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Analysis

Heterogeneous users and willingness to pay in an ongoing payment for watershed protection initiative in the Colombian Andes

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ABSTRACT

Flat fees in payment for environmental services (PES) schemes promote administrative ease, and are perceived as egalitarian. However, when environmental-service (ES) buyers are heterogeneous in their income and water-consumption levels, this scheme may not be optimal, as total payments might become too low and services under-supplied. This paper estimates willingness to pay (WTP) higher fees from hydrological-service buyers in an ongoing PES initiative in an Andean watershed in Colombia, where small, flat user payments have been introduced. ES users fall into two highly heterogeneous categories: smallholder peasants and recreational-house owners. We perform a contingent valuation analysis in a representative sample of 218 households. For improved water services, ES buyers on average are willing to pay monthly about US$1 premium over current flat PES rate. Users' heterogeneity, however, affects significantly this outcome: while recreational-house owners are willing to pay monthly on average US$1.61 more than the current fee, smallholders only US$0.41. Spatial variables, such as distance to the water distribution point and to the town center, importantly influence WTP. Results may help designing user-driven PES schemes in line with efficiency and equity objectives.

1. Introduction

Environmental services (ES) are essential for human well-being and all life on Earth; however, they are deteriorating at an alarming rate (MEA, 2005). Protecting ecosystems has thus become a major goal for governments and conservation agencies. Several conservation mechanisms ranging from command-and-control strategies to economic incentives have been implemented to help detaining ecosystems services decline. Among these, payments for environmental services (PES) are proving to be a direct and effective conservation tool that translate uncompensated externalities into financial incentives for landowners to preserve the ecosystems (Ferraro and Kiss, 2002; Pagiola and Platais, 2007; Wunder, 2007).

The underlying idea sustaining PES mechanism consists in 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. However, determining who pays can be challenging when designing PES schemes. In government-financed PES schemes, payments come mostly from taxpayers (e.g. Northern Hemisphere agri-environmental programs), natural resource rents (e.g. Ecuador's Socio Bosque program), obligatory user payments (Mexico's national watershed PES), or a combination of public, private and foreign donor sources (e.g. Costa Rica's national PES scheme is mostly financed from obligatory fees, such as fuel taxes and water tariffs), while few cases are financed by other sources. In user-financed schemes, funds may come directly from reduced costs (e.g. water utilities' savings from reduced water sedimentation), but more commonly a cost surcharge is passed on to benefiting service users (Porras et al., 2008; Wunder and Alban, 2008).

On the other hand, PES scheme designers need to determine how much different users should pay. Ideally, they would rely on biophysical and socioeconomic studies, first linking targeted land-use changes to increased ES quantities, and then comparing service users' willingness to pay (WTP) to landholders' willingness to accept (WTA) compensations. However, many user-financed watershed PES emerge spontaneously from users' perceived needs of conserving ecosystem services, with few ex-ante studies (Asquith and Wunder, 2008). The transaction between buyers and sellers is usually a negotiated solution, i.e. a so-called "Coasian" (Pagiola and Platais, 2007), "self-organized" (Perrot-Maitre and Davis, 2001) or "private" PES (Wunder, 2007). This type of PES may most likely become efficient, as the actors with the strongest interest in and information about the use and provision values of the service directly determine the transaction and monitor functionality (Pagiola and Platais, 2007).

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The price paid for ES should at least equal the opportunity costs of ES providers, and at most the maximum WTP of service users. As long as total payments to providers exceed their provision costs, and total fees paid by users are less than their maximum WTP, both providers and users will have net utility surpluses from PES.

User payments could be either flat or differentiated among users, i.e. either lump-sum payments where all contributors pay the same uniform fee or, alternatively, users could pay customized contributions. The latter could be linked to ES consumption, for instance a volumetric constant ES fee (a fixed per-unit fee) or a volumetric increasing block fee (increasing progressively with consumption). Fees can also be stratified according to users' wealth and income levels, reflecting likely differences in their WTP.

