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DO ENVIRONMENTAL SERVICES BUYERS PREFER DIFFERENTIATED RATES? A CASE STUDY FROM THE COLOMBIAN ANDES

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Abstract

Flat user fees in payment for environmental services (PES) schemes promote administrative ease, and are sometimes perceived as egalitarian. However, when environmental service (ES) buyers are heterogeneous in their income and water consumption levels, this may not be optimal, as total payments become too low and services are under-supplied. This paper identifies ES buyer preferences and estimates their willingness to pay (WTP) differentiated fees in an ongoing PES initiative in an Andean watershed in Colombia. Small, flat user payments have recently been introduced to implement incipient watershed protection upstream. Environmental service users fall into two highly heterogeneous categories: smallholder peasants and owners of recreational houses. We performed a contingent valuation analysis in a representative stratified sample of 218 user households. For improved water services, ES buyers on average were willing to pay a monthly US$1 premium over current flat PES rates. Owners of recreational houses were willing to pay about US$1.50 more; smallholders only US$0.5. 85% of ES buyers also agree to pay differentiated fees. Of these, 41% would prefer fees differentiated by water consumption, 23% by household income, 30% criteria combination, and 6% by other criteria. Spatial variables, such as distance to the water distribution point and to the town center, importantly influenced WTP. The results may help designing users-driven PES schemes in accordance with efficiency and equity objectives.

Key words: PES, WTP, environmental services, Colombia, watershed protection.

JEL classification: Q56, Q25, Q5, Q51, C25, D10, D12, D61, D63.

¿PREFIEREN LOS COMPRADORES DE SERVICIOS AMBIENTALES HACER PAGOS DIFERENCIADOS?: UN CASO DE ESTUDIO EN LOS ANDES COLOMBIANOS

Resumen

Los pagos únicos en esquemas de pagos por servicios ambientales (PSA), financiados por usuarios, facilitan su administración y algunas veces son considerados equitativos. Sin embargo, cuando los compradores de servicios ambientales (SA) son heterogéneos en términos de ingreso y de consumo del SA, los pagos únicos y pequeños no son la solución óptima, porque el recaudo total es muy bajo y los servicios no son provistos al nivel deseado. En una microcuenca de los Andes colombianos, usuarios de servicios hídricos han implementado un pago único a los propietarios localizados aguas arriba. Los usuarios del SA son heterogéneos y se agrupan en pequeños campesinos y propietarios de casas recreacionales. Este artículo identifica las preferencias de los compradores de SA y estima la disponibilidad a pagar (DAP) por tarifas diferenciadas en una iniciativa de PSA en marcha, aplicando el método de valoración contingente en una muestra estratificada de 218 hogares compradores actuales de SA. Para mejorar la provisión de los servicios hídricos, los compradores del SA están dispuestos a pagar mensualmente, en promedio, US$ 1 adicional a la tarifa que se paga actualmente (US$0.5/mes). Los propietarios de las casas de recreo estarían dispuestos a pagar US$1.5 más, mientras los pequeños campesinos pagarían adicionalmente US$0.5. El 85% de los compradores de SA están dispuestos a hacer pagos diferenciados. De estos, 41% preferiría tarifas diferenciadas por nivel de consumo de agua, 23% por ingreso, 30% por ambos criterios, y 6% por otros criterios. Variables espaciales como la distancia al punto de distribución de agua o a la cabecera municipal, influencian de manera importante la DAP. Estos resultados pueden contribuir al diseño de esquemas de PSA manejados por usuarios con objetivos de eficiencia y equidad.

Palabras clave: PSA, DAP, servicios ambientales, Colombia, protección de cuencas.

Clasificación JEL: Q56, Q25, Q5, Q51, C25, D10, D12, D61, D63.

1. Introduction

Ecosystem services (ES) have been defined by the Millennium Ecosystem Assessment as “the benefits people obtain from ecosystems”. Although ecosystem services are essential for human well-being and all life on Earth, they deteriorate at an alarming rate (MEA, 2003, 2005). Protecting ecosystems has thus become a major goal for governments and conservation agencies (Wunder et al. 2008). Several conservation mechanisms ranging from traditional command -and-control strategies to different types of economic incentives, including Integrated Conservation and Development Projects (ICDP), have been implemented to help detaining ecosystems services decline (Wunder, 2007). Among these, Payments for Environmental Services (PES) have proved to be a direct and effective conservation tool (Jack et al. 2008) by translating external, non-market environmental services into financial incentives for landowners to preserve the ecosystems that provide the services (Wünscher et al. 2008).

The underlying idea sustaining PES mechanism consists on direct and contractual payments that users of ecosystem services make to local land managers in return for adopting land and resource uses that secure ecosystem conservation and restoration. PES schemes internalize benefits from conservation by compensating landholders for the opportunity costs they incur in their conservation efforts (Pagiola & Platais, 2007; Jack et al., 2008).

Wunder (2007) defines PES as: (a) a voluntary transaction where (b) a well-defined environmental service (or a land use likely to secure that service) (c) is being ‘bought’ by a (minimum one) service buyer (d) from a (minimum one) service provider (e) if and only if the service provider secures service provision (conditionality). In practice, most current PES experiences do not fulfill the five characteristics defined by Wunder (2005); there exist many “*PSE like*” schemes that met, at different degrees, some of those characteristics (Landell-Mills & Porras, 2002; Southgate & Wunder, 2007; Wunder, Wertz & Moreno-Sánchez, 2007).

Ideally, the design of a PES scheme would rely on previous biophysical and socioeconomic studies regarding e.g. links between land-use change and ES, ecosystem service incremental quantities and values, and users' WTP as well as landholders' willingness to accept (WTA) conservation payments. In reality, many PES schemes, mainly those financed and driven by local service users, emerge more spontaneously from service buyers' perceived needs of conserving local ecosystem services, while few studies are carried out to support design -- especially in the case of water ecosystem services. Watershed PES schemes use direct payments to compensate upstream landowners for changes in land use, which will assumedly generate improvements in the provision of hydrological services for downstream users (Asquith & Wunder, 2008). In a number of these cases, the transaction between buyers and sellers is a negotiated solution, and has thus been called a "Coasian PES program" (Pagiola & Platais, 2007), "self organized PES" (Perrot-Maitre & Davis, 2001) "private PES" (Wunder, 2007), or perhaps as the most consistent distinction "user-financed" vs "government-financed" PES (Engel et al., 2008; Wunder et al., 2008). Pagiola & Platais (2007) argue that this type of PES is in most cases likely to be efficient, as actors with most interest in and information about the value of the service are directly involved in the transaction, and there exists enough incentives for users and providers to ensure its functionality.

Where does the money for PES provider payments usually come from? In government-financed PES schemes, it is mostly from taxpayers (Northern Hemisphere agri-environmental programs), sometimes natural resource rents (Ecuador's Socio Bosque program), obligatory user payments (Mexico's national watershed PES), or a combination of these and other sources (Costa Rica's national PES). In user-financed schemes, in some cases the funds come directly from water utilities' and companies' reduced costs (e.g. reduced sedimentation reduces cleaning costs), and are thus achieved by a reorganization of company budgets. In other cases, a cost surcharge is passed on to users in the form of a price premium (Porras et al. 2008).

When users are paying a premium, is it usually flat or differentiated? In government-financed schemes with obligatory taxes or user payments, these are typically flat (as e.g. in the Mexican case). In user-financed schemes, in some schemes there is only a single user – e.g. a brewery, water bottler or a hydroelectric power plant. In those with multiple users, practices vary. In Heredia (Costa Rica), a fixed PES premium per cubic meter was applied (Porras et al. 2008: 43). In Pimampiro (Ecuador), the unit price was also raised, but relatively more for residential households (20%) than for industrial users (14%) (Echavarría *et al.* 2004: 23). In the Los Negros scheme, user payments were made through the municipality, and were thus proportional to municipal tax payments (Asquith et al. 2008).

It may thus be fair to say that user-financed fees tend not to be much differentiated. However, when service users are heterogeneous with respect to both ES consumption and income levels, and thus likely have a highly differential WTP, a fixed fee may not be the optimal solution: it may not achieve sufficient aggregate payments to pay for desirable service level provision, and/ or it may distribute the burdens in an inequitable way.

Although some PES literature has pointed out the need of improving the understanding of the demand for ES (Arocena-Francisco, 2003; Postel & Thompson, 2005; Southgate & Wunder, 2007), most *ex ante* and *ex post* studies on PES have arguably focused more on issues related with ES supply: i) the estimation of the payment cost- effectiveness (Latacz-Lohmann & Schilizzi 2005; Naidoo & Adamowicz, 2006; Jack, Leimona & Ferraro, 2008; Quintero, Wunder & Estrada, 2009) and ii) equity considerations related with ES providers (Miranda, Porras & Moreno, 2003; Echavarría *et al*, 2004; Grieg-Gran, Porras & Wunder, 2005; Pagiola et al. 2005). Few studies have analyzed, for example, the characteristics of ES users, or distributional considerations related with ES buyers, including to what extent poor service users were made better off from PES (Shultz & Soliz, 2007; Ortega-Pacheco, Lupi & Kaplowitz, 2009).

In the Chaina micro watershed, located in the eastern Colombian Andes, an ongoing PES scheme is financed and driven by water users organized in a water user association. Five rural aqueducts (about 4,300 people) pay around US$250/ha/yr to nine upland farmers for the latter to change land-use practices, aimed at reducing water sedimentation and improving seasonal stream flow regulation. These conservation actions are incipient; significant upstream areas are not yet under PES, primarily for lack of funding. Water users pay a small, fixed monthly fee of about US$0.5 per household. The two user types, smallholder farmers and recreational house owners, exhibit different socioeconomic characteristics and usage levels, but payments depend neither on water consumption nor on incomes (Borda et al, 2009).

Based on the PES initiative in Chaina, in this paper we try to answer the following questions: i) *What are the most significant socioeconomic or demographic differences between different ecosystem service buyers*? ii) *Are ecosystem service buyers in Chaina's PES program willing to pay a fee differentiated either by water consumption or income levels*?, and iii) *What factors determine respondents stated WTP?*

The paper is organized as follows: in the second section, we present our methods, including description of the zone and users, and the theoretical and empirical model. Third, we present the descriptive statistics from our water user survey. The fourth section then turns to the econometric results. In the last two sections, we discuss our findings and present conclusions.

