satisfy human needs in the short run and, secondarily, to satisfy ecosystem needs in the long run. The estimated annual amount of 690€ per household provides a proxy of the use-value of groundwater. The elicited values can be effectively used in policymaking, natural resource damage assessment, and remediation planning. For Tentes & Damigos (2015), the conclusion is that DCE provides a challenging opportunity for the researcher to decipher individuals' preferences and to provide an econometric model that can be used in the economic analysis of water resources. In the case of Asopos groundwater, the analysis revealed that respondents hold use and nonuse values for groundwater, which also signifies the resource opportunity cost.

Additionally, Ouma et al. (2007) investigated preferences for cattle characteristics in field experiments from 506 livestock farming households in Kenya. The findings indicate that heterogeneity in preferences occurs under livestock production schemes. The fitness of traction and trypanotolerance is a valuable cattle trait for crop systems, while in pastoral systems the traits associated with the increase of the stock are significant. The empirical findings provide many insights into cattle keepers' decision-making. Based on the environment and production system, the mixed logit model revealed significant preference heterogeneity among cattle owners. In the model of bull preferences, good traction potential, fertility, and trypanotolerance were found to be the most favored traits.

Trypanotolerance and reproductive success were the most highly regarded traits in the cow preference models. The authors suggest among other things that more research of farmers' interests is needed, especially in the process of decision-making. Our study attempts to contribute to the literature by examining preferences over practices on water use, solid and animal management, and conflict resolution, under a particular scenario, the actual pandemic. We would like to understand that under crisis, sustainable development objectives are still present in dairy production.

THE THEORETICAL AND ECONOMETRIC STRATEGY

According to Mangham et al. (2009), a quantitative approach for eliciting human preferences is a discrete choice experiment. It allows the researchers to know how individuals value particular programs, products, or service characteristics by asking people to select between different hypothetical alternatives. DCEs often require respondents to choose from a range of options. Any alternative is characterized by a collection of attributes, which serve to determine the significance of each attribute. Compared to some specified choices, allowing to the consumer classify, and find alternatives. DCE is a comparatively easy process that corresponds more closely to a real-life condition and a world decision (Mangham et al., 2009).

Econometric Model

The random utility of the consumer, which is linked to an alternative or profile, has been presumed to depend on observed characteristics (attribute levels) and non-observed alternative features. In this case, everyone chooses the option that maximizes its usefulness, when faced with an option of many alternatives. The utility function is characterized by the level of the alternatives as an indirect utility function, plus random error term as following:

$$\cup_i = V(\beta, X_i) + \epsilon_i \quad (1)$$

There:

$\cup_i$ - Alternative utility i, individually with the consumer.

V - The deterministic or measurable portion of the utility estimated by the observer.

ϵ_i - Random error term. X_i is an attribute level vector that defines alternatives i.

β is a vector of preference weighing estimates and an attribute level relative contribution to the utility attributed to the choice of an alternative by respondents.

According to Train (2001), in conditional logit (CL), ϵ_i is assumed to adopt an independently and identically distributed type I distribution (IID). Moreover, unobserved preference variability can be captured using the mixed logit (ML) model, enabling consumers' replacement patterns to become completely versatile. The assumption of Independence of Irrelevant Alternatives (IIA) is relaxed in an ML approach. According to the ML model, individual preferences for heterogeneity distributions will then be estimated as a random variable. This means that the impact of a single variable on the preferred option differs from person to person. The mixed logit, or random parameter logit, has the following choice probability:

$$\Pr(\text{ choice}_n = i) = \int \frac{\exp(x'_{ni}\beta)}{\sum_{j=1}^{j} \exp\left(x'_{nj}\beta\right)} f(\beta) d\beta \tag{2}$$

Where $\Pr(choice_n = 1)$ denotes the probability of particular n for alternative i.

The ML model allows the parameters β_n be random. $\beta_n = \beta + v_n$, where $v_n N[0, \sigma_v^2]$ is a common assumption according to Cameron, A. C., & Trivedi (2005). This use of random parameters (β_n) has the appealing property of inducing association between alternatives. Individual variation is represented by the random coefficients. The utilities for various alternatives have assumption correlations in the ML. CL's choice probability is a special case of the random choice probability where $\sigma = 0$ with this assumption regarding $f(\cdot)$. By defining the independent random parameter for the price, normally distributed, we take note of the degree of heterogeneity and obtain significant WTP estimates. Hole (2007) states as a ratio of approximate model parameters, that simulated unconditional WTP estimates for i attributes by consumption n shall account for the random component:

$$WTP_n^i = -\left(\frac{\beta_i}{\beta_{\text{price}}}\right) \tag{3}$$

This probability of preference does not have a closed-form solution, so an approximation of the maximum probability is needed see (Train, 2009). By simulating draws from distributions with known means and standard deviations, the Maximum Likelihood algorithm finds a solution.

Following the compilation of studies carried out by Liu et al. (2018), farmers' characteristics (income, demographics, education), farm characteristics (experience, farm size, fertility, slope, altitude, proximity to urban areas), and the characteristics of the best management practices (cost-effectiveness, time requirement, ease of use, flexibility, observability, the potential for spatial and temporal spillover effects) were found to be common factors associated with adoption in studies published between 2008 and 2017. Thus, we used production variables (government aid, income, use of the financial system) and socio-economic variables (marital status, ethnicity, education, age).

THE DESIGN OF THE DISCRETE CHOICE EXPERIMENT

Attribute and level selection

A proper CE valuation needs to define the attributes and their levels properly (Cerda, 2013). Therefore, in late 2019 and early 2020, 6 interviews with local experts (agronomists, veterinarians, and biologists) and 12 interviews with farmers were conducted. Identifying twenty cattle-raising practices for water conservation. To validate the proposed practices and receive recommendations from the farmers also, were carried out 2 mixed-gender focus groups (online meetings) with milk producers from different places of Mejia. This preliminary research provided a frame of reference for the values in the CE. Defining the following attributes and their respective levels, as detailed below in Table 1[1] and Table 2.

According to Erazo (2015), the main problems for farmers are the lack of irrigation or the inadequate irrigation system in the plots due to poor water conduction and distribution. Taking these issues into account and relying on Paredes' analysis (2018), we propose to introduce micro-sprinklers that help deter soil erosion and minimize irrigation time, saving water, given the excessive use of water in irrigation of the pastures. Citing Avila's (2013) research, which was developed to determine the effects of pasture crops on soil quality; the study site was the Chigchicocha farm, located in Mejía. The study found that soil texture plays a key role in the distribution of nutrients especially in permanent crops land with pastures. An excellent option that we suggest is solid rain, an example of superabsorbent polymer. We based on Ostrand et al. (2020) research, who found that superabsorbent polymers have primarily been used to improve and prolong soil water holding capacity and increase the time between irrigation events. There have been positive results for SAPs' ability to reduce soil compaction.

[1] See Figures [1-2] - For explanation of all benefits and costs in Spanish.