Government-financed schemes with obligatory user payments may use differentiated per-unit fees either constant or increasing, but most do not vary fees with environmental services consumption. For the former type, Costa Rica's fossil fuel users, for instance, pay a tax on each liter of gasoline consumed that helps financing the national PES program and offsetting emissions (Pagiola, 2008). In user-financed schemes, sometimes there is only a single paying user —e.g. a brewery or a hydroelectric power plant. In cases with multiple users, practices vary. In Heredia (Costa Rica), a fixed PES premium per cubic meter of water consumed, i.e. a volumetric constant ES fee, is applied (Barrantes and Gámez, forthcoming). In Pimampiro (Ecuador), residential households pay a higher premium (20%) than industrial users (14%) (Echavarría et al., 2004), implying a stratification of users. In Los Negros (Bolivia), user payments were made as a lump sum through the municipality, on behalf of individual irrigators (Asquith et al., 2008). Hence, user payments are at least sometimes differentiated according to the consumption of the ES, while stratification according to user types or wealth is less frequent.

How do these matters look in our study case? In the Chaina micro-watershed, located in the eastern Colombian Andes, an ongoing PES scheme is financed and driven by households organized in a water-user association (WUA). The WUA is made up by five rural aqueducts, which are in charge of distributing water from the Chaina watershed to 880 households. For improving hydrological services (sedimentation reduction and dry-season flow), water users pay a small, flat monthly fee of US$0.5 per household. Two distinct types of water users, smallholder farmers and recreational-house owners, exhibit different socioeconomic characteristics, but current ES payments depend neither on water consumption nor on income (Borda et al., 2010). The ES fee was initially established by the WUA with the purpose of covering annual costs of a management plan for the protection of the watershed, which included not only payments to upstream landholders to change land-use practices but also constructing and maintaining a nursery, reforestation and assisted forest regeneration, a ranger's salary for monitoring, and buying out some strategic land parcels. However, the currently collected modest fees fall short of financing all planned watershed conservation actions. The WUA is thus exploring the viability of increasing and discriminating ES fees.

The PES literature has called for more research on ES demand (Arocena-Francisco, 2003; Postel and Thompson, 2005; Southgate and Wunder, 2009), but while several recent studies have estimated overall WTP (Whittington and Pagiola, 2011, for an overview), few have analyzed in depth the differentiation of ES users with heterogeneous WTP and the distributional implications of different fee structures (Ortega-Pacheco et al., 2009; Shultz and Soliz, 2007).

In this study, we thus attempt to fill this gap by applying contingent valuation methods to water users in the Chaina watershed, answering two applied questions: i) Are service buyers in Chaina's PES program willing to pay higher fees for improved services? ii) Does heterogeneity within ES buyers affect their WTP? While convincing arguments have been made that differentiated ES-provider payments can greatly boost cost efficiency (Wünscher et al., 2008); is the same not true also for differentiated user payments? When service users are heterogeneous, and thus likely have a differentiated WTP, a flat, collectively agreed-upon consensus fee may become too small to pay for desirable ES levels, and it may also distribute the payment burdens inequitably.

Our findings show that water users in the Chaina watershed are willing to pay on average about 180% more than current payment for improved ES, but with significant socioeconomic and spatial differences. Fee differentiation may thus in this case of high-user heterogeneity be desirable, but implementing it may also trigger incremental operational costs that could eventually reduce efficiency and equity gains.

The paper is organized as follows: in Section 2, we present our study area and survey methods, and in Section 3 our model of analysis. Section 4 presents results, including both descriptive statistics from our water-user survey and the econometric modeling outputs. Finally, we discuss our findings and conclude in Section 5.

2. Study context and methods

2.1. Study area and water uses

The Chaina micro-watershed is located in Colombia's eastern Andes region, in the municipalities of Villa de Leyva and Chiquiza (Boyacá Department), at 2400 to 3600 m.a.s.l. The micro-watershed is strategic not only for supplying drinking water to about 4300 people (880 households), but also for conserving biodiversity. It maintains important ecosystems, which constitute the habitat for at least 135 plants, 155 insects, and 30 bird species. Of its 444 ha, 198 overlap the Iguaque Flora and Fauna Sanctuary, a national park created in 1997 (Borda et al., 2010).

In the upper watershed, on the Villa de Leyva side, five families hold government-approved land titles. On the Chiquiza side, two families have more than 40 years of non-titled occupation, and six families rent in land. These households receive incomes from both off-farm labor and on-farm agricultural production (Borda et al., 2010).