2. Methods and study context

To answer our research questions, we chose a stated preference method, the contingent valuation method (CVM). CVM has been widely used to estimate the unknown economic (use and non-use) value of ecosystems –and services they provide (Carson, 2000; Carson & Groves, 2007), by asking people to state directly the WTP for (implemented or avoided) changes in the ecosystem, or in the provision of an environmental service-, which are described through a hypothetical scenario (Carson, 2000; Haab & McConnell, 2002).

CVM has proved to be a valuable tool in the economic assessments of water projects, including in some cases from developing countries (Whittington, 1998; Russell *et al*., 2001). Market valuation of water services, in absence of free and competitive markets, does often not reflect water's true worth (Rodríguez, Southgate & Haab, *forthcoming*). Particularly, CVM has been increasingly employed to estimate the WTP for improved water supply (Bohm et al. 1987; Briscoe *et al*., 1990; Whittington *et al*., 1990; Whittington et al. 1990; Whittington et al. 1991) and improved water quality (Hoehn & Kriege, 2000; Reddy, 1999; Johnson & Baltodano, 2004).

The application of CVM to the PES framework is recent. For instance, Rodríguez, Southgate & Haab (*forthcoming*) use CVM to examine a proposed fee for upstream watershed management that would alleviate seasonal shortages suffered by downstream water users in Cotacachi, Ecuador. Ortega-Pacheco et al. (2009) use dichotomous choice contingent valuation to examine households WTP for a local PES in Costa Rica, changing upstream land-use practices so as to improve downstream water quality.

In our study, we applied a referendum-type CV to elicit the WTP of service buyers to change their *current* voluntary ES fee; specifically, to pay higher ES fees differentiated by either water consumption and/or income levels. As a novelty, we thus valued an environmental service for which a collective fee already existed. Users thus understood the underlying PES concept and had a benchmark from which to reevaluate their individual WTP for a differentiated service. We used a single household survey to simultaneously collect socioeconomic information on ES buyers, register their perception about current PES payments, identify differences in ES buyers' water availability and consumption, gather spatial data, and to elicit their WTP for environmental services.

Study area

The Chaina micro-watershed is located in the eastern Andes of Colombia, in the municipalities of Villa de Leyva and Chíquiza (Boyacá Department), at 2,400-3,600 m.a.s.l. (Figure 1). The micro-watershed is strategic for supplying drinking water to about 4,300 people in seven rural villages, and also for biodiversity conservation. The -watershed preserves important remnants of dry *páramo* (alpine grassland), oak Andean, encenillo (*Weinmannia tomentosa*) and mixed forests. It constitutes the habitat for at least 135 plants, 155 insects and 30 bird species. Of its 444 ha, 198 ha overlap the Iguaque Flora and Fauna Sanctuary, a national park created in 1997 (Borda et al, 2009).

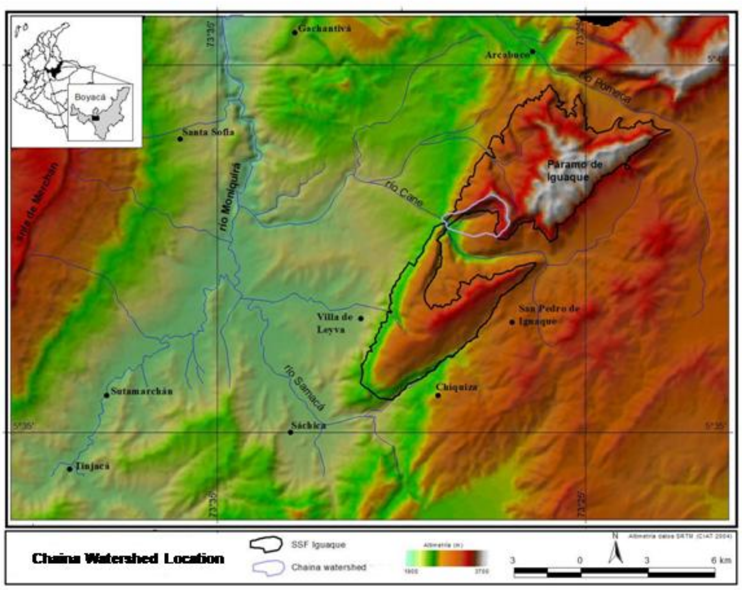

Figure 1 Location of Chaina watershed

As for land tenure in the upper watershed, there are five landowner families with government-approved title on the Villa de Leyva side. On the Chíquiza side, there are two families with more than 40 years of possession, and six families renting the land. These households receive incomes mainly from own agricultural production (with annual net benefits averaging US$252/ha/yr[1]), and from off-farm work.

Water users

Water users in the Chaina watershed live in seven villages belonging to the Municipality of Villa de Leyva, and are organized around five Water Management Boards (WMB). WMBs are community organizations in charge of distributing water from the Chaina watershed to approximately 880 households dispersed in five zones: i) Alto & Los Migueles, ii) Mosocallo, iii) Río Chaina, iv) Roble Alto and v) Sábana Alta (Figure 2 and Table 1). Of all water users, 52% are smallholder farmers who reside permanently the area, while the remaining 48% corresponds to owners of recreational houses.

Table 1 Distribution of water users along WMB

Aqueduct	Smallholder farmer	Recreational houses owners	Total
Alto & Los Migueles	123 (14%)	0 (0%)	123(14%)
Mosocallo	229 (26%)	88 (10%)	317 (36%)
Rio Chaina	9 (1%)	150 (17%)	159 (18%)
Roble Alto	9 (1%)	114 (13%)	123 (14%)
Sabana Alta	88 (10%)	70 (8%)	158 (18%)
Total	**458 (52%)**	**422 (48%)**	**880 (100%)**

[1] Monetary values are converted to 2007 US dollars.

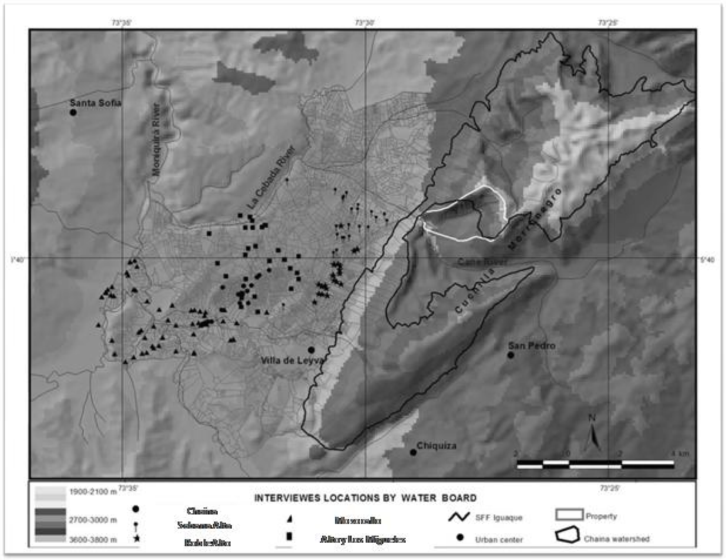

Figure 2 Location of different water management boards surveyed

The WMBs collect variable fees to operate and maintain the water system. Table 2 shows variations between WMBs in fees that households pay for the operation of pipe networks and water distribution. In particular, peasant households from three WMB receive implicit subsidies on their water consumption, either through reduced fixed (Mosocallo) or total fees (Rio Chaina, Roble Alto).

Significant ecosystems transformation has taken place for over 100 years in the Chaina micro-watershed through land fragmentation, expansion of the agricultural frontier, pastures expansion, and the intensive harvesting of timber species such as oak (*Quercus humboldtii*), cedar (*Cedrela montana*) and encenillo (*Weinmannia tomentosa*). These changes generated strong impacts on the ecological function of the Chaina watershed, including water quality and availability**.** First, water users face scarcity during some months of the year, triggering conflicts among rural aqueducts. Second, high water turbidity caused by watershed erosion creates serious damages in the pipe network, and current aggregate water treatment costs have risen to about US$3.600 per year.

Table 2 Monthly water fees paid at the different WMB

Aqueduct	Fixed fees (dollars of 2007)		Variable fees (dollars of 2007)	
	Peasants	Recreational houses owners	Peasants	Recreational houses owners
Alto y Los Migueles	Fixed fee of $1.44. It includes 40 m3		No charge	
Mosocallo	Fixed fee of $3.62. Includes 58 m3	Fixed fee of $7.24. Includes 58 m3	59-89 m3 = $0.14 each 90-140 m3 = $0.24 each 140-250 m3 = $0.48 each	
Rio Chaina	Fixed fee of $3.34 and 4.73 depending on stratum. It does not include any consumption	Fixed fee of $5.57. It does not include any consumption	$0.19 and $0.27 per cubic meter depending on stratum for the first 20 m3. After that $0.32	$0.32 per m3
Roble Alto	Fixed fee of $1.94. It does not include any consumption	Fixed fee of $12.77. It does not include any consumption	$0.22 for the first 20 m3. After that $0.72 per m3.	$0.72 per m3.
Sabana Alta	Fixed fee of $1.44. Includes 40 m3		$0.24 per cubic meter beyond 40 m3	

After 1977, when the Iguaque Sanctuary was declared, protected area rules have prohibited any type of productive activity within its limits, attempting to regulate the use of natural resources that historically were recognized as open access. This policy change, coupled with the unrecognized tenure rights of long-term residents, caused deep socio-environmental conflicts between watershed inhabitants, the protected area and water users.

In this context, a PES scheme emerged as a collective-action institutional arrangement to conserve watershed services and bridge escalating upstream-downstream conflicts through landowner compensations. Water users from the five WMBs, covering 880 households and about 4300 people, are annually paying US$1,850 in cash to nine upland farmers for changing their land-use practices so as to reduce soil erosion and stream sedimentation, and to improve soil structure so as to facilitate stream-flow regulation. Water users make a monthly voluntary contribution of about US$0.5 per household to finance PES. The scheme has been implemented since 2006, and has so far secured the preservation of approximately 162 hectares of natural forest, and the regeneration through natural succession of riparian vegetation in 14 additional hectares. Thus, so far only a fraction of the upper watershed's area is enrolled in the PES scheme. The small total amount available from flat user payments is thus a main bottleneck for extending the scheme to larger areas, and for achieving a higher ES efficiency.

In institutional terms, the PES process has been supported by different stakeholders, such as the Biological Research Institute Alexander von Humboldt (IAvH) gathering baseline information, the Municipality of Villa de Leyva as facilitator, and more recently, the Center for International Forestry Research (CIFOR) continuing technical support.