Animal manure could impact water quality when discharged to natural bodies of water in consideration of Ting's research (2007). If the duration of the release is strong, the effect would be greater. Cattle rubbish is a possible food source that can be used as seed nutrients. In Mejia, we identified the pollution of irrigation channels by the manure produced during milking time in the stable. Our suggestions, based on Paredes (2018), are the manure dispersion[2] in the paddock since it is simple to apply. Paredes (2018), also mentioned a compost bin, which reduces the possibility of leaching into the groundwater. Stressing that both initiatives would limit the use of chemicals. Another problem identified was the absence of solid waste treatment, both infectious (surgical syringes used in the vaccination process) and non-infectious (chemical fertilizer containers). To solve these issues, we propose based on expert recommendations as a first level, that the farmers themselves recycle these wastes by transferring them to private collection centers. The second alternative contemplates the implementation of containers by the municipality. These containers will be installed in strategic locations, for this, the commune must organize and request it to the local government, the cost to be assumed is the increase of two percentage points to the electricity bill.[3]

[2] According to Cisneros & Machuca (2014), and Andrango & Sandoval (2021) studies, manure dispersion is the status quo for small farmers in Mejia. But in the focus groups, this practice emerged as a potential alternative, but for medium and large farmers.

[3] To justify the 2% increase in the electricity bill, we consider the current model of the Government of Mejia, which charges for the garbage collection service only based on the monthly electricity consumption. Which corresponds to 10% of the electricity consumption (kWh/month). Based on the study by Gualichicomín (2018), it verified in the field that the frequency of solid waste collection that each of the routes has in the parishes of Aloasi and Machachi, ranges from 1 to 5 days a week, that is, from 4 to 20 days a month, respectively. There are 8 garbage collection routes for Aloasi and Machachi, the present calculation of the additional 2% was an estimate of the increase in the routes for the management of solid waste from the farms, given the focus groups and experience of the farmers themselves, they proposed a collection 2 times a month (every 15 days).

Table 1. Choice Experiment with Attributes and Levels

Attributes	Levels
Irrigation system	Micro sprinklers
	Solid rain
Manage animal waste	Manure dispersion
	Compost bin
Solid waste management	Private collection centers
	Municipal waste containers
Farmers' cooperation promoting the efficient use of water	Training on conflict resolution and cooperation in the management of water resources
Percent of costs to cover	30%, 60%, 70%

The fourth attribute is the cooperation between farmers, proposed in a focus group, an activity that we consider necessary because of the dynamics of water use between farmers in the upper part of the irrigation canal and the lower areas. Currently, a program to educate farmers to take care of water resources does not exist. According to Anderies et al. (2011), combining experiments with other methods is necessary. The experiments are a valuable way to increase understanding of the value of social action for consumers of natural resources. Experiment findings may be used to provide policymakers perspectives and they can at least build a bridge for dialogue among policymakers, regulators, and communities (see Table 2 for a detailed description of attributes and levels).

Table 2. Description of attributes and levels

Attributes	Levels	Advantages	Disadvantages
Irrigation System	**Micro sprinklers**	- Prevents erosion	-They need more installation time than sprinklers and are more expensive
	Solid rain	-Save water and irrigation time - Significant savings in irrigation and frequency-time	-Need skilled labor
Management of animal waste	**Manure dispersion**	- Easy to implement - Helps prevent soil erosion	- Requires extra effort by the worker to collect and disperse manure - Needs more time for the paddock to assimilate it
	Compost	- Helps recover eroded soils - Eliminates risks of leaching to water sources. - Improves the texture and structure of the soil favoring its fertility and permeability. - Reduces the cost of fertilization	-Requires extra effort by the worker to collect and move manure to the compost bin
Solid waste management	**Private collection centers**	-Preventing solid waste from going to irrigation canals or rivers -Collection centers (private company) will be in charge of solid waste	-The farmers will have to go to the collection centers -The only cost is to travel to drop off the waste at the collection centers
	Municipal waste containers	-Solid waste treated by the Municipality -Preventing solid waste from going to irrigation canals or rivers.	-The project must be submitted by the commune. -A value of 12% of the electricity bill payment is proposed for the implementation and collection of these waste, currently the value of garbage collection in the Mejia canton is equal to 10% of the electricity bill payment
Farmers' cooperation promoting the efficient use of water	**Training on conflict resolution and cooperation in the management of water resources**	-Training may be carried out as social involvement by the USFQ -No cost to the farmers	-The training will be regular during the current year -The irrigation boards will oversee ensuring the attendance at these training

As the last attribute, we present three levels of cost-share that the rancher has to invest to implement these aforementioned practices, and which are 30 %, 60 %, and 70 %. These percentages were obtained from a review of the different assistance and subsidy plans that the government has implemented detailed in Table 3, and also based on the focus groups. In the introduction of the DCE, we provide an estimated average cost of implementation of $ 1.144,00.[4]

Table 3. Justification of the percentages

Percent to cover by farmers	Percent subsidized	Summary
70%	30%	Farmers acquire cattle with a 30% subsidy within the repopulation and genetic improvement program promoted by the Ministry of Agriculture (MAG), the purchase of highly genetic cattle is promoted (MAG, n.d.).
60%	40%	The MAGAP, to promote the crops, delivers kits to the producer families, which include certified seeds, fertilizers, and agricultural inputs, it is a subsidy of approximately 40% (Productor, n.d.).
30%	70%	MAG subsidy from 50, 70, and up to 90% for conserving the forests. The distribution of the operating costs of Socio Bosque (main program) is destined to the payment of incentives (Ambiente, 2013).

Design of the choice sets

We employ a fractional factorial design with a D-efficiency of 1.[5] The design consists of 12 choice sets divided into three groups (4 choice sets per group), with each respondent receiving one block. With each set, respondents were asked to choose one of two hypothetical plan A or plan B in which they will be involved to fund a share of the costs of adoption. The percent value assumed depends on the plan features, attributes include irrigation system, management of animal waste, solid waste management, and farmer's cooperation promoting the efficient use of water. The status quo option was also included (see Table 4).

[4] See Appendix D for average cost detail.
[5] The design has been created with help of R-packages: *Idefix* and *Radiant*. See appendix A, B, C for more details.

Table 4. Choice Experiment Example Choice Set

Plan Characteristics	Plan A	Plan B	
Irrigation System	Micro sprinklers	Solid Rain	I would not adopt either plan
Management of animal waste	Manure dispersion	Compost bin	
Solid waste management	Private collection centers	Municipal waste containers	
Farmers' cooperation promoting the efficient use of water	Training on conflict resolution and cooperation in the water management	None	
Percentage of costs assumed by the User	60%	30%	
Preferred Plan:	☐	☐	☐

Hypothesis on preferences

We hypothesize that farmers may prefer solid rain over micro-sprinklers, based on the Elshafie & Camele (2021) study, the applications of super-absorbent polymers (SAPs), such as solid rain, have the advantages of restoring degraded lands and enabling plants to survive under more seasonal stress, an important solution to the problem of the water crisis in Mejia, particularly during the dry season. There was also another indication, farmers demonstrated great interest in the use of this technology by learning about the benefits of solid rain in focus groups. According to Paredes (2018) research, who took into account farmers of 14 - 16 milking cows in stalls, which had not previously implemented any treatment for livestock excreta (including manure dispersion). The farmers prefer easy methods with low investment costs that produce positive results and generate cost-effective systems. Then we hypothesize that medium and larger farmers would favor manure dispersion for animal waste management. For solid waste management, we hypothesize that farmers may prefer private collection centers to take advantage of the price per kilogram of recycled plastics[6]. According to Zaldumbide

[6] According to Renarec (Red Nacional de Recicladores del Ecuador) a kilo of recycled PET plastic containers costs USD 0.50 (Primicias, 2020).