Water users in the Chaina watershed are organized in communal water management boards (WMBs) that operate the water infrastructure and distribute water from the Chaina watershed to 880 households and around 1000 water connections. The five WMBs are: i) Alto & Los Migueles, ii) Mosocallo, iii) Rio Chaina, iv) Roble Alto, and v) Sabana Alta. Table 1 shows household distribution and income across the WMBs. 52% are farmers who are predominantly native smallholders residing permanently in the area, while the remaining 48% correspond to owners of recreational houses who usually reside in urban areas. Average income for the latter is around 2.5 times that of smallholder farmers.

The WMBs collect fees to operate and maintain the water system. Table 2 shows how water fees that households pay for the operation of pipe networks and water distribution varies among the five WMBs.

Table 1
Water users, WMBs, and household incomes (US$/month).

Water Management Board	Smallholder farmers	Recreational-house owners	Total
Alto & Los Migueles	117 (13%) US$288	6 (1%) US$933	123(14%) US$417
Mosocallo	229 (26%) US$301	88 (10%) US$520	317 (36%) US$339
Rio Chaina	9 (1%) US$800	150 (17%) US$1,091	159 (18%) US$1,058
Roble Alto	9 (1%) US$643	114 (13%) US$757	123 (14%) US$719
Sabana Alta	88 (10%) US$305	70 (8%) US$733	158 (18%) US$404
Total	458 (52%) US$333	422 (48%) US$832	880 (100%) US$503

Table 2
Monthly water fees paid across WMBs.

WMB	Fixed fees (2007 US$)		Quantum-dependent fees (2007 US$)	
	Smallholders	Recreational-house owners	Smallholders	Recreational-house owners
Alto & Los Migueles	$1.44—includes 40 m^3		No charge	
Mosocallo	$3.62 includes 58 m^3	$7.24 includes 58 m^3	59–89 $m^3 = \$0.14/m^3$ 90–140 $m^3 = \$0.24/m^3$ 140–250 $m^3 = \$0.48/m^3$	
Rio Chaina	$3.34 to $4.73, depending on stratum	$5.57	$<20\ m^3 = \$0.19–0.27/m^3$ $>20\ m^3 = \$0.32/m^3$	$0.32/$m^3$
Roble Alto	$1.94	$12.77	$<20\ m^3 = \$0.22/m^3$ $>20\ m^3 = 0.72/m^3$	$0.72/$m^3$
Sabana Alta	$1.44—includes 40 m^3		Above 40 m3 = $0.72/$m^3$	

In particular, peasant households from three WMBs receive implicit subsidies on their water consumption, either through reduced fixed or total fees.

Significant ecosystems transformation has taken place during the last century in the Chaina micro-watershed through land fragmentation, expansion of the agricultural frontier, and intensive harvesting of timber species such as oak (*Quercus humboldtii*), cedar (*Cedrela montana*) and encenillo (*Weinmannia tomentosa*). These changes seem to have affected ecological functions, including water quality and quantity. Water users have faced scarcity during dry season, also triggering some conflicts among aqueducts. Additionally, high water turbidity caused by erosion and sedimentation has affected the pipe network. During periods of intense precipitation, landslides accelerate sedimentation. Borda et al. (2010) used the patchy available data to simulate seasonal flows and sedimentation with the SWAT (Soil & Water Assessment Tool) software and found severe water deficit during the dry season (June–August).

The water infrastructure is artisanal and consists basically of a common uptake tank, individual tanks (for each WMB) and pipelines for collection, storing and distribution of water. Only two WMBs carry out water treatment: Rio Chaina since 2006 and Roble Alto since 2007. The treatment plants consist of sedimentation boxes between the common uptake tank and individual WMB tanks. The two WMBs disinfect water using standard techniques and their operating costs in 2008 were US$6350 for chemical inputs, treatment plant maintenance and labor.

Capital costs for constructing the water system were assumed by the municipality more than 30 years ago. It is difficult to estimate subsequent investment costs, e.g. for sedimentation boxes, borne mainly by WMBs with some funds coming from Villa de Leyva municipality. The Municipality and WMBs have funded improvements carried out on water system infrastructure jointly. However, operational costs are financed exclusively with user-paid water fees (Table 2).