Data collection

We applied face-to-face interviews with 218 households, members of the Water Users Association (WUA) of the Chaina Watershed. It was stratified taking into account two factors: distribution of households on the two user categories of smallholder farmers and recreational houses owners and distribution of water users in the five WMBs. The stratified sample was randomly assigned using the cadastral information from the municipality's official cartography. From the 218 applied surveys, 206 were valid for statistical purposes. The final distribution according to WMB and type of household is shown in Table 3.

Table 3 Stratified sample for contingent valuation survey

Water Management Board	Smallholder farmers	Recreational house owners	Total
Alto & Los Migueles	30 (15%)	9 (4%)	39 (19%)
Mosocallo	60 (29%)	14 (7%)	74 (36%)
Rio Chaina	2 (1%)	29 (14%)	31 (15%)
Roble Alto	9 (4%)	17 (8%)	26 (13%)
Sabana Alta	24 (12%)	12 (6%)	36 (17%)
Total	**125 (61%)**	**81 (39%)**	**206 (100%)**

To increase the probability of finding owners of recreational houses, surveys were applied during the holiday period (December-January) and weekends. In addition, some surveys of absentee owners were completed by phone. This sample provides a confidence level of 95% and a maximum error of 6%. Global positioning system (GPS), was applied for geographical referencing of interviewed households. Figure 2 shows the locations of surveyed households.

To assess how easy the survey is to understand (Carson, 2000; Mitchell & Carson, 1989), in December 2007 we pretested it with 12 households, eliciting a range of WTP to define four starting points for a referendum-type CVM question. In the full survey, carried out between December 2007 and April 2008, four starting points were randomly assigned between smallholder farmers and recreational house owners, and distributed on the sample as follows: 30% of households were asked for US$0.75 as starting point; 30% were asked for US$1.25; 25% were asked for US$1.75 and 15% of households were asked for US$2.25. The final CVM survey was made up by seven sections (Table 4).

Table 4 Final CVM survey content

Survey Section	Type of information
Survey identification and location	Date Name of interviewer Survey ID Name of the water management board Name of the village Name of the parcel
Introduction	Brief introduction Questions to determine if interviewee is suitable and willing to answer the survey
Knowledge about Chaina watershed.	Interviewee knowledge about current watershed conditions Perceptions about threats to the watershed, and relationships between water availability and watershed condition Perceived intensity and frequency of changes in quantity and quality of water supplied by watershed
Water consumption information	Sources of water for household consumption Household water consumption volume from Chaina watershed Average monthly payment for water services from Chaina watershed Average monthly money spent on other water sources (e.g. bottled water) Investments in water storage facilities
Ex ante scenario	Explaining current PES initiative Interviewee knowledge and perceptions about current PES scheme
Ex post scenario	Presenting PES hypothetical scenario with ES fees differentiated by household's consumption and income levels Pictures of current watershed condition and expected watershed condition if a larger differentiated ES fee is approved. Perception about differentiation of ES fees DAP referendum type question DAP follow-up referendum question DAP open question
Demographic and socioeconomic context	Age, gender, education level, marital status, size of household, household income, household expenses, etc.

We presented "the *ex ante* scenario" and reminded households about both the functioning of the ongoing PES program and the use of the money collected through current contributions (ES fees). We asked respondents about their knowledge and perceptions about the current PES scheme. In keeping with the CVM literature (Mitchell & Carson, 1989; Carson, 2000; Haab & McConnell, 2002), we then presented a hypothetical *ex post* scenario, where individual voluntary contributions would be used for enhanced payments to upstream landholders for conservation that would help improving water quality and flow stability throughout the year. The counterfactual we asked respondents to compare with a scenario of "no PES program", where also the current partial protection efforts would be halted. ES fees would also potentially be differentiated among water users. We screened respondent preferences with respect to water consumption and/or income levels as discriminators: households who consume more water would pay more for the ES, as would households with higher income ES. ES differentiated fees would be paid along with the water bill, and the collected money would continue to be administered by the WBMs.

After presenting the *ex post* scenario, we asked the following questions:

1. Would you agree with establishing differentiated ES fees for Chaina water users?

   YES____ NO____
2. Should the ES fees be differentiated according to
   a. Household water consumption level____
   b. Household income level_____
   c. both_____
3. Would you be willing to pay an ES monthly fee of US$ (*randomly assigned starting point*) to improve and increase conservation activities being carried out upstream which will contribute to obtain better water quality and more stable stream flows during the year?

   YES___ NO____

Surveys were applied by pre-trained local people, to diminish fears regarding sensitive questions. From the 218 applied surveys, 206 were valid, and 170 surveyed answered the referendum WTP question. Approximately 15% of households did not agree with paying a differentiated ES fee. Among those, 40% think that the current ES fee is adequate and 27% argue that is fair to have a flat fee. Referendum question was only asked to households who agreed to pay a differentiated fee.

Theoretical model

CVM is based on the random utility model (Haab & McConnell, 2002). Through this model, Hanemann (1984) demonstrated that responses to dichotomous CVM questions can be used to estimate and interpret parameters. In the survey, the respondent is to choose one out of two alternatives (*i = 0, 1*); *i=0* meaning that the respondent currently is under the *status quo*, and *i=1* means that the respondent is under the state when the CVM program is implemented. Indirect utility of respondent *j* can be written as:

$$u_{ij} = u_i(y_j, \mathbf{z}_j, \varepsilon_{ij})$$

y_j represents the income of individual *j*, $\mathbf{z}_j$ represents a vector of household characteristics, and ε_{ij} is a component of preferences not observed but perhaps known to the respondent (Haab & McConnell, 2002). Under the dichotomous question, respondent *j* will prefer the proposed CVM scenario (that is, will answer 'yes'), assuming a payment of t_j, if the utility derived from the CVM program is greater than that under the *status quo*, even after paying the proposed bid:

$$u_1(y_j - t_j, \mathbf{z}_j, \varepsilon_{1j}) > u_0(y_j, \mathbf{z}_j, \varepsilon_{0j})$$

Given that not all respondent preferences are known to the researcher, only probability statements can be made about this relationship. Therefore, the probability of a 'yes' response is the probability that the respondent expects to be better off under the proposed scenario, that is:

$$prob(yes_j) = Prob(u_1(y_j - t_j, \mathbf{z}_j, \varepsilon_{1j}) > u_0(y_j, \mathbf{z}_j, \varepsilon_{0j}))$$

In order to use this framework for a parametric estimation, there are two decisions to make: the functional form of the utility function and the distribution of the term ε_{ij}. The most direct way of solving the functional form is to assume that utility function is additively separable in deterministic and stochastic preferences (Haab & McConnell, 2002):

$$u_i(y_j, \boldsymbol{z}_j, \varepsilon_{ij}) = v_i(y_j, \boldsymbol{z}_j) + \varepsilon_{ij}$$

In that way, the expression for the probability of answering 'yes' can be written as:

$$prob(yes_j) = Prob(v_1(y_j - t_j, \boldsymbol{z}_j) + \varepsilon_{1j} \quad > v_0(y_j, \boldsymbol{z}_j) + \varepsilon_{0j} \quad)$$

Haab & McConnell (2002) show that the stochastic components can be aggregated as $\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$. From that, the next step is to determine a functional form for the utility function. The simplest version is to assume a linear utility function, i.e. linear in income and covariates:

$$v_{ij}(y_j) = \boldsymbol{\alpha_i z_j} + \beta_i(y_j)$$

$\boldsymbol{\alpha_i}$ is a vector of parameters and β_i is a parameter associated to the marginal utility of income. Assuming that changes between the *status quo* and the proposed scenario are not big enough to alter the household characteristics and attributes, nor the marginal utility of income, subscripts for parameters can be dropped, and the probability of answering 'yes' would become:

$$Prob(yes_j) = Prob(\boldsymbol{\alpha z}_j - \beta t_j + \varepsilon_j > 0)$$

The only remaining decision is about the random term. If the terms ε_j are independently and identically distributed with mean zero, either a normal distribution (probit model) or a logistic distribution (logit model) can be used for the model estimation of the parameters. Both models are estimated using the maximization of a likelihood function, and differences between the two models tend to be only slight (Haab & McConnell, 2002). Once the parameters are estimated, the expectation of WTP can be projected by calculating (Haab & McConnell, 2002):

$$E_\varepsilon(WTP_j | \boldsymbol{\alpha}, \beta, \boldsymbol{z_j}) = \frac{\boldsymbol{\alpha z}_j}{\beta}$$

Empirical model

We can now turn to our search for the most adequate set of explanatory variables. In the estimated model, the dependent variables takes the value of one if the respondent answers positively to the payment of the proposed bid, and zero otherwise. This variable is regressed against a set of explanatory variables that can be grouped in categories:

- **Variables related to the proposed scenario**. . Besides the proposed bid, as a quintessential explanatory 'price' variable, we include respondents' preference for a differentiated fee, and whether this differentiation should be done by income or by consumption.
- **Spatial variables**. Distance to urban center and distance to water distribution point are included, as are dummies for the water management board (WMB) to which the respondent belongs.
- **Individual variables**. Socioeconomic and demographic attributes refer to origin, gender, age, education level, birth place, household size, ownership of house, expenses and income levels. In the linear utility model, the marginal utility of income is assumed to be constant across scenarios, and therefore income might be dropped from the list of regressors. This assumption, however, needs to be empirically reviewed and therefore we include two models, one with income and another one without it.
- **Access to water**. Households also face different access to water, and that may affect their contingent responses. This refers also to perceived water availability during the year, and spending on alternative water sources.
- **Payments for environmental services**. Although there is an ongoing PES program, some households might not be aware of that or disagree with the program, which may also shape WTP.

From the survey, variables were included in the regression so as to reach the model specification with the maximum likelihood, adequately handling typical econometric problems such as collinearity, autocorrelation and heteroskedasticity.

3. Descriptive results

Perceptions about the environmental service

Almost all households (99%) perceived that the deterioration of the watershed's páramos and forests affects both the quality and quantity of water they receive. 54% of them argued that both quality and quantity of water are affected permanently, while 41% thought this effect occurred only during dry seasons. Recreational households perceived this problem as more permanent (84% against 35% from smallholders), while smallholders tended to argue it is more related to dry season (59% against 15% from recreational households) (Figure 3).