(2012), only Los Romerillos private recycling center is currently working in Mejia (To date 2021, this has not changed). Also quoting Alvares & Cajas' (2020) study, The Romerillos recycling center has an agreement for the purchase and sale of recycled materials. Based on Levy & Sidel (2011), we assume that cooperative measures contribute to resolving water disputes and to social, environmental, and economic stability. It can also help avoid violent water conflict and build lasting peace.

DATA COLLECTION AND STUDY AREA

A private market research company collected a face-to-face survey during November 2020. [7] Given the actual pandemic and budget limitations, 98 farmers participated in this analysis, which is close or superior to sample sizes used in previous DCE studies (Ngoc et al., 2016; Sauthoff et al., 2016; Schreiner & Latacz-Lohmann, 2015; Vassalos et al., 2015). Two filter-question in the survey protocol ensured that respondents were milk producers and took decisions about their farm. The survey was conducted by visiting several parishes in the Mejia canton, mainly visiting farmers on their farms. The description of the experiment and the practices was read to the respondents ensuring that respondents consider the average cost of implementation of USD 1144. An example is shown in Figures 1-2.

[7] Perspectiva Consultores Estrategicos CIA Ltda - Management Consulting Services

Figure 1. Instruction to the CE.

Introducción al DCE:

Id:001

Esta sección explora sus preferencias sobre diferentes tecnologías o prácticas ganaderas que son compatible con la conservación de los recursos hídricos (ríos, canales de riego, pozos de agua, entre otros), e indispensables para su producción.

Este experimento presenta paquetes de estas prácticas agropecuarias, que tiene beneficios y costos. ***El costo de implementación de estos paquetes promedia en $1,144 por hectárea.***

Las tecnologías propuestas son las siguientes:

1. **De sistemas de riego:**

1.1 Microaspersores:

- Previene la erosión
- Ahorran agua entre un 40 a 60% de agua al necesitar menor presión que los aspersores y reducen el tiempo de riego hasta en un 50%
- Necesitan más tiempo de instalación que los aspersores.
- Costo inicial por hectárea $1.200
- Costo por mantenimiento por hectárea mensual $40

1.2 Lluvia sólida:

- Polímero biodegradable no tóxico en polvo que se convierte en gel al contacto con el agua y es capaz de absorber 200 veces su peso en agua, y puede almacenar el líquido hasta por 40 días.
- Ahorra tiempo y frecuencia de riego: riego de una hectárea a la semana por 8 horas, se podría reducir con lluvia solida a una vez cada quince días por una hora.
- Requiere mano de obra especializada para la dispersión uniforme de la lluvia solida por el terreno
- Costo de implementación por hectárea $650 cada 5 años
- Costo de mantenimiento mensual por hectárea: $10

2. **Tratamiento de excretas del Ganado en el establo**

Costo de implementación se estimó para un promedio de 4500 kg/mes – 4600 kg/mes de estiércol seco, lo que corresponde a la producción de estiércol de 14 – 16 vacas durante 4 horas/día corral

2.1 Compostera:

- Es un recipiente (bloque y hormigón) en donde se descomponen las excretas (materia orgánica) que se van depositando para obtener un abono ecológico que sirve para nutrir los pastizales.
- Elimina riesgos de lixiviación a fuentes de agua
- Mejora la textura y estructura del suelo favoreciendo su fertilidad y permeabilidad facilitando la siembra del pasto
- Reduce el gasto de fertilización en $50 mensuales (obtención del producto desde el 2do mes)
- Costo de implementación $438
- Costo de mantenimiento mensual: $45

2.2 Dispersión de estiércol en el potrero:

- Se realiza sin un tratamiento previo del estiércol semi-seco
- De fácil implementación
- Ayuda a recuperar suelos erosionados
- Provee de carbono orgánico y micronutrientes a los suelos
- Reduce el gasto de fertilización en $12.5 mensuales (obtención del producto desde el 1er mes)
- Presenta dificultad para esparcir de manera uniforme
- Costo en mano de obra $30 mensuales

Figure 2 Instruction to the CE (continued)

- Mejor opción para el productor que no posee una estructura de almacenamiento

3. **Manejo de Residuos Solidos**

3.1 Contenedores de desechos Municipales:

- Serán ubicados por el Municipio de Mejía previa presentación de proyecto por parte de la comuna.
- Residuos sólidos tratados por el municipio.
- Se trata de evitar que los desechos sólidos vayan a los canales de riego o ríos.
- Se propone para la implementación y recolección de estos residuos un valor del 12% de la planilla de consumo de energía eléctrica, actualmente el valor de recolección de la basura en el cantón Mejia es iguala al 10% de dicha planilla.

3.2 Centros de acopio privados:

- Los ganaderos tendrán que dirigirse a los centros de acopios.
- Se trata de evitar que los desechos sólidos vayan a los canales de riego o ríos.
- Los centros de Acopio (empresa privada) se encargará de los desechos sólidos.
- El único costo es el de viajar para ir a dejar los desechos a los centros de acopio.

4. **Cooperación entre Ganaderos para el buen uso del agua**

4.1. Capacitaciones sobre resolución de conflictos y cooperación en el manejo de recursos hídricos:

- Capacitaciones podrán ser llevadas como vínculos con la sociedad por parte de la Universidad San Francisco de Quito.
- Las capacitaciones serán regulares durante el año en transcurso.
- Las juntas de riego se encargarán de velar por la asistencia a estas capacitaciones por parte de los ganaderos interesados.
- No tendrá ningún costo para el productor.

Los costos por la adopción de las ya mencionadas prácticas podrían ser parcialmente cubiertos mediante fondos de financiamiento entregados por entidades locales y extranjeras, que buscan alcanzar el objetivo de preservar los recursos naturales en el mundo.

Ejemplo de fuentes de estos fondos:

- MORRIS ANIMAL FOUNDATION
- 11th Hour Racing
- Fondo Regional de Tecnología Agropecuaria (FONTAGRO)
- Programa de adaptación para pequeños agricultores (ASAP)

The farmers were then asked to determine which of these practices in the hypothetical case of adoption were its highest priority for implementation. The percentage of costs assumed by a user was obtained from the average of the implementation costs of the different practices previously described.[8] Figures 3-4 show a complete example of the CE.

[8] See Appendix D for average cost detail.

Figure 3. Example of the CE presented to respondents.