In this context, together with a research institution the WUA took the initiative to develop a PES scheme to conserve threatened watershed services and bridge upstream-downstream conflicts through landowner compensations (Borda et al., 2010). In addition to the fees collected for operation and maintenance of water system, the WMBs introduced a flat environmental-service fee of US$0.50/household/month. This fee has started to finance watershed management costs, including payments to upstream landholders. Occasionally, the municipality contributes in kind to watershed management costs. The flat ES fee of US$0.5/household/ month was voted for by simple majority in each WMB general assembly and, after that, became mandatory for water users. This flat fee corresponds, on average, to 18% and 8% of the water bill of smallholders and recreational owners, respectively.

The WMBs are annually paying US$1850 in cash to nine upland farmers for changing their land-use practices, i.e. to set aside riparian zones for regenerating natural vegetation, reduce cattle ranching on steep slopes, and stop deforestation. This is supposed to reduce soil compaction and erosion, thus also diminishing water sedimentation and facilitating stream-flow regulation. Average payments to landholders are about US$136/ha, with individually negotiated variations, based on a previous opportunity cost study. The scheme has been implemented since 2006, and has preserved 162 ha of natural forest, and regenerated 14 ha of riparian vegetation.

The shortage of funds from flat user payments is a main bottleneck for extending the scheme to larger areas, and thus arguably for achieving a higher ES efficiency.

2.2. CVM scenario

The contingent valuation method (CVM) has been widely used in different settings, including the estimation of unknown economic value of ecosystems services, by asking people to directly state their WTP for (avoided) changes in ecosystems and service provision, which are described explicitly through a hypothetical scenario (Carson, 2000; Carson and Groves, 2007; Haab and McConnell, 2002).

CVM has proved to be a valuable tool in the economic assessments of water projects, including in developing countries (Russell et al., 2001; Whittington, 1998). It has been increasingly employed to estimate the WTP for improved water supply (Briscoe et al., 1990; Whittington et al., 1990, 1991) and quality (Hoehn and Krieger, 2000; Johnson and Baltodano, 2004; Reddy, 1999).

Applying stated preference methods to the PES framework is more recent. Whittington and Pagiola (2011) review several recent studies, especially in Mexico and Costa Rica. Rodríguez et al. (2009) use CVM to examine a proposed fee for upstream watershed management to increase dry-season flow in Cotacachi, Ecuador. Ortega-Pacheco et al. (2009) use dichotomous choice contingent valuation to examine households WTP for a proposed PES in Cairo-Francia and Milano (Costa Rica); Alpízar and Otárola (2007) and Alpízar and Madrigal (2007) elicit WTP of water users for watershed management in Cartago and Canton Esparza respectively (Costa Rica), as do Cisneros et al. (2007) for Copan Ruinas (Honduras).

In this study, we applied a referendum-type format to elicit the WTP of service buyers to raise their pre-existing ES fee in return for consolidated and improved upstream conservation actions. Additionally, we asked water users whether they would prefer an ES fee differentiated by income, water consumption, or both criteria. As a novel aspect, we value increments in an environmental service for which a collective fee already exists. Users thus understand the underlying PES concept and have a benchmark from which to reevaluate their individual WTP and declare their preferences for differentiated fees. Through a household survey, we collected socioeconomic information on ES buyers, registered their perceptions about current PES payments, and identified differences in ES buyers' water access and consumption.

We applied face-to-face interviews with 218 households, all members of the WUA. The sample took into account the two main user categories—smallholder farmers vs. recreational owners—and the distribution of water users across the five WMBs. The sample was randomly assigned using municipal cadastral information. To assess the structure and understanding of the survey (Carson, 2000; Mitchell and Carson, 1989) and elicit a WTP bid range for a referendum-type CVM question, we pre-tested the questionnaire with 12 households. In the full survey (December 2007 to April 2008), four bids were randomly distributed on the sample as follows: 30% of households were asked for a US$0.75 increment in the fee; 30% for US$1.25; 25% for US$1.75 and 15% of households for US$2.25. The final questionnaire contained seven sections: i) Household identification and location, ii) Introduction, iii) Knowledge and perceptions about the Chaina watershed (current condition, threats, etc.), iv) Water consumption (sources, uses, monthly consumption and expenditures), v) ex-ante watershed scenario, vi) ex-post watershed scenario, and vii) demographic and socioeconomic context .

When presenting the *ex-ante* scenario, we reminded respondents about both the functioning of the ongoing PES program, the use of the money collected through current contributions and additional needs in the current PES program. In particular, we presented to respondents the following situation: "To guarantee watershed protection and sustainability of the PES program, it is necessary to complement current actions with other conservation measures: i) enrolling more upstream landholders in PES, ii) building and maintaining a nursery to support reforestation and, iii) buying out some strategic upstream plots." We also asked respondents for their knowledge and perceptions about the current PES scheme.