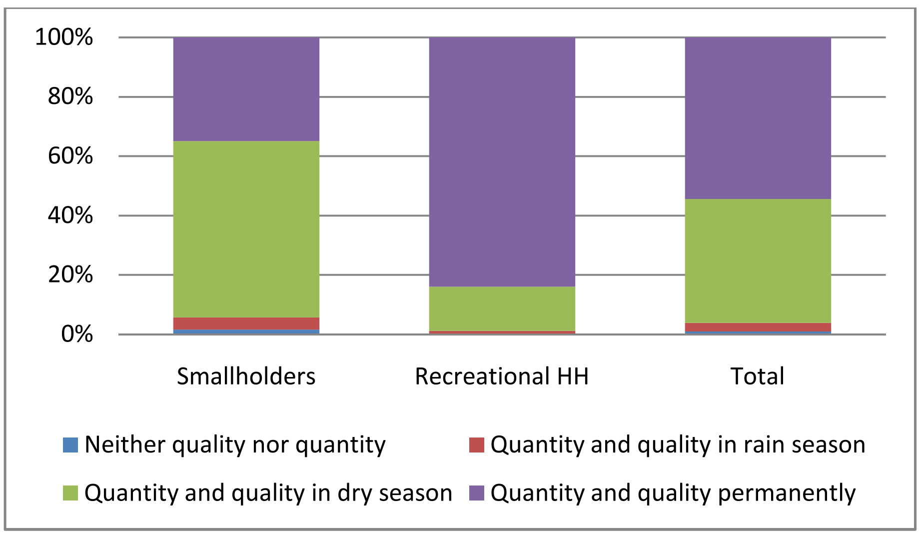

Figure 3 Perceived effect of forests and páramos deterioration on water availability

60% of households (63% of smallholders and 56% of recreational) stated that they had problems with water coming from the Chaina watershed, related either to water quality (30%), quantity (9%), or both (21%) (Figure 4). As mentioned above, water quality is affected greatly by erosion causing water turbidity and sedimentation. Three out of five WMBs currently carry out water treatments before distributing water to households, incurring in high costs. With respect to quantity, water flow is has been perceived to become more fluctuating during the year, specifically with more dry-season shortages, caused upstream by soil compaction and other watershed-degrading practices.

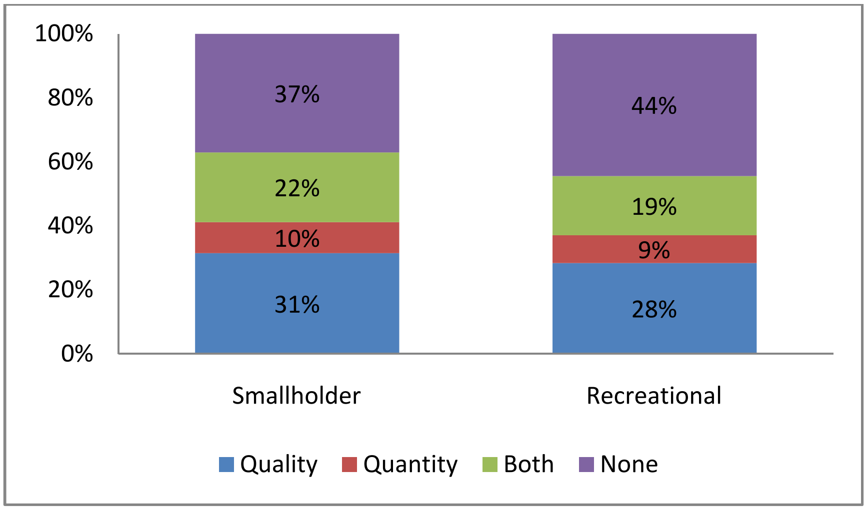

Figure 4 Main problems associated to the Chaina watershed

Both smallholder farmers and recreational houses owner recognized that the protection of the watershed is important for water provision. This perception was greater (a statistically significant difference) in peasant households (97% for peasants vs. 83% for recreational house owners; see Table 5), perhaps because they have been longer time in the zone (on average 31 years vs. 14 years). Smallholders also perceived greater season quantity and quality variations than do recreational homeowners (Table 5).

Table 5 Percentage of positive answers to perception questions by type of homeowner

Perception	Smallholder	Recreational	Total
Knowledge about natural park?	60%	65%	62%
Has visited upstream watershed?	44%	37%	41%
Aware of the importance of watershed for water supply?	97%	83%	91% ***
Receives steady quality of water along the year?	48%	64%	54% **
Receives steady quantity of water along the year?	58%	83%	68% ***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

However, the perception of watershed deterioration was greater for owners of recreational houses: 52% of them perceived high or moderate threats, compared to 40% for peasants (Table 6). More than 30% in both respondent categories stated not to know the condition of forests and páramos in the Chaina watershed.

Table 6 Perception about the threat to páramos and forests in the Chaina watershed

Perception	Smallholder	Recreational	Total	
Not in danger	11%	2%	8%	**
Low danger	18%	10%	15%	*
Moderate danger	26%	16%	22%	*
High danger	14%	36%	22%	***
Don't know	32%	36%	33%	
Total	**100%**	**100%**	**100%**	

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Water sources and household water consumption

Households interviewed make use of several water sources, not only the Chaina watershed. Alternatives included bottled water (48%), other natural sources (32%), and rain water saved in tanks (67%). However, patterns diverge between peasants and recreational houses (Table 7): a higher proportion of peasants declared the use of natural sources such as rain water (72%) compared to recreational houses (60%), while more recreational house homeowners report the use of bottled water (64%) than smallholders do (38%).

Table 7 Use of alternative water sources

Source	Smallholder	Recreational	Total	
Bottled water	38%	64%	48%	***
Other natural sources	34%	30%	32%	
Collect rain water	72%	60%	67%	**

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Many households have alternative sources of water, and use water from the Chaina watershed primarily for satisfying basic needs such as personal hygiene (96%), direct consumption (90%) and house cleaning (86%). The use of alternative sources of water varies between types of users (Table 8): smallholders rely more on alternatives than recreational households for direct consumption (95% vs. 81%), recreational households more for e.g. house cleaning (89% vs. 85%), pet needs (26% vs. 18%), car washing (7% vs. 4%), and other uses (14% vs. 4%). These results make evident the differences in water consumption patterns.

The preferred use of bottled water was due mainly to a perceived low quality of water coming from the Chaina watershed (e.g. color, turbidity, sediments, etc). Bottled water is always used for direct consumption, including cooking.

Table 8 Uses of water coming from Chaina watershed

Source	Smallholder	Recreational	Total	
Direct consumption	95%	81%	90%	***
Personal hygiene	97%	95%	96%	
House cleaning	85%	89%	86%	**
Pet needs	18%	26%	21%	***
Car washing	4%	7%	5%	**
Other	4%	14%	8%	***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

The reported volume of water consumed monthly from the Chaina watershed averages 17 m3 per household, being slightly greater for smallholder farmers (18.5 m3) than for recreational households (14.7 m3), likely because peasants are permanent residents while owners of recreational houses visit their parcels more sporadically during the year. However, recreational houses owners reported much greater monthly payments of water bills (Table 9), which can be explained by the existence of subsidies to smallholders. It is important to mention that peasants did not report the use of water from Chaina watershed for agricultural purposes which was explicitly asked in the survey.

With respect to bottled water, peasants also report more consumption and monthly expenses for buying it. Conversely, owners of recreational houses reported higher investments on water built storage facilities (Table 9). The differences between smallholders and recreational houses are not statistically significant though.

Table 9 Descriptive statistics on households' water consumption

Variable	Smallholder farmer	Recreational house owner	Total
Households' water consumption from Chaina watershed (m^3/month)	18.5	14.7	17.1*
Households' expenses on water bills (dollars/ month)	4.2	10.4	6.6***
Households' consumption of bottled water (liters/month)	89.1	72.3	80.4
Households' expenses on bottled water (dollars/month)	14.1	7.4	10.4
Households' investments on built water storage facilities (dollars)	51.7	77.4	61.8

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Knowledge about current PES program

Although most households agree with the current PES program (which was explained in the survey), less than a half knew they paid into the PES initiative (Table 10). Decisions at the Water User Association are made at the general assembly, which is not attended by all users. Although the monthly ES contribution appears explicitly on water bills, less than a quarter of households knew how much they were contributing.

Table 10 Knowledge about current PES program in Chaina watershed

Question	Smallholder	Recreational	Total
Did you know about PES program?	42%	46%	44%
Do you agree this program?	93%	94%	94%
Do you know how much you pay?	23%	22%	23%

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%.

Once we explained interviewees how the PES program works and how much they are contributing monthly, we asked if they think the fee is adequate. Most households (77% of smallholder farmers and 58% of recreational houses owners) think that the current fee is adequate (Table 11). However, interestingly, as we will show later, most individuals interviewed were also willing to pay a higher ES fee. Some smallholders in particular think the fee is high/ too high, while most of recreational home owners think it is low/ too low.

Table 11 Perception about the adequacy of current PES fee in Chaina watershed

Perception	Smallholder	Recreational	Total	
Too high	7%	1%	5%	**
High	4%	0%	2%	**
Adequate	77%	58%	69%	***
Low	6%	15%	9%	**
Too low	5%	17%	10%	***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Socio economic characteristics

Using the national socioeconomic strata, we can in Figure 5 see that 91% of smallholder farmers declare to belong to the two lowest strata, while about 76% of recreational house owners belong to strata three and four, with a higher diversity in the latter group[2].

[2] In Colombia, households are categorized in six economic strata which are mainly used for purposes of charging -and subsidizing- public utilities or services. Starting at one, strata increase with income level and other indicators of wellbeing, up to level six. Possibly interviewees answered strategically to this question, thus under reporting their stratum, which might be why strata 5 and 6 are not represented.

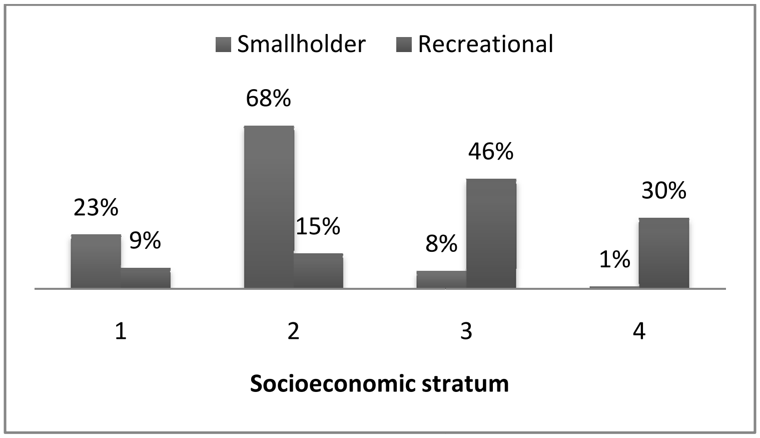

Figure 5 Distribution of interviewed households along socioeconomic strata

The distribution of inhabitants among WMBs shows that Mosocallo and Alto & Los Migueles are mainly inhabited by smallholders, while Rio Chaina and Roble Alto are mostly populated with recreational home owners (Figure 6).