Inicio del CE

Id:001

Por favor, seleccione si desea adoptar el plan A, el plan B o ningún plan

Características del Plan	**Plan A**	**Plan B**	No me gustaría implementar ningún plan
Sistema de Riego	Lluvia Solida	Microaspersores	
Tratamiento de Excretas del Ganado en el establo	Dispersión de estiércol en el potrero	Compostera	
Manejo de residuos solidos	Centros de Acopio privados	Contenedores Municipales	
Cooperación entre ganaderos	Capacitaciones sobre cooperación entre agricultores de la cota alta y baja de los canales de riego	Ninguna	
Costo asumido por el Usuario	30%	70%	
Plan Preferido:	☐	☐	☐

Por favor, seleccione si desea adoptar el plan A, el plan B o ningún plan

Características del Plan	**Plan A**	**Plan B**	No me gustaría implementar ningún plan
Sistema de Riego	Microaspersores	Lluvia Solida	
Tratamiento de Excretas del Ganado en el establo	Compostera	Dispersión de estiércol en el potrero	
Manejo de residuos solidos	Centros de Acopio privados	Contenedores Municipales	
Cooperación entre ganaderos	Capacitaciones sobre cooperación entre agricultores de la cota alta y baja de los canales de riego	Ninguna	
Costo asumido por el Usuario	30%	70%	
Plan Preferido:	☐	☐	☐

Figure 4. Example of the CE presented to respondents (continued)

Id:001

Por favor, seleccione si desea adoptar el plan A, el plan B o ningún plan

Características del Plan	Plan A	Plan B	
Sistema de Riego	Microaspersores	Microaspersores	No me gustaría implementar ningún plan
Tratamiento de Excretas del Ganado en el establo	Compostera	Dispersión de estiércol en el potrero	
Manejo de residuos solidos	Centros de Acopio privados	Contenedores Municipales	
Cooperación entre ganaderos	Ninguna	Capacitaciones sobre cooperación entre agricultores de la cota alta y baja de los canales de riego	
Costo asumido por el Usuario	30%	60%	
Plan Preferido:	☐	☐	☐

Por favor, seleccione si desea adoptar el plan A, el plan B o ningún plan

Características del Plan	Plan A	Plan B	
Sistema de Riego	Lluvia Solida	Microaspersores	No me gustaría implementar ningún plan
Tratamiento de Excretas del Ganado en el establo	Dispersión de estiércol en el potrero	Compostera	
Manejo de residuos solidos	Contenedores Municipales	Centros de Acopio privados	
Cooperación entre ganaderos	Capacitaciones sobre cooperación entre agricultores de la cota alta y baja de los canales de riego	Ninguna	
Costo asumido por el Usuario	30%	70%	
Plan Preferido:	☐	☐	☐

Descriptive statistics

Table 5 shows the survey overview figures, which include 98 % of the 100 respondents who gave accurate DCE responses and full sociodemographic information. Most respondents (74%) are male, with an average age of 55.3 years. Concerning the level of education, 91% reported having a high school diploma or less and, 83% of the farmers reported a monthly income between 0 - 1000 USD. A typical farmer has experience in milk production, as shown by an average of 23.14 years among the respondents. The land size is around 7.36 hectares, on average, similar to what is found in Cisneros (2014). Eighty percent of farmers use a rotational grazing system, this contrasts with Cisneros (2014), in which 99.7% of farmers use a rotational grazing system.

Table 5. Descriptive statistic of the sample (N = 98)

Variable	Mean	S.D.	Min	Max
Respondents' characteristics				
Age	55.30	12.20	18.00	82.00
Experience (years)	23.14	12.75	0.00	55.00
1 if respondent is male	0.74	0.44	0.00	1.00
1 if high school diploma or less	0.91	0.28	0.00	1.00
1 if monthly income between 0 - 1000 (USD)	0.83	0.37	0.00	1.00
Farm features				
Farm size (ha)	7.36	17.81	0.25	160.00
1 if uses rotational grazing	0.80	0.40	0.00	1.00
1 if uses chemical fertilization	0.61	0.49	0.00	1.00
1 if uses organic fertilization	0.27	0.44	0.00	1.00
1 if uses mixed fertilization	0.23	0.42	0.00	1.00
1 if not nutrient management	0.34	0.48	0.00	1.00
Irrigation system				
1 if uses water from subterranean sources	0.35	0.48	0.00	1.00
1 if uses river water	0.31	0.46	0.00	1.00
1 if uses water from irrigation canals	0.17	0.38	0.00	1.00
1 if uses sprinkler	0.43	0.49	0.00	1.00
1 if uses micro-sprinkler	0.02	0.14	0.00	1.00
1 if does not use irrigation	0.24	0.43	0.00	1.00
1 if uses gravity irrigation system	0.13	0.34	0.00	1.00
1 if uses surface irrigation	0.12	0.33	0.00	1.00
1 if uses other irrigation system	0.12	0.33	0.00	1.00
Characteristics of production				
Livestock (total cows)	18.19	30.63	4.00	282.00
Livestock (milking cows only)	11.04	14.92	0.00	118.00
Daily liters produced	101.37	207.81	0.00	1850.00
Milk price (liter) USD	0.35	0.05	0.25	0.52
1 if sells at a price >= 0.42 USD (fix by the government)	0.04	0.20	0.00	1.00
1 if sells to intermediaries	0.52	0.50	0.00	1.00
1 if sells to private companies	0.42	0.49	0.00	1.00
1 if they know the economic incentives for BMP's certification	0.09	0.29	0.00	1.00
1 if they do not receive government assistance	0.90	0.29	0.00	1.00
1 if self-reported has Agrocalidad certification	0.53	0.49	0.00	1.00
1 if increases the milk price for certification	0.05	0.22	0.00	1.00
1 if sales decreased due to covid	0.29	0.19	0.00	1.00
1 if sales increased due to covid	0.01	0.01	0.00	1.00
Animal waste treatment				
1 if uses manure dispersion	0.79	0.41	0.00	1.00
1 if uses biodigester	0.02	0.14	0.00	1.00
1 if uses compost bin	0.06	0.24	0.00	1.00
1 if does not use treatment	0.14	0.35	0.00	1.00
Waste treatment				
1 if solid waste it is sent to common trash (no recycling)	0.69	0.46	0.00	1.00
1 if infectious waste it is sent to common trash (no recycling)	0.69	0.46	0.00	1.00

For grassland cultivation, 61% of farmers use chemical fertilization, followed by organic fertilization with 27% and, 23% responded that they use both. But 34% of respondents replied that they were not carrying out any technical management for fertilizer application. Also, 35% of the respondents use water from subterranean sources, 31% use water from rivers and 17% obtain water from irrigation channels. The most used irrigation type is sprinklers (43% of respondents), followed by gravity irrigation (13%,), surface irrigation (12%), and micro-sprinklers (2%). Among respondents, 24% do not have any irrigation system. Our study is interested in inefficient water behaviors, which are especially important for farmers who have irrigation systems.