In keeping with the CVM literature (Carson, 2000; Haab and McConnell, 2002; Mitchell and Carson, 1989), we then presented a hypothetical *ex-post* scenario, where individual incremental voluntary contributions would be differentiated according to increasing income and/or water-consumption levels.[1] The additional funds would be used for the aforementioned purposes, resulting in a likely improvement in water quality and dry-season flow. This was illustrated with photos showing current and future expected watershed conditions. Incremental ES fees could potentially be differentiated among water users. We screened respondent preferences with respect to water-consumption and/or income levels as discriminators: households who consumed more water would pay more for the ES, as would households with higher income. The fees would be paid along with the water bill, and funds would continue to be administered by the WBMs.

From the 218 applied surveys, 170 answered the referendum WTP question. Approximately 15% of households did not agree with paying a higher, differentiated ES fee. Among those, 40% thought the current ES fee was already adequate, and 27% argued that a flat fee is fair. Referendum questions were only asked to households who agreed a differentiated fee.

3. Modeling willingness to pay

In addition to the descriptive statistics, we performed a referendum analysis using a probit model to explain variations in WTP. In the parametric analysis, we used the acceptance of proposed bid (US$0.75, 1.25, 1.75 and 2.25) as the dependent variable, which takes the value of 1 if respondents accept the proposed bid, and zero otherwise. The explanatory variables fell into four categories:

a. *PES perceptions*. We included a categorical variable that takes the value of one if the respondent agrees with the current PES scheme, and zero otherwise.
b. *Spatial variables*. We incorporated two spatial variables: a) *distance to the water distribution point and* b) *distance to the center of Villa de Leyva*. The hypothesis about a) is that due to the rudimentary character of the water infrastructure, service levels (water quantity and/or quality), and thus WTP, might depend on the spatial location of households relative to water distribution point. For instance, households from Mosocallo are the farthest away from water distribution point (about 10.7 km), and being "last in the queue" their probability of suffering water shortages in dry seasons is also the highest. As for b), distance to the urban center is, according to local observers, closely and negatively correlated with wealth, as the center combines easy access, attractive colonial buildings, and tourist infrastructure. Since we could not directly measure wealth, distance might give us a good proxy. Fig. 1 shows a map of the study region with the location of the watershed, the urban center, the water distribution point and the WMBs.
c. *Socioeconomic and demographic variables*. Many differences in these attributes—such as education, household size and income levels (Table 3)—are captured by the distinction between smallholders and recreational owners, which we hence use as the key socioeconomic variable ("origin").
d. *Access to alternative sources of water*. Spending on bottled water because of quantity and quality concerns is also included as an explanatory variable.

4. Results

4.1. Descriptive statistics

As for environmental perceptions, 41% of respondents found that both water quality and quantity were affected mainly during dry seasons. Households interviewed made use of several water sources, not only the Chaina watershed. Alternatives included bottled water (48%), other natural sources (32%), and rain water stored in tanks (67%). However, peasants use more rain water (72%) and less bottled water (38%), compared to recreational houses (60% and 64%, respectively). Households use water from the Chaina watershed primarily for satisfying basic needs, such as personal hygiene (96%), house cleaning (86%), and drinking water (90%), though the latter share is much higher for smallholders' households (95%) than recreational owners (81%). We also asked for the use of water for agricultural purposes (e.g. irrigation) in the survey, but peasants indicated not to use water from the Chaina watershed for that purpose.

The reported monthly volume of water consumed from the Chaina watershed averages 17.1 m^3 per household, being higher for smallholder farmers (18.5 m^3) than for recreational households (14.7 m^3), likely because all peasants are permanent residents (Table 3). Among recreational households, some are residing permanently there, or hire local persons or families to maintain the house (and consume, on average, 17.6 m^3/household/month); and some visit their house sporadically (and consume, on average, 11.3 m^3/household/month). Recreational-house owners reported higher monthly water bills (US$10.4/month vs. US$ 4.2/month) due to different payment schemes for each group (see Table 2).