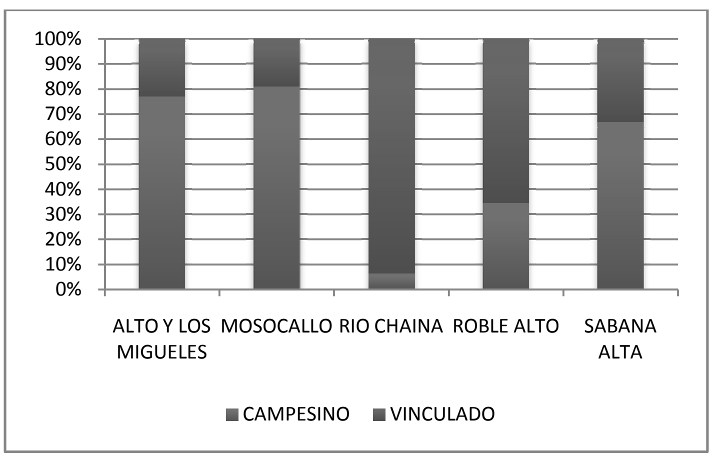

Figure 6 Distribution of inhabitants among WMBs in Chaina watershed

At the same time, WMBs where more peasant population resides have a lower average of socioeconomic strata, and vice versa for WMBs dominated by recreational households (Figure 7).

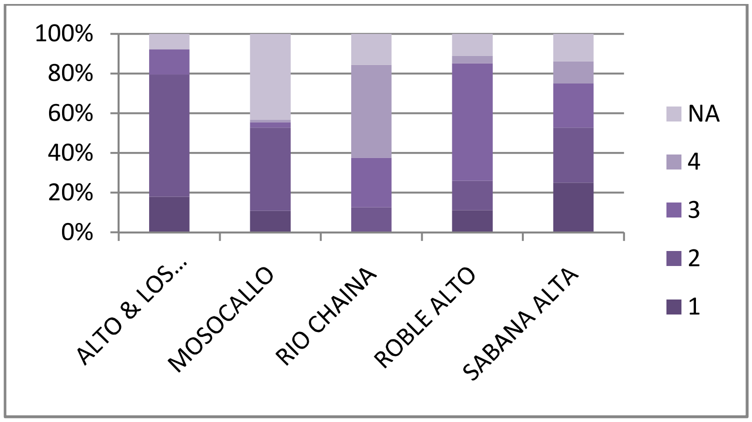

Figure 7 WMBs and socioeconomic strata of interviewees

Households declared to spend on average USD 417 per month, being statistically lower for smallholders (USD 277) than for recreational households (USD 699). The reported average income is USD 503 per month, and, as expected, differences between smallholders and recreational households are highly significant (Table 12), as could be expected from the reported socioeconomic strata. In terms of permanence in the area, most smallholders have lived there longer than recreational households, but they own less land. They also tend to have larger families and less education.

Table 12 Socio-economic and demographic characteristics of interviewees

Variable	Smallholders	Recreational	Total
Monthly expenses (USD)	277	649	417***
Monthly income (USD)	333	832	503***
Born in Villa de Leyva	82%	0%	50%***
Live permanently in Villa de Leyva	89%	44%	71%***
Owner of property in Villa de Leyva	77%	90%	82%***
Gender: male interviewed	58%	59%	59%
Age: years	54	55	54

Education: years of schooling	4.5	11.2	7.1***
Married	74%	75%	74%
Household size	4.2	3.0	3.7***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Spatial variables

On average, households are located 4.4 km far from the urban center (Villa de Leyva). However, those belonging to the Rio Chaina and Roble Alto Water Management Boards, with predominance of recreational owners, are somewhat closer to town (3-3.6 km) (Figure 8)

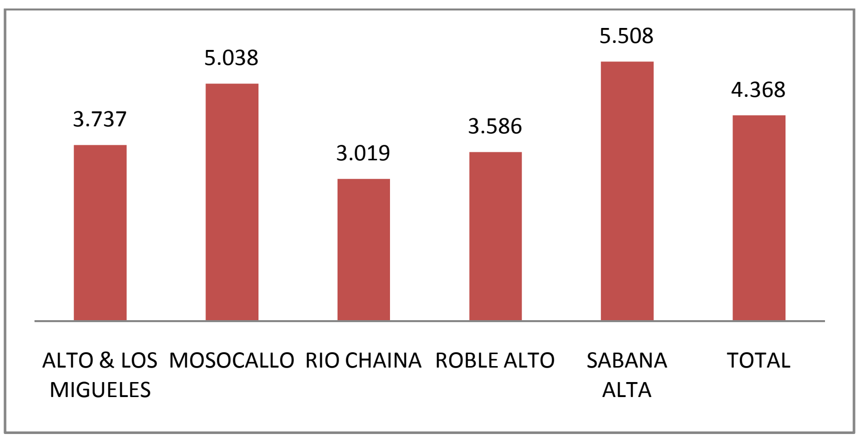

Figure 8 Average distance from households to urban center by WMB, (in m)

The average distance to the water distribution point is seven kilometers (Figure 9). Households from Mosocallo are farthest away (about 10.7 km), and thus being “last in the queue” their probability of suffering water shortages in dry seasons is also highest. This is followed by Rio Chaina WMB (about 7.5 km), while Alto & Los Migueles (6.3 km), Sabana Alta (about 2.75 km) and Roble Alto (about 3.85 km) are closer.

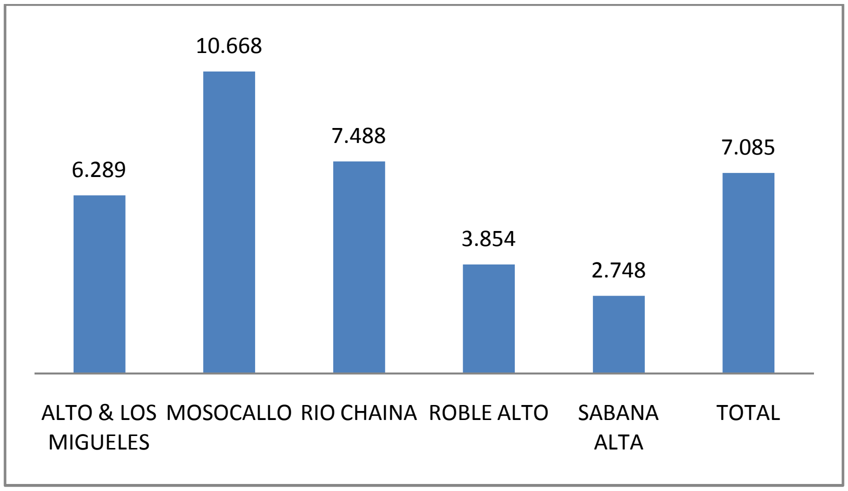

Figure 9 Average distance (in m) from interviewed households to water distribution point, by WMB

Does distance differ systematically for categories of water users? On average, smallholder farmer's parcels are located farther from the urban center (about 4.7 km) and the water distribution point (7.6 km) than recreational houses are (about 3.8 and 6.3 km respectively) (Table 13).

Table 13 Distances from interviewed households to town center and water distribution point (in m)

Distance to	Smallholder	Recreational	Total	
Urban center	4,737	3,811	4,378	***
Water distribution point	7,616	6,275	7,093	***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Hypothetical scenario: PES program with higher and differentiated fees

From 206 completed surveys, 201 answered the question: *Do you agree with a system where differentiated ES fees are paid? If yes, according to which criteria should the ES fee be differentiated?* 85% of households agreed to a differentiated fee. Of those, 41% think the ES fee should be differentiated by household water consumption, 23% by household income level, 30% by both criteria and, 6% by other criteria (Figure 10).

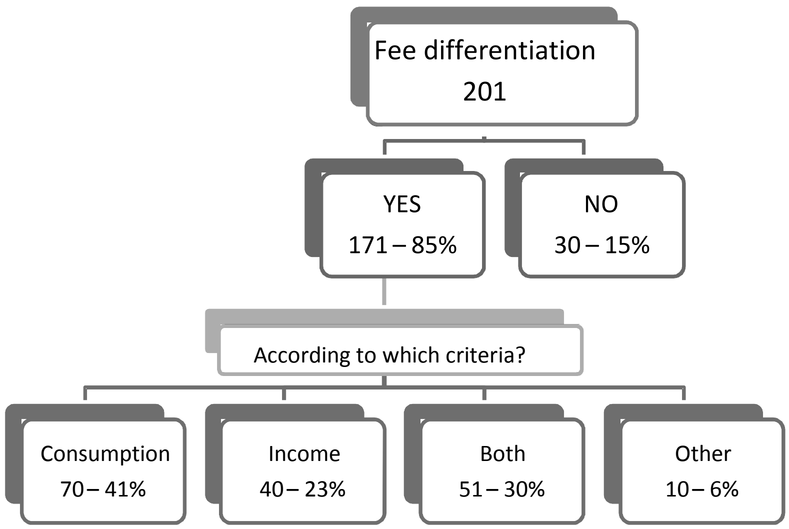

Figure 10 Answers with respect to the proposed differentiated fee

Comparing smallholders to recreational households, 83% of the former answered yes to the randomly assigned referendum bid, while 89% of the latter did so (insignificant difference). As to criteria for differentiation, more recreational households think it is fair to pay according to water consumption levels, while a greater proportion of smallholders consider the need of combining consumption and income (Table 14).

Table 14 Preferred criteria for differentiating the PES fee

Criterion	Smallholder	Recreational	Total
Consumption	36%	47%	41% *
Income	22%	24%	23%
Both	34%	23%	30% *

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

Behavior of responses to bid starting points is as expected: the percentage of households willing to accept the proposed bid decreases as the proposed value increases (Figure 11).