The average total number of cows per respondent is 18,19, but this statistic decreases when we ask how many cows are producing milk, averaging 11.04 cows. We took the median of 7 cows as a reference given the S.D. of 14.92 animals. The daily production per farmer reported is 101.37 liters, similar to Cisneros's (2014) results. Our sampled farmers receive on average USD 0.35 per liter, that is, only 4% sell at or above the government established price of USD 0.42 per liter. The biggest difference we found with Cisneros (2014), is the milk price. Cisneros's study shows that the milk price of 60% of the respondents is in the range of 0.40 - 0.50 USD. This for small producers but regarding large producers reach prices in the range of 0.50 - 0.60 USD, surpassing even the value decreed by the government. Also, 52% of respondents said that their production was sold to intermediaries, 42% said they were selling their products to private companies, which yielded a similar result to the Cisneros & Machuca (2014), in which Machachi livestock farmers delivered 50% for private-sector production. Due to the impact of covid, 29% of farmers reported a decrease in sales compared to the same period and only 1% reported an increase in sales. In the survey, we also introduced questions to know the role of the government. We found the same results as Cisneros (2014), who found that 90.33% of respondents have not received any support from public or private agencies. In our case, we reported 90% of respondents do not receive assistance from the government. Even though 53% of the farmers reported having some kind of agro-quality certification, only 5% reported an increase in the price for such certification. One interesting fact we found, over 90% of respondents do not know about the incentives to get a BMPs certificate.

Participants were asked also to specify which treatment for manure they had implemented. Most farmers have manure dispersion practice (79%),[9] compost bin in 6%, biodigester in 6%, and 14% of respondents had not implemented any treatment. Besides, we found that 69% of the respondents do not treat their solid and infectious waste, sending it directly to the common garbage.

The abstract statistics of the experimental responses are given in Table 6. In 48.72 percent of the optional experiments, respondents chose either Plan A or Plan B. On the other hand, in 51.28% of options experiments, interviewees choose "I will not participate".

Table 6. Respondent's answers (N = 98)

Choice	**Percent**
Selected Plan either A or B	48.72%
Selected neither Plan	51.28%

[9] Note that manure dispersion is shown here as the status quo, and we added the experiment as an alternative. To explain this, we must cite two studies conducted in Mejia Canton. First, according to the study conducted by Cisneros & Machuca (2014), with a sample of 300 milk producers, farmers who own 5 to 7 milking cows perform the milking process manually. In a recent study by Andrango & Sandoval (2021), with a sample of 120 farmers, they found that 85% of the farmers milked by hand, especially in the same paddock, lacking stables or mechanical milking installation. It should be noted that the survey was conducted on small farmers with an average of 8. 25 milking cattle.
Regarding our sample, the data collected show a median of 7 milking cattle, a similar case to those mentioned above, in which the farmers could be milking manually in the paddock, so for this group of farmers, the practice of manure dispersion is their status quo. This is reflected in the descriptive statistics by having 79% of farmers use this practice. We would like to emphasize that the practices proposed in this paper for manure management were established for producers of 14 - 16 milking cows in stalls. Based on a recent FAO study summarized by Paredes (2018), that includes a sample of farmers from several provinces of Ecuador (Manabi, Imbabura, and Napo). Furthermore, given the focus groups, the interviews with experts and field visits that were conducted, noted the null treatment of the stable manure that contaminates the irrigation canals.

RESULTS

Table 7 reports the result from six logit specifications. The first set of parameters result from 3 conditional logit (CL) specifications using: only attributes; attributes and production variables; and attributes, production, and socioeconomic variables, respectively. The second set, from 3 mixed logit (ML) models that assume that the monetary attribute (percentage assumed by the farmer), is normally distributed and correlated.[10]

Across the six econometric specifications, the signs of all five parameters are as expected. The alternative-specific attribute expressing a preference for solid rain is positive, suggesting a preference for implementing modern water-saving technology. The parameter associated with the preference to send infectious and solid waste back to the collection center is positive indicating the predisposition of farmers to recycle their waste in private centers. The parameter-focused conflict resolution and training is positive, indicating the predisposition to attend training workshops on management water resources and conflict resolution. The percent of the cost to cover parameter is negative indicating a disutility from pay the cost associated with the implementation of the plan. All these parameters are significant at 90% of confidence, but concerning the parameter capturing the preference for composter bin, we do not obtain significance in all models. The insignificance can be attributed to two factors: the first, the dispersion of manure is a practice used by 79% of the surveyed producers (therefore do not require treatment of excreta) and the second, the small sample size.

[10] The correlation of choices across alternatives relaxes the IIA assumption required by the conventional ML and CL model. For more information see cmxtmixlogit command (StataCorp, 2019)

Table 7. Logit specifications on the entire Sample (98 respondents)

Attribute	Conditional Logit	Conditional Logit	Conditional Logit	Mixed Logit	Mixed Logit	Mixed Logit
1 If preference for solid rain	0.67***	0.77***	0.84***	1.17***	1.18***	0.94***
	(0.17)	(0.19)	(0.21)	(0.21)	(0.23)	(0.24)
1 If preference for compost bin	-0.19	-0.18	-0.13	-0.03	-0.10	-0.18
	(0.15)	(0.17)	(0.19)	(0.18)	(0.20)	(0.22)
1 If preference for private collection center's	0.22	0.33*	0.37**	0.52***	0.60***	0.43**
	(0.15)	(0.17)	(0.19)	(0.18)	(0.20)	(0.22)
1 If preference for training on conflict resolution	0.81***	0.77***	0.75***	1.27***	1.21***	0.94***
	(0.17)	(0.20)	(0.23)	(0.21)	(0.24)	(0.27)
Percent of costs to cover	-3.48***	-3.26***	-3.45***	-6.66***	-6.60***	-7.81***
	(0.40)	(0.47)	(0.60)	(0.96)	(1.13)	(1.36)
Production Variables	No	Yes	Yes	No	Yes	Yes
Socioeconomic Variables	No	No	Yes	No	No	Yes
Observations	1161	1029	1005	1161	1029	1005
ll	-357.53	-299.53	-269.03	-299.36	-254.44	-231.22
AIC	725.06	621.06	576.06	610.73	532.87	502.44
BIC	750.35	675.36	669.4	641.07	592.11	600.7

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8 reports marginal willingness to pay (WTP). The results change according to the model specifications reported in Table 7 for mixed logit specifications and conditional logit only attributes**.** The first row of estimates corresponds to WTP for implement solid rain as an irrigation system on a hectare of pasture. The second row set of estimates refer to WTP for implementing a compost bin as a treatment for manure waste from stable. The third row refers to preferences about recycling in private centers, and the fourth row refers to the willingness to participate in training on water resources management and conflict resolution. All the results are obtained in percentages that the producer will assume in the hypothetical case of enrolling in a plan. To obtain the monetary value in dollars (USD), we multiply this percentage by the average cost of implementation of the proposed plans (USD 1144)[11].

[11] To review the calculation of the average implementation cost, please see appendix D.