Less than half of respondents knew, or remembered, that they are currently paying into the PES initiative (44%). Decisions at the WUA 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. Once informed, we asked if they think the fee is adequate. Most households (77% of smallholder farmers and 58% of recreational-house owners) agreed, yet most respondents were also willing to pay a higher ES fee for improved services. Some smallholders in particular thought the fee was too high, while most of recreational owners thought it was too low.

The reported average household income is US$503 per month, and, as expected, differences between smallholders and recreational households are highly significant (Table 3). Households declared to spend on average US$417 per month, being statistically lower for smallholders (US$277) than for recreational households (US$649). Most smallholders have resided longer in the region than recreational households, but they own less land, tend to have larger families, and less education.

[1] Authors can provide details on these scenarios upon request.

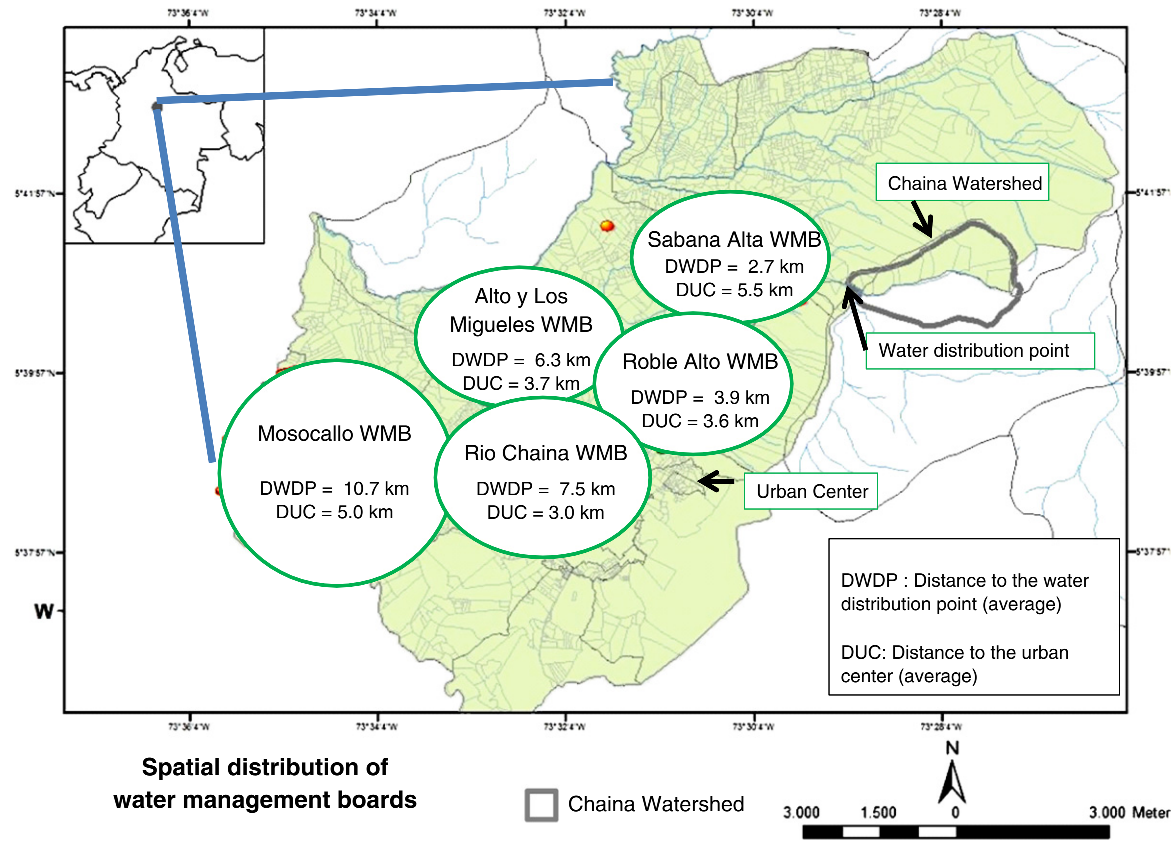

Fig. 1. Location of Chaina watershed, and WMB distances to the urban center and water distribution point (in kilometers).

Do distances differ systematically for categories of water users? On average, peasants' parcels are located farther from the urban center (about 4.7 km) and the water distribution point (7.6 km) than recreational houses are (3.8 and 6.3 km, respectively), both differences being statistically significant (Table 3).