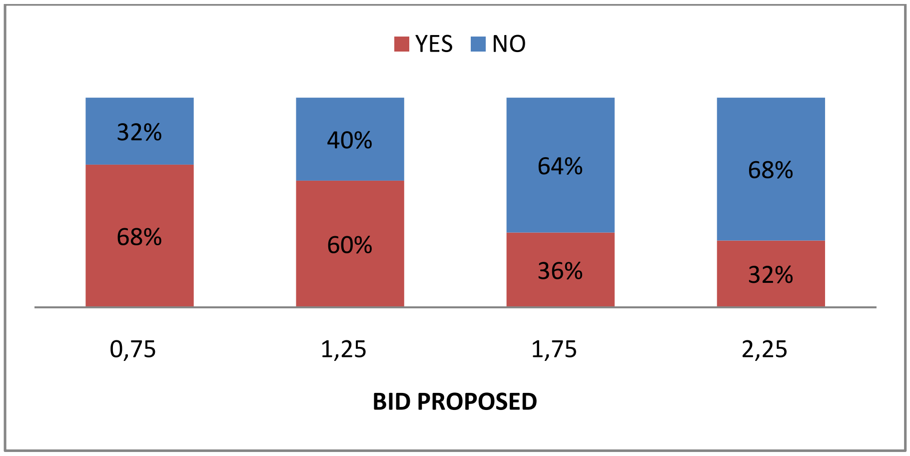

Figure 11 Proportion of responses to proposed bids

When separating smallholder farmers from owners of recreational-houses, it was found that bid acceptance is generally, and significantly, higher for the latter (Table 15), which could e.g. have to do with the groups' differential income levels. In general, smallholders accept at most 60% of the proposed bids (when the offered bid was the lowest), while recreational households accept at least 59% of the proposed bids.

Table 15 Acceptance of proposed bids by user type

Proposed bid (USD)	Smallholder	Recreational	Total	
0.75	60%	83%	68%	**
1.25	34%	86%	60%	***
1.75	23%	59%	36%	***
2.25	8%	70%	35%	***
Total	**36%**	**77%**	**53%**	***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%

If the proposed bid is shown on the vertical axis, and the acceptation rate on the horizontal, a downward-sloped demand curve for the water environmental service emerges at least in rough contours. The curve's starting point (extrapolated intercept in y-axis) is thus clearly lower for peasants than for recreational owners, whereas peasant elasticity of demand is seemingly higher, i.e. increases in ES fees reduce peasant WTP more quickly than that of recreational house owners. (Figure 12). These first observations must be confirmed by the formal parametric analysis, though

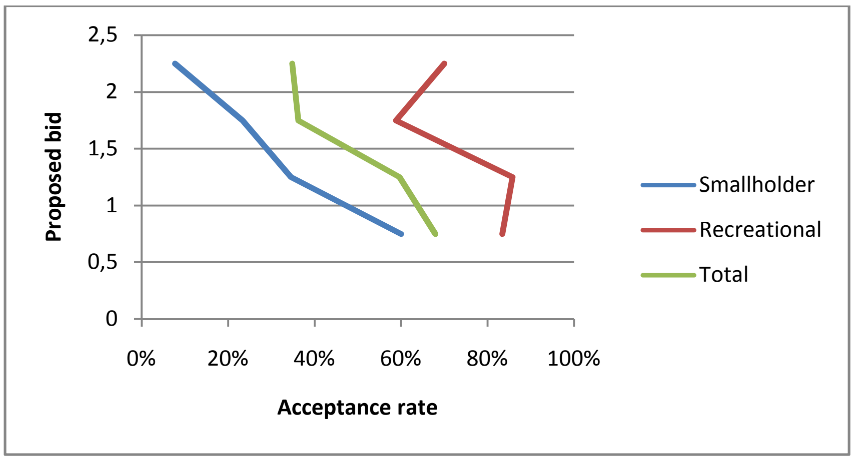

Figure 12 Approximation to demand curves for the environmental service by type of user in Chaina watershed

We also tried to plot WTP curves for other potential differentiating factors, such as household water consumption and income level; however, these criteria do not really correlate bilaterally with the acceptance rate, and thus the plots add little to our understanding.

4. Multivariate analysis of WTP determinants

The previous section has shown some descriptive facts about the interviewed households in the Chaina watershed. First, socioeconomic and demographic characteristics differed widely and significantly between smallholder peasants and recreational households, including their monthly income and socio-economic strata. Second, these differences seemed to impact the acceptance of the hypothetically proposed higher and differentiated ES payments. Third, knowledge and perception variables may co-determine bid acceptance and differentiation preferences. Finally, spatial variables such as distance to urban centers and distance to the water distribution point might have affected this acceptance, too.

However, we also know that many of the potential explanatory variables are internally correlated, and thus bilateral variations may not show the full picture. To consolidate partial observations, we will thus now turn to a multiple-variable, parametric analysis. We developed a traditional referendum analysis using a probit model to explain WTP. We used the acceptance of proposed bid as the dependent variable, which takes the value of 1 if respondent agreed to pay that bid, and 0 otherwise. The explanatory variables were grouped in categories:

- Variables related to the proposed scenario.
    - Proposed bid: Different proposed values for the fee -- USD 0.75, 1.25, 1.75, 2.25.
    - Differentiation by consumption: 1=yes, 0=no.
    - Differentiation by income: 1=yes, 0=no.
- Geographical variables
    - Distance to urban center (km)
    - Distance to water distribution point (km)
- Water access variables
    - Same quality: Respondent thinks water quality is little changed during the year. 1=yes, 0=no.

    - Same quantity: Respondent thinks water amounts are little changed during the year. 1=yes, 0=no.
    - Buy water: Respondent buys water from other sources (bottled). 1=yes, 0=no.
- Variables related with the PES program
    - PES agreement: The respondent agrees with the existence of the PES initiative. 1=yes, 0=no.
- Individual and household variables
    - Sex: 1=man, 0=women.
    - Age: (years).
    - Household size: Number of members in the house.
    - Origin: 1= smallholder peasant, 0= recreational household.
    - Income. Monthly household income reported, (USD).
    - Expenses. Monthly household expenses reported (USD)

Averages for these variables, for types of users, and for bid acceptors vs. rejecters are presented in Table 16.

Most variables in Table 16 were used in the econometric analysis. During the estimation process, some explanatory variables exhibited high correlation. Specifically, the variable *origin* (type of user) correlated with other relevant characteristics, including income.

Table 16 Mean of selected variables by type of user and acceptance of proposed bid

Variable	Total	Smallholders	Recreational	Accept the bid	Reject the bid
Acceptance of proposed bid. Dependent variable. 1=yes, 0=no.	52%	36%	77%	100%	0%
Differentiation by consumption. 1=yes, 0=no.	35%	29%	43%	40%	40%
Differentiation by income. 1=yes, 0=no	19%	18%	22%	22%	22%
Distance to urban center. Kilometers.	4.4	4.7	3.8	4.0	4.9
Distance to water distribution point. Kilometers	7.1	7.6	6.3	6.6	7.6
Same quality. 1=yes, 0=no	54%	48%	64%	62%	43%
Same quantity. 1=yes, 0=no.	68%	58%	83%	75%	63%
Buy water. 1=yes, 0=no.	48%	38%	64%	55%	38%
PES agreement. 1=yes, 0=no	94%	93%	94%	97%	92%
Sex. 1=man, 0=women.	58%	58%	59%	62%	52%
Age. Years.	54.4	53.8	55.2	53.9	53.5
Household size. Number of members	3.7	4.2	3.0	3.4	3.8
Origin. 1= smallholder, 0=recreational	61%	100%	0%	41%	80%
Household monthly income. USD.	503	333	834	619	363
Household monthly expenses. USD.	417	277	649	515	303

We thus propose two models presented in Table 17. The first one excludes the variable income, which admittedly is unusual in explaining WTP. This is only valid if we can assume that marginal utility of income is constant (so we will have a linear utility model) which is plausible when income changes are insignificant or null (Haab & McConnell, 2002). In the current scenario, PES represented on average only 0.26% of household income, and this proportion would in the hypothetical scenario increase on average, at most, to just 0.60% of households income. Besides, given the differences between smallholders and recreational households, we can assume that this variable captures a great proportion of the difference in income and education of these two groups.

Table 17 Probit regression for acceptance of proposed fee

	Model 1				Model2			
Variable	Coefficient		Marginal effect		Coefficient		Marginal effect	
Proposed bid	-1.233 (0.265)	***	-0.491 (0.106)	***	-1.240 (0.284)	***	-0.495 (0.113)	***
Differentiation by consumption	-0.167 (0.279)	Ns	-0.067 (0.111)	Ns	-0.064 (0.284)	Ns	-0.026 (0.113)	Ns
Differentiation by income	-0.313 (0.334)	Ns	-0.124 (0.131)	Ns	-0.210 (0.359)	Ns	-0.083 (0.142)	Ns
Distance to urban center	-0.212 (0.089)	**	-0.084 (0.035)	**	-0.208 (0.094)	**	-0.083 (0.038)	**
Distance to water point	-0.090 (0.045)	**	-0.036 (0.018)	**	-0.092 (0.047)	*	-0.037 (0.019)	*
Same quality throughout year	0.565 (0.266)	**	0.222 (0.102)	**	0.579 (0.284)	**	0.228 (0.109)	**
Same quantity throughout year	-0.218 (0.281)	Ns	-0.086 (0.110)	Ns	-0.252 (0.299)	Ns	-0.100 (0.118)	Ns
Buy water	0.395 (0.255)	Ns	0.156 (0.099)	Ns	0.245 (0.272)	Ns	0.097 (0.108)	Ns
PES agreement	1.286 (0.587)	**	0.429 (0.128)	**	1.266 (0.602)	**	0.415 (0.128)	***
Sex	0.096 (0.238)	Ns	0.038 (0.095)	Ns	0.025 (0.262)	Ns	0.010 (0.105)	Ns
Age	0.002 (0.008)	Ns	0.001 (0.003)	Ns	0.001 (0.008)	Ns	0.001 (0.003)	Ns
Household size	0.020 (0.056)	Ns	0.008 (0.022)	Ns	0.039 (0.058)	ns	0.016 (0.023)	ns
Smallholder	-0.928 (0.277)	***	-0.352 (0.096)	***	-0.828 (0.321)	***	-0.318 (0.115)	***
Expenses					0.000 (0.000)	Ns	0.000 (0.000)	Ns
Constant	2.266 (1.022)	**			2.112 (1.063)	**		
Observations	163				144			
LR chi2(16)	66.92				53.80			
Prob > chi2	0.000				0.000			
Pseudo R2	0.297				0.270			

Asterisks denote statistical significance: * significant at 90%, ** significant at 95%, *** significant at 99%, Ns not significant. Standard deviations in parenthesis.

The second model is an attempt to maintain the variable income. However, given the high correlation between income and expenses, we prefer to use the latter as there are more valid surveys declaring expenses than those declaring income, and still it captures the desired effect.