Table 8. Willingness to pay (WTP) and 90% confidence intervals (USD) resulting from specifications reported in the previous table (based on the average cost of implementation USD 1144)

Set	WTP for implement	Conditional Logit		Mixed Logit		Mixed Logit		Mixed Logit	
		%	USD	%	USD	%	USD	%	USD
1	Solid Rain	0.19	217.36	0.18	205.92	0.18	205.92	0.12	137.28
	Lower Bound	0.13	148.72	0.13	148.72	0.12	137.28	0.06	68.64
	Upper Bound	0.26	297.44	0.23	263.12	0.24	274.56	0.18	205.92
2	Compost bin	-0.06	-68.64	0	0	-0.01	-11.44	-0.02	-22.88
	Lower Bound	-0.13	-148.72	-0.05	-57.2	-0.07	-80.08	-0.07	-80.08
	Upper Bound	0.02	22.88	0.04	45.76	0.04	45.76	0.02	22.88
3	Recycle in private centers	0.06	68.64	0.08	91.52	0.09	102.96	0.06	68.64
	Lower Bound	-0.01	-11.44	0.03	34.32	0.04	45.76	0.01	11.44
	Upper Bound	0.13	148.72	0.12	137.28	0.14	160.16	0.1	114.4
4	Training on conflict resolution	0.23	263.12	0.19	217.36	0.18	205.92	0.12	137.28
	Lower Bound	0.17	194.48	0.14	160.16	0.12	137.28	0.06	68.64
	Upper Bound	0.3	343.2	0.24	274.56	0.25	286	0.18	205.92
5	Production Variables	No		No		Yes		Yes	
	Socioeconomic Variables	No		No		No		Yes	

Due to fitness metrics such as Log-Likelihood (ll), and Akaike Criterion of Information (AIC), indicate that mixed logit specifications outperform conditional logit models. We concentrate our attention on estimates arising from the mixed logit with production and socioeconomic characteristics for the rest of this paper. Table 9 reports average estimates of WTP using an ML with production and socioeconomic variables. We analyzed the respondents by different factors to obtain information on different groups and see their WTP changes.

In Table 9, set number one, the first column says: A typical female producer is willing to pay on average 33% of implementation cost to adopt solid rain. This is equivalent to pay a cost of implementation of USD 377.52 per hectare, which is 58% of the cost of implementing rain solid and soil analysis alone. Grouping by sex, we can notice that the women’s willingness to pay is higher compared to men. They are willing to pay on average 7% of the implementation cost to adopt solid rain, namely, to pay a cost of implementation of USD 80.08 per hectare, which is 12.32% of the cost of implementation rain solid and soil analysis alone. Grouping by reduced farmer sales due to Covid 19, the affected farmers are willing to pay an average cost of 12% to implement solid rain. This means an implementation cost of USD 137.30 per hectare, which is 14.45% of the cost of implementation rain solid and soil analysis alone.

Table 9. Willingness to pay (WTP) and 90% confidence intervals (American Dollars USD) resulting from Mixed Logit including socio-economic and production variables (based on the average cost of implementation USD 1144)

Set	WTP for implement	Gender				Reduced sales due to Covid-19				Farmer >15 min by car from center				University			
		Female		Male		Yes		No		Yes		No		Yes		No	
		%	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$
1	Solid Rain	0.33	377.52	0.07	80.08	0.12	137.3	0.09	102.96	0.18	205.9	0.32	366.08	0.12	137.28	0.12	137.3
	Lower Bound	0.1	114.4	0.02	22.88	0.06	68.64	-0.1	-137.3	0.07	80.08	0.07	80.08	0.01	11.44	0.05	57.2
	Upper Bound	0.55	629.2	0.12	137.3	0.18	205.9	0.3	343.2	0.3	343.2	0.56	640.64	0.23	263.12	0.19	217.4
2	Composter bin	-0.1	-103	-0	-22.88	-0	-11.44	-0.1	-125.8	0.04	45.76	-0.1	-80.08	0.01	11.44	-0	-34.32
	Lower Bound	-0.2	-263.1	-0.1	-68.64	-0.1	-68.64	-0.3	-354.6	0	0	-0.1	-160.2	-0.1	-103	-0.1	-91.52
	Upper Bound	0.04	45.76	0.02	22.88	0.03	34.32	0.1	114.4	0.12	137.3	0	0	0.1	114.4	0.03	34.32
3	Recycle in private centers	0.01	11.44	0.06	68.64	0.04	45.76	0.24	274.56	0.09	103	0.04	45.76	0.03	34.32	0.06	68.64
	Lower Bound	-0.1	-148.7	0.01	11.44	0	0	0	0	0	0	0	0	-0.1	-68.64	0	0
	Upper Bound	0.14	160.16	0.1	114.4	0.09	103	0.48	549.12	0.18	205.9	0.11	125.84	0.12	137.28	0.12	137.3
4	Training on conflict resolution	0.25	286	0.08	91.52	0.1	114.4	0.32	366.08	0.19	217.4	0.1	114.4	0.18	205.92	0.11	125.8
	Lower Bound	0.05	57.2	0.03	34.32	0.04	45.76	0.07	80.08	0.07	80.08	0.02	22.88	0.05	57.2	0.04	45.76
	Upper Bound	0.46	526.24	0.14	160.2	0.16	183	0.56	640.64	0.32	366.1	0.19	217.36	0.3	343.2	0.19	217.4

Grouping by distance from the farm to the city center in minutes (a measure of market access), farmers living less than 15 minutes by car are willing to pay an average cost of 32% to implement solid rain. This means an implementation cost of USD 366.08 per hectare, which is 56.32% of the cost of implementation rain solid and soil analysis alone. On the other hand, farmers living more than 15 minutes by car from the center are willing to pay USD 205.92 per hectare, which is 31.68% of the cost of implementation rain solid and soil analysis alone. This represents an increased willingness to pay from farmers living less than 15 minutes by car. Grouping by education (with or without a university degree), we did not notice a difference in willingness to pay. Both groups show an average cost of 12% of implementation cost to adopt solid rain, what is means pay a cost of implementation of USD 137.28 per hectare, which is 21.12% of the cost of implementation of solid rain and soil analysis alone. Grouping by distance from the farm to the city center in minutes (a measure of market access), farmers living less than 15 minutes by car are willing to pay an average cost of 32% to implement solid rain. This means an implementation cost of USD 366.08 per hectare, which is 56.32% of the cost of implementation rain solid and soil analysis alone. On the other hand, farmers living more than 15 minutes by car from the center are willing to pay USD 205.92 per hectare, which is 31.68% of the cost of implementation rain solid and soil analysis alone. This represents an increased willingness to pay from farmers living less than 15 minutes by car. Grouping by education (with or without a university degree), we did not notice a difference in willingness to pay. Both groups show an average cost of 12% of implementation cost to adopt solid rain, what is means pay a cost of implementation of USD 137.28 per hectare, which is 21.12% of the cost of implementation of solid rain and soil analysis alone.