First, the amount proposed in the hypothetical scenario reconfirmed the expected downward sloping demand behavior in both models: as the proposed bid increases, the probability of acceptance was reduced, even when a series of other variables are controlled for. In both models, an increase of one dollar in the proposed bid reduced the probability of acceptance in about 50%.

Second, agreeing to discriminate the price either by consumption or by income did not have any effect in the probability of accepting the differentiated fee. That is, once the proposed bid was accepted, the criterion preferred by respondents did not affect WTP. As with almost every variable included, the results are similar for both models.

Third, spatial variables affected the willingness to pay of respondents. In particular, distance to the urban center reduced the probability of accepting the payment. A household living one kilometer farther had, ceteris paribus, about 8% less of probability of accepting the bid. Higher distance to the water distribution point also exerted a negative effect on WTP. In both cases, the parameters were significant.

The perception of households about the quality of the water they receive along the year affects the willingness to pay: those households that perceive a constant level of quality –presumably good quality- are more willing to accept the bid than those that do not. That result would imply that households receiving a constant quality of water may link this benefit with the fact that the PES program is in place. In contrast, perceptions about regularity in the quantity of water along the year seem not to be related with the willingness to pay.

What strongly affected the probability of paying a differentiated fee is the agreement with the ongoing PES program. Agreeing to the current program increased in about 42% the probabilities of accepting the WTP bid fee, showing that users who know about and are satisfied with the program perceived a potential for further improvement, stimulating their WTP.

Demographic variables, such as the respondent's sex, age and family size seemed to have little impact on WTP. A significant difference between smallholder peasants and recreational households was, however, reconfirmed. Smallholders are 35% (32% in model 2) less likely to accept a given proposed bid, compared to recreational households.

Monthly household expenses seem not to affect the willingness to pay. This result might imply that the differences in income are captured by other variables, such as origin and distances to urban center and to water distribution point. The same effect was observed when monthly income is included, although with fewer observations in the regression; that is the reason why we present this model with expenses as explanatory variable.

Given the similarity between models 1 and 2, for the remaining analysis we used the results from model 1, which exhibits better goodness of fit and more prediction ability.

Following the standard WTP calculation, we scrutinize in Table 18 the estimated WTP values and their distribution. The average WTP is around US$1.48, which is about one dollar more than the current flat fee. WTP from recreational households is almost double that from smallholders.

Table 18 Estimation of willingness to pay in the two models (in US$)

Statistic	Values
Mean	1.48
Median	1.41
Minimum	0.18
Maximum	3.01
Standard deviation	0.69

As for the different WMBs (Table 19), Roble Alto and Rio Chaina are the WMBs with highest WTP (exceeding two dollars), while Mosocallo exhibits a WTP of around one dollar. In each WMB, though, the estimated WTP still exceeds the current fee.

Table 19 Estimated willingness to pay by origin and WMB

WMB	Recreational	Smallholder	Total
ALTO Y LOS MIGUELES	2.28	1.39	1.63
MOSOCALLO	1.69	0.82	0.98
RIO CHAINA	2.20	1.59	2.15
ROBLE ALTO	2.22	1.63	2.02
SABANA ALTA	2.14	1.00	1.37
Total	**2.13**	**1.07**	**1.48**

WTP differences can also be analyzed according to socioeconomic and demographic background variables (Table 20). Besides the already noted WTP divergence between smallholders and recreational households, another evident discrepancy is related to the agreement with the ongoing PES: people who do not agree with the current PES, have lower WTP. The other variable with a high variance is the one related with origin: those that were born in Villa de Leyva exhibited a WTP that is US$0.80 smaller than those who were not.

Table 20 Estimated WTP according to different socioeconomic, demographic and perceptional variables

Variable	NO	YES	Difference
Differentiation by consumption	1.42	1.56	-0.14 ns
Differentiation by income	1.50	1.35	0.15 ns
Differentiation by both criteria simultaneously	1.49	1.40	0.09 ns
Main problem is quality	1.52	1.36	0.16 *
Main problem is quantity	1.47	1.47	0.00 ns
Main problem is both quality and quantity	1.52	1.24	0.28 **
Same quality	1.22	1.68	-0.46***
Same quantity	1.21	1.58	-0.37***
Buy water	1.23	1.73	-0.50***
PES knowing	1.39	1.57	-0.18 **

PES agreement	0.64	1.51	-0.87***
Current fee is adequate	1.68	1.37	0.32***
Current fee is high and too high	1.51	0.97	0.54***
Current fee is low and too low	1.36	1.91	-0.55***
Born in Villa de Leyva	1.86	1.07	0.79***
Sex=man.	1.43	1.50	-0.07 ns
Property ownership	1.31	1.51	-0.19*
Origin=smallholder	2.09	1.07	1.02***

Asterisks denote statistical significance of the difference between smallholders and recreational homeowners: * significant at 90%, ** significant at 95%, *** significant at 99%, ns not significant.

Differentiation of WTP according to the declared expenses and income shows that the environmental service is a normal good, i.e. increases in income raise WTP (Table 21).

Table 21 Estimated WTP according to declared expenses and income

Income intervals (USD)	Declared expenses (USD)	Declared income (USD)
Less than 100	1.08	1.10
100 to 200	1.17	0.96
200 to 300	1.31	1.09
300 to 400	1.61	1.52
400 to 500	1.44	1.54
500 to 700	1.72	1.28
700 to 1.000	2.05	1.75
more than 1.000	2.17	2.05

Spatial variables also exhibit an interesting pattern. For instance, distance to the urban center creates a negative effect on WTP: the farther the household to the urban center, the lower the WTP, as shown in Figure 13.

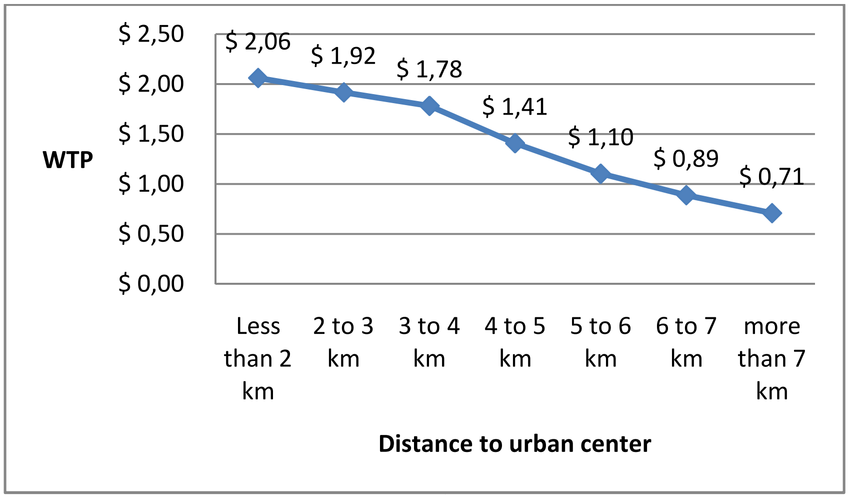

Figure 13 Effect of distance to urban center on estimated WTP

In the same sense, we investigate the effect of distance to the water distribution point. Figure 14 shows that the highest WTP is obtained when the household is located between four and six kilometers from the water distribution point, and that the relationship is inversely U-shaped.

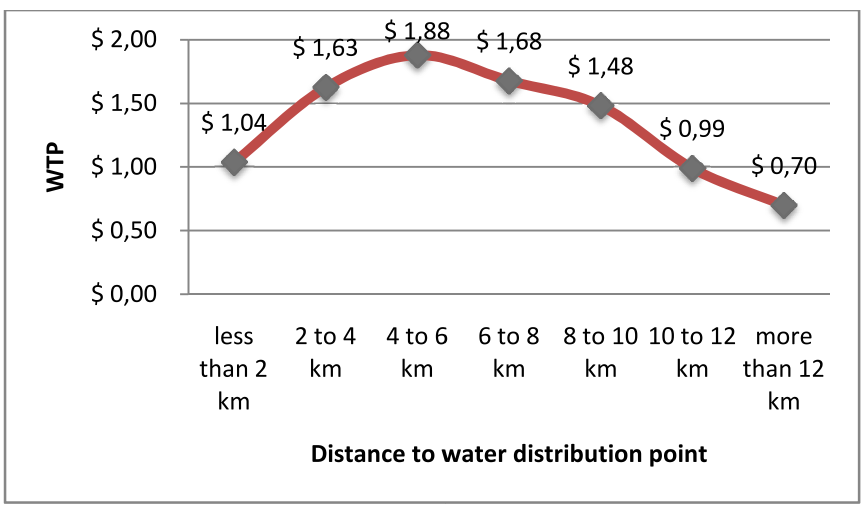

Figure 14 Distance to water distribution point on estimated WTP

5. Could fees be tied to water consumption and income levels?

Our results about willingness to pay for the environmental service of improved water provision showed that both smallholder farmers and recreational households perceived a positive effect from implementing the PES program, and they were willing to pay a significant amount above the current fee: 1.47 USD compared to the current 0.50 USD. Many respondents also agreed to differentiate this fee either by consumption or by income level. In this section, we attempt to scrutinize further the actual scope for fee differentiation in the light of stated WTP.

Discrimination by water consumption would imply that households consuming more water should progressively pay a higher fee. This is assuming that the services enjoyed increase monotonously with water consumption levels – an assumption we will discuss in the closing section. Currently, the flat fee (0.50 USD) makes payment by unit of water service a decreasing function: while households reporting, for instance, a monthly consumption of five cubic meters are paying on average 10 cents for each cubic meter of water delivered "with a service included" (i.e. not for the water itself), those households reporting 50 m^3 of consumption would be paying on average one cent for each cubic meter. In contrast, if the current fee was charged per each cubic-meter consumed, and differentiation by consumption were the most important criterion, the charge would be 6 cents per m^3 if that fee – ignoring for the moment any transaction costs – was to generate the same funds as the currently collected[3].

Performing the same analysis but using the estimated average WTP, the households in the sample would agree to pay on average 19 cents per m^3.

Now, we might want to analyze whether surveyed households were consequential with the proposal of discriminating payments by own consumption. We can postulate that if consumers were willing to pay a fee differentiated by consumption,

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[3] To obtain the 6 cents per m^3 figure, we aggregate the current payment of 50 cents per household and divide this total value by the aggregated current water consumption.

the total estimated WTP should be an increasing function of the observed consumption level. To test this hypothesis, we regress household stated WTP against the reported consumption. In this regression we control for the WMB to which the respondent belongs and for the type of household (smallholder or recreational). The regression also includes as explanatory variable the perception of respondents about whether fee should be differentiated by consumption or by both criteria (consumption and income).

Estimated coefficients are presented in Table 22. What we can infer from the regressions is that, even though respondents agree that fee should be differentiated by consumption, this assertion is not reflected in the stated WTP, as the coefficient associated with water consumption is not significant.

Table 22 Regressions of stated calculated WTP as a dependent variable against current consumption of households for the whole sample, and for recreational households and smallholders separately

Variable	Whole sample		Recreational households		Smallholders	
Water consumption (m3)	0.001 (0.004)	Ns	-0.008 (0.013)	Ns	0.004 (0.003)	Ns
Mosocallo WMB	-0.647 (0.112)	***	-0.690 (0.311)	**	-0.656 (0.111)	***
Rio Chaina WMB	-0.178 (0.127)	Ns	-0.227 (0.212)	Ns	-0.022 (0.092)	Ns
Roble Alto WMB	0.232 (0.138)	*	-0.015 (0.299)	Ns	0.427 (0.158)	***
Sabana Alta WMB	-0.462 (0.116)	***	-0.397 (0.403)	Ns	-0.557 (0.094)	***
Smallholder	-0.833 (0.109)	***	-		-	
Fee should be differentiated by consumption	0.111 (0.092)	Ns	0.088 (0.182)	Ns	0.150 (0.087)	*
Fee should be differentiated by both criteria	0.187 (0.090)	**	0.169 (0.168)	Ns	0.205 (0.108)	*
Constant	2.189 (0.137)	***	2.412 (0.336)	***	1.282 (0.103)	***
Observations	116		42		74	
R-squared	0.715		0.294		0.551	

Asterisks denote statistical significance: * significant at 90%, ** significant at 95%, *** significant at 99%, Ns not significant. Standard deviations in parenthesis..

Differentiation by water consumption levels is thus not *de facto* reflected in stated WTP, but what about household income levels? The hypothesis behind this question is that if consumers were willing to pay a fee differentiated by income, the total estimated WTP should be an increasing function of the declared income level. In Table 23, we regress the calculated stated fee for each household against its declared income level. As in the previous analysis, we control for the WMB to which the respondent belongs, for the type of household (smallholder or recreational), and for the perception of respondents about whether fee should be differentiated by income or by both criteria (consumption and income). Unlike the case of consumption, for income it is evident that households with higher levels of declared income are willing to pay a higher fee.

Table 23 Regressions of stated calculated WTP as a dependent variable against reported income of households for the whole sample, and for recreational households and smallholders separately

Variable	Whole sample		Recreational households		Smallholders	
Declared income (hundreds of dollars)	0.023		0.025		0.014	
	(0.009)	***	(0.011)	**	(0.014)	Ns
Mosocallo WMB	-0.517		-0.624		-0.479	
	(0.100)	***	(0.244)	**	(0.110)	***
Rio Chaina WMB	-0.141		-0.268		0.056	
	(0.138)	Ns	(0.171)	Ns	(0.190)	Ns
Roble Alto WMB	0.377		0.194		0.564	
	(0.106)	***	(0.161)	Ns	(0.151)	***
Sabana Alta WMB	-0.394		-0.438		-0.385	
	(0.106)	***	(0.326)	Ns	(0.115)	***
Smallholder	-0.617					
	(0.091)	***	-		-	
Fee should be differentiated by income	-0.112		-0.118		-0.119	
	(0.099)	Ns	(0.212)	Ns	(0.105)	Ns
Fee should be differentiated by both criteria	0.152		0.251		0.104	
	(0.069)	**	(0.137)	*	(0.079)	Ns
Constant	1.886		1.957		1.276	
	(0.125)	***	(0.150)	***	(0.119)	***
Observations	133		44		89	
R-squared	0.707		0.479		0.483	

Asterisks denote statistical significance: * significant at 90%, ** significant at 95%, *** significant at 99%, Ns not significant. Standard deviations in parenthesis..

When separating the regression between recreational households and smallholders, however, it is observed that the income effect is evident for recreational households but nor for smallholders.

Those findings seem to indicate stronger *de facto* preferences for users to align their WTP with own income levels, especially for recreational households.

6. Conclusions and perspectives

We analyzed a pre-existing user-driven PES initiative in a small watershed in the Colombian Andes, where about 1,000 ES buying households pay a dozen of upstream landholders for carrying out land-use changes that are assumed to generate hydrological services. Despite the small scale of the watershed, environmental service users exhibit high heterogeneity and can be grouped into two types: smallholder peasants and owners of recreational houses. To date, a monthly flat ES fee of US$0.5 is paid by all ES buyers.

Our findings confirm that ES users at Chaina watershed differ significantly not only in socioeconomic and demographic characteristics, and water consumption patterns, but also in their knowledge and understanding about the current condition of Chaina watershed, and in perceptions about the quality and quantity of water they receive from it during the year. In addition, we found that those users are clustered in such way that most of the recreational house owners are concentrated in two out of five water management boards, which in turn are located closer to both the urban center and to the water distribution point.

Surprisingly, almost half of all households declared not to know neither the PES program nor the monthly fee they were currently paying, and yet most of them agreed to paying a higher ES fee, once the current PES program had been explained to them (85%). Owners of recreational houses prefer an ES fee differentiated by consumption levels, in keeping with the fact that they consume significantly less water than peasant households.

Our findings on WTP confirm that peasant have a more elastic demand for hydrological services, and a shock price that is lower than that of owners of recreational houses. This result is not surprising, given the significant differences we found in income levels and other characteristics between these two user types. Spatial variables also exhibit important effects on WTP, especially when people receive different benefits depending on their location. For instance, because users far from the water distribution point are only being "serviced" after a majority of other users have received their share, they are also willing to pay less for the ES provided. PES scheme designers may thus also want to consider spatial variables when ES quantity, quality or both might be decreasing with distance.

Most interviewed ES users stated preferences for a differentiated fee that included water consumption criteria (about 40% preferring differentiation based only on water consumption and 30% on consumption and income combined). However, our findings show that households actually do not increase their stated WTP in accordance with water-consumption levels. More feasible seems to be a fee differentiated by income, since WTP as expected does increase with household income. Also, user types matter: owners of recreational houses are willing to pay on average US$1 more than peasant households. Similar relationships between income and WTP for water services have been reported for Costa Rica (Ortega-Pacheco *et al*, 2009), Ecuador (Rodríguez *et al.*, forthcoming), Bolivia (Shultz & Soliz, 2007) and Mexico (Mendoza *et al.,* 2007).

How could our results be applied to the specific implemented PES scheme? If we can assume that water-user associations in their scheme design generally pursue objectives of efficiency (low-cost provision of high-level services) and fairness (equitable contributions from different users), then we can observe several features.

First, the current small, flat monthly PES fee of US$0.5 falls short of almost all households' stated WTP for improved watershed services. Since upstream conservation actions at least initially are relatively expensive to implement (e.g. high opportunity costs of revegetating riverine areas, costs of establishing nursery, possibly the necessity to buy certain property entirely), one can make a strong argument to say that current payments are too low and that, on efficiency grounds, currently environmental services are being under-supplied – to the detriment of both service users and providers.

Second, if more payments are needed, and users are so heterogeneous as in this case, payment differentiation obviously is a pragmatic way of raising revenues: if water consumers can be brought to contribute more resources according to their private willingness and ability to pay, thus digging into their individually different 'consumer surplus' for the services received, then this may be the easiest and socially most acceptable way to raise revenues. But if so, how should this differentiation be done in practice?

Water-consumption levels would be one possible pricing discriminator: those who consume most water should also receive more services, so it would seem fair that they pay more. This seems to be true at least for water quality. Linking additional payments to water quantities could also at the margin increase efficiency, since a small additional incentive to save water could have a positive impact in dry-season periods of shortage. However, in equity terms one could counter-argue that the water-quantity service -- to diminish the expected number of yearly days with insufficient water availability -- is not necessarily related to current water-consumption levels. Our respondents thought that, in principle, water consumption would be a desirable differentiation criterion, but in practice they did not think much about their own water-consumption levels when they stated their WTPs. In addition, local water metering currently functions deficiently, which would either increase transaction costs (fixing the problem) or decrease credibility (as an equitable indicator).

Household income was also locally seen as a widely acceptable price discriminator. Unlike for water consumption, respondents were also consistent in that those with higher stated income did actually state higher WTP figures. Having the rich contribute more than the poor equals a 'progressive user fee', which from an equity viewpoint could be desirable. One practical problem is that household income information, solicited by us in a confidential interview, is not publicly available – and having it disclosed it for the specific public purpose may lead to significant non-response and biased estimates.

In addition to water consumption and income, other WTP determining variables surfaced from our analysis (see econometric results in Table 17), and could be scrutinized as possible candidates for price discrimination. Spatial variables such as "distance to water point" have a clear service implication, and therefore measured higher distances could potentially be used to lower user fees. In comparison, "distance to urban center" as a proxy does not reflect service variations, and probably picks up some greater degree. The other variables that significantly influenced WTP are predominantly perceptional: knowledge of and agreement with PES scheme, and recognition of water-quality problems. The problem with these is that they do not represent objectively verifiable variables, and thus could not possibly be used for fee differentiation.

The one other non-perceptional variable that came out as highly significant throughout the entire analysis is 'household origin': there is a significant difference between the WTP of native peasant and immigrated recreational households. While origin correlates with incomes and distance to urban center, there are also independent impacts relating to conservation attitudes, tradition, etc. Is 'native origin' an objectively verifiable variable that could justify a binary distinction into low and high user payments? At the very least, there would seem to be non-trivial obstacles in operationalisation, e.g. with households of mixed origin, or with long-term recreational users that have spent more years in the region than a younger, native household. There is also the equity question of justifying why payment levels should be based on 'origin', which neither relates to service consumption nor ability to pay.

Finally, peasant households state a lower WTP *inter alia* because they are less familiar with the environmental problem at hand, less educated about the land-use linkages, and have already been long-term subsidized, in the sense that in various local water-user associations they are paying lower water fees. In other words, they have historically experienced water supply as a much more abundant service than an urban dweller who comes to the region with a different background and appreciation of environmental values. Is strictly WTP-based fee setting, which punishes those who have recognized the problem, and lets those who ignore it easily off the hook, the most educational way of pursuing a long-term environmental agenda? We do not have a single solution for selecting the ideal fee discrimination system, but hope to have contributed in this article to a better understanding of the trade-offs at hand.

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