In Table 9, set number three, the second column says: A typical male producer is willing to pay on average 6% of implementation cost to recycle in private centers. This is equivalent to pay a cost of implementation of USD 68.64 per hectare. Something interesting that caught our attention is the fact that all the models of the different groups present at 90% significance in the attribute related to attending training on conflict resolution and water resources management. Then in Table 9, set number 4, a typical female producer is willing to pay on average 25% of implementation cost to attend training on conflict resolution. This is equivalent to pay a cost of implementation of USD 286 per hectare. Grouping by sex, we can notice that the women's willingness to pay is higher compared to men. They are willing to pay on average 8% of the implementation cost to attend training on conflict resolution, namely, to pay a cost of implementation of USD 91.52 per hectare. Grouping by if farmers reduced sales due to Covid 19, the affected farmers are willing to pay an average cost of 10% to attend training on conflict resolution, this is equivalent to pay a cost of USD 114.4. Grouping by covid affectation, we can notice that the nonaffected farmer's willingness to pay is higher compared to affected farmers. They are willing to pay on average 32% of the implementation cost to adopt training in conflict resolution, namely, to pay a cost of implementation of USD 366.08 per hectare.

Grouping by distance from the farm to the city center in minutes, farmers living less than 15 minutes by car are willing to pay an average cost of 10% to implement the training on conflict resolution and water resources management. This means an implementation cost of USD 114.4 per hectare. On the other hand, farmers living more than 15 minutes by car from the center are willing to pay USD 217.4 per hectare. This represents an increased willingness to pay from farmers living more than 15 minutes by car. Grouping by education (with or without a university degree), farmers having a higher degree are willing to pay an average cost of 18% to implement the training on conflict resolution and water resources management. This means an implementation cost of USD 205.92. On the other hand, farmers without a higher degree are willing to pay USD 125.8 per hectare. This represents an increased willingness to pay from farmers having a university degree. According to Cárdenas & Ostrom (2004), a widespread consensus is that cooperation can occur and be chosen as a reasonable strategy by individuals. Thus, it is important to learn how people in communities decide about their ecosystem use. Finally, in Table 10, we show the results of the respondents to the question of which entity should subsidize the part that the farmer does not pay, where 56.52% of the respondents answered that this cost should be assumed by the Ministry of the Environment, followed by the municipality of Mejia with 14.78%.

Table 10. Who should finance the part not paid by the farmer

Entity	Percent
Ministry of Environment	6.96%
Ministry of Agriculture	56.52%
Municipality of Mejia	14.78%
Water Secretary	9.57%
NGO's	0.00%
Other entities	12.17%

Table 11 shows the responses, to which entity does the farmer would like to apply to finance his share, where 55% of the respondents answered BanEcuador (public bank) followed by 13.86% of private banks and 11.88% CFN (public financial institution).

Table 11. To which entity would you apply to finance your share

Entity	Percent
CFN	11.88%
Private Banking	13.86%
BanEcuador	55%
Other entities	18.81%

DISCUSSION AND POLICY RECOMMENDATIONS

According to Shahady & Boniface (2018), government corruption, a lack of community involvement, and inadequate management thwart attempts to prepare for successful water and watershed management. If an accurate, practical water sampling methodology is readily available to the community use, it would be a positive step towards community engagement and better management of water resources. The features of the common plans, as well as the preferences of farmers, were examined in this paper. But also, the change in the willingness of farmers to pay for different livestock practices.

Our work focused on how water quality would increase, and how water would be used more efficiently if best management practices (BMPs) were more widely adopted. Cost-sharing systems can be used as a reward for ecosystem services to facilitate the introduction of BMPs. Our results show that cost-sharing schemes could help farmers who want to take improved water management into account and the use of emerging technology such as solid rain. These are interesting findings given the vast range of environmental proposals that any form of organization such as Agrocalidad or MAGAP might implement. Policymakers should devise cost-sharing plans, mostly based on the farmers' features and needs, reducing high implementing costs. Also, to take advantage of this perceived complementarity (community and government), agents should explain to the farmers that BMPs do not raise the probability of production decrease if it is technically managed. The productive use of water applying BMPs and increasing enrollment rate to get Agrocalidad certification would minimize uncertainty about future water sources in Mejia canton. As a result, training and education are required to give these farmers trust that BMPs will be efficient, profitable, and increase the availability of water over time. In this regard, the university would play an essential role in raising farmers' understanding of the value of water resource management and the resolution of conflicts through courses. After enrolling in a cost-share program, new adopters may be provided with technical assistance to ensure they have all the information and resources they need to implement BMPs efficiently and effectively.

This research opens a field to design subsidy policies based on the reality and preferences of Mejia's farmers. An approach that can improve the farmer's enrollment rate to get the certification of best management livestock practices, benefiting not only the farmers by receiving a plus at milk price, but also the community ensuring improved water supply quality and availability. Also, farmers show interest in implementing new techniques to reduce costs, time, and amount of irrigation for their paddocks. More extensive research could be done to obtain information on the application of solid rain, access to private collectors of solid wastes, and training in water conflict resolution in the Mejia context. Overall, the findings point to both obstacles and opportunities in achieving long-term environmental objectives. Any rise in BMP adoption would help the areas achieve their water quality and conservation objectives. Short-term plans should be planned as a basis for enlisting more members and encouraging city councils, counties, and municipalities to undertake the work could be provided. Finally, more studies are needed to evaluate the net results, depending on the practice implemented and adoption rates over time. Taking into consideration also according to Yehouenou (2020), higher subsidy characteristics could lead to higher hypothetical inscription rates for costs-sharing attributes.

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INDEX OF APPENDICES

APPENDIX A: D-EFFICIENT DESIGN

The experimental design was based on R-packages*: Idefix*[12] and *Radiant*[13].

Trials for partial factorial: 12

Trials for full factorial: 48

Random seed: 1234

[12] *Idefix:* Efficient Designs for Discrete Choice Experiments: https://cran.r-project.org/package=idefix
[13] *Radiant:* Business Analytics using R and Shiny: https://cran.r-project.org/package=radiant

APPENDIX B: FULL FACTORIAL DESIGN

Trial	Irrigation system	Manage of animal waste	Solid waste management	Farmers cooperation	Cost
1	Micro sprinklers	Compost bin	Municipal waste containers	Training	30%
2	Micro sprinklers	Compost bin	Municipal waste containers	Training	40%
3	Micro sprinklers	Compost bin	Municipal waste containers	Training	70%
4	Micro sprinklers	Compost bin	Municipal waste containers	none	30%
5	Micro sprinklers	Compost bin	Municipal waste containers	none	40%
6	Micro sprinklers	Compost bin	Municipal waste containers	none	70%
7	Micro sprinklers	Compost bin	Private collection centers	Training	30%
8	Micro sprinklers	Compost bin	Private collection centers	Training	40%
9	Micro sprinklers	Compost bin	Private collection centers	Training	70%
10	Micro sprinklers	Compost bin	Private collection centers	none	30%
11	Micro sprinklers	Compost bin	Private collection centers	none	40%
12	Micro sprinklers	Compost bin	Private collection centers	none	70%
13	Micro sprinklers	Manure Dispersion	Municipal waste containers	Training	30%
14	Micro sprinklers	Manure Dispersion	Municipal waste containers	Training	40%
15	Micro sprinklers	Manure Dispersion	Municipal waste containers	Training	70%
16	Micro sprinklers	Manure Dispersion	Municipal waste containers	none	30%
17	Micro sprinklers	Manure Dispersion	Municipal waste containers	none	40%
18	Micro sprinklers	Manure Dispersion	Municipal waste containers	none	70%
19	Micro sprinklers	Manure Dispersion	Private collection centers	Training	30%
20	Micro sprinklers	Manure Dispersion	Private collection centers	Training	40%
21	Micro sprinklers	Manure Dispersion	Private collection centers	Training	70%
22	Micro sprinklers	Manure Dispersion	Private collection centers	none	30%
23	Micro sprinklers	Manure Dispersion	Private collection centers	none	40%
24	Micro sprinklers	Manure Dispersion	Private collection centers	none	70%

APPENDIX C: FULL FACTORIAL DESIGN (CONTINUED)

Trial	**Irrigation system**	**Manage of animal waste**	**Solid waste management**	**Farmers cooperation**	**Cost**
25	Solid rain	Compost bin	Municipal waste containers	Training	30%
26	Solid rain	Compost bin	Municipal waste containers	Training	40%
27	Solid rain	Compost bin	Municipal waste containers	Training	70%
28	Solid rain	Compost bin	Municipal waste containers	none	30%
29	Solid rain	Compost bin	Municipal waste containers	none	40%
30	Solid rain	Compost bin	Municipal waste containers	none	70%
31	Solid rain	Compost bin	Private collection centers	Training	30%
32	Solid rain	Compost bin	Private collection centers	Training	40%
33	Solid rain	Compost bin	Private collection centers	Training	70%
34	Solid rain	Compost bin	Private collection centers	none	30%
35	Solid rain	Compost bin	Private collection centers	none	40%
36	Solid rain	Compost bin	Private collection centers	none	70%
37	Solid rain	Manure Dispersion	Municipal waste containers	Training	30%
38	Solid rain	Manure Dispersion	Municipal waste containers	Training	40%
39	Solid rain	Manure Dispersion	Municipal waste containers	Training	70%
40	Solid rain	Manure Dispersion	Municipal waste containers	none	30%
41	Solid rain	Manure Dispersion	Municipal waste containers	none	40%
42	Solid rain	Manure Dispersion	Municipal waste containers	none	70%
43	Solid rain	Manure Dispersion	Private collection centers	Training	30%
44	Solid rain	Manure Dispersion	Private collection centers	Training	40%
45	Solid rain	Manure Dispersion	Private collection centers	Training	70%
46	Solid rain	Manure Dispersion	Private collection centers	none	30%
47	Solid rain	Manure Dispersion	Private collection centers	none	40%
48	Solid rain	Manure Dispersion	Private collection centers	none	70%

APPENDIX D: PARTIAL FACTORIAL DESIGN

Nsets	block	A1_1	A1_2	A1_3	A1_4	A1_5	A2_1	A2_2	A2_3	A2_4	A2_5
1	1	0	0	1	0	0	1	1	0	1	2
2	1	0	1	1	1	2	1	0	0	0	0
3	1	1	0	0	1	0	1	1	1	0	1
4	1	1	1	1	1	0	0	0	0	0	0
5	2	0	0	1	1	1	1	1	0	0	1
6	2	0	1	0	1	1	1	0	1	0	1
7	2	1	0	1	1	2	0	1	0	0	0
8	2	0	1	0	0	2	1	0	1	1	0
9	3	1	0	0	1	0	0	1	1	0	0
10	3	1	1	0	1	0	0	0	1	0	2
11	3	0	1	1	1	2	1	0	0	0	2
12	3	1	1	1	0	1	0	0	0	1	2

Ai_j, i = alternative and j = attribute

APPENDIX E: THE AVERAGE IMPLEMENTATION COST IN DOLLARS (UNITED STATED DOLLAR)

Attributes	Levels	Implementation Costs (hectare)	Maintenance Monthly cost (hectare)	Savings Cost (Monthly)	Monthly Net Cost (hectare)
1. Irrigation System	a. Micro sprinklers	$ 1.200,00	$ 40,00	$ -	$ 40,00
	b. Solid rain	$ 650,00	$ 10,00	$ 70,00	-$ 60,00
2. Management of animal waste	a. Compost bin	$ 438,00	$ 30,00	$ 50,00	-$ 20,00
	b. Manure dispersion	$ -	$ -	$ 12,50	-$ 12,50
3. Solid Waste Management	a. Private collection centers	$ -	$ -	$ -	$ -
	b. Municipal Waste container	$ -	$ -	$ -	$ -
4. Cooperation between Farmers	a. Cooperation training	$ -	$ -	$ -	$ -
	b. None	$ -	$ -	$ -	$ -
Cost for each plan	1a, 2a, 3a, 4a	$ 1.638,00	$ 70,00	$ 50,00	$ 20,00
	1a, 2a, 3a, 4b	$ 1.638,00	$ 70,00	$ 50,00	$ 20,00
	1a, 2a, 3b, 4a	$ 1.638,00	$ 70,00	$ 50,00	$ 20,00
	1a, 2a, 3b, 4b	$ 1.638,00	$ 70,00	$ 50,00	$ 20,00
	1a, 2b, 3a, 4a	$ 1.200,00	$ 40,00	$ 12,50	$ 27,50
	1a, 2b, 3a, 4b	$ 1.200,00	$ 40,00	$ 12,50	$ 27,50
	1a, 2b, 3b, 4a	$ 1.200,00	$ 40,00	$ 12,50	$ 27,50
	1a, 2b, 3b, 4b	$ 1.200,00	$ 40,00	$ 12,50	$ 27,50
	1b, 2a, 3a, 4a	$ 1.088,00	$ 40,00	$ 120,00	$ -80,00
	1b, 2a, 3a, 4b	$ 1.088,00	$ 40,00	$ 120,00	$ -80,00
	1b, 2a, 3b, 4a	$ 1.088,00	$ 40,00	$ 120,00	$ -80,00
	1b, 2a, 3b, 4b	$ 1.088,00	$ 40,00	$ 120,00	$ -80,00
	1b, 2b, 3a, 4a	$ 650,00	$ 10,00	$ 82,50	$ -72,50
	1b, 2b, 3a, 4b	$ 650,00	$ 10,00	$ 82,50	$ -72,50
	1b, 2b, 3b, 4a	$ 650,00	$ 10,00	$ 82,50	$ -72,50
	1b, 2b, 3b, 4b	$ 650,00	$ 10,00	$ 82,50	$ -72,50
	Min	$ 650,00	$ 10,00	$ 12,50	$ -80,00
	Max	$ 1.638,00	$ 70,00	$ 120,00	$ 27,50
	Average	**$ 1.144,00**	$ 40,00	$ 66,25	$ -26,25