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, and 6% by other criteria. As to criteria for differentiation, more recreational households regarded it fair to pay according to water-consumption levels, while a greater proportion of smallholders preferred combining consumption and income.

Behavior of responses to proposed bid was as expected. 83% of smallholders answered "yes" to the randomly assigned referendum bid, while 89% of recreational households did so (insignificant difference). The percentage of households willing to accept the proposed bid decreased as the proposed bid increased. Bid acceptance is significantly higher for recreational owners: smallholders accepted maximum 60% of the proposed bids (when the offered bid was the lowest) while recreational households accept minimum 59% of the proposed bids (Table 4).

Table 3
Socioeconomic, demographic and spatial characteristics of respondents (standard deviations in parentheses).

Variable	Smallholders	Recreational	Total
Monthly expenses (US$)	277 (23.7)	649 (52.0)	417*** (27.9)
Monthly income (US$)	333 (30.5)	832 (59.9)	503*** (34.4)
Born in Villa de Leyva	82% (3.5)	0% (0)	50%*** (3.5)
Lives permanently in Villa de Leyva	89% (2.9)	44% (5.7)	71%*** (3.2)
Owns property in Villa de Leyva	77% (3.8)	90% (3.3)	82%*** (2.7)
Gender: male interviewed	58% (4.4)	59% (5.5)	59% (3.4)
Age: years	54 (1.5)	55 (1.5)	54 (1.1)
Education: years of schooling	4.5 (.37)	11.2 (.43)	7.1*** (.37)
Married	74% (4.0)	75% (4.8)	74% (3.1)
Household size	4.2 (.22)	3.0 (.25)	3.7*** (.17)
Distance to urban center (km)	4.74 (.13)	3.81 (.13)	4.38*** (.10)
Distance to water distribution point (km)	7.62 (.31)	6.28 (.29)	7.09*** (.23)
Water consumption (m^3/month)	18.49 (1.6)	14.69 (1.5)	17.13* (1.2)
Monthly water bill (US$)	4.20 (.32)	10.42 (1.27)	6.59*** (.57)

*Significant at 90%, *** significant at 99%.

4.2. Multivariate analysis

Some explanatory variables exhibited high correlation; specifically, the variable *origin* (type of user) is correlated as expected with other socioeconomic characteristics, including income. We propose two different models. The first excludes the variable income, which admittedly is unusual in explaining WTP, but defendable if we can assume that marginal utility of income is constant (so we will have a linear utility model), which is plausible as long as income changes remain insignificant (Haab and McConnell, 2002). In the current scenario, PES represented on average only 0.26% of household income,

Table 4
Acceptance of proposed bids by user type.

Proposed bid (US$)	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%	***

** significant at 95%, *** significant at 99%

Table 5
Probit regression for acceptance of proposed fee.

Variables	Model 1				Model 2			
	Coefficient		Marginal effect		Coefficient		Marginal effect	
Proposed bid	−1.087 (0.233)	***	−0.433 (0.093)	***	−1.002 (0.251)	***	−0.400 (0.100)	***
Distance to urban center	−0.486 (0.131)	***	−0.194 (0.052)	***	−0.401 (0.130)	***	−0.160 (0.052)	***
Distance to water distribution point	−0.592 (0.269)	**	−0.236 (0.107)	**	−0.402 (0.276)	Ns	−0.160 (0.110)	Ns
Square distance to water dist. point	0.041 (0.019)	**	0.016 (0.008)	**	0.027 (0.020)	Ns	−0.011 (0.008)	Ns
Agrees with PES	1.271 (0.489)	***	0.422 (0.107)	***	1.243 (0.478)	***	0.414 (0.108)	***
Origin (Smallholder)	−1.056 (0.242)	***	−0.398 (0.082)	***	−0.905 (0.258)	***	−0.346 (0.091)	***
Buys water because of quality issues	0.129 (0.234)	Ns	0.051 (0.093)	Ns	−0.036 (0.252)	Ns	−0.014 (0.100)	Ns
Buys water because of quantity issues	1.662 (0.556)	***	0.447 (0.068)	***	1.617 (0.590)	***	0.449 (0.079)	***
Household expenditures (US$)					0.345 (0.396)	Ns	0.138 (0.158)	Ns
Constant	4.742 (1.33)	***			3.600 (1.35)	***		
Observations	178				157			
Wald chi2(k)	61.54***				44.58***			
Pseudo R^2	0.276				0.246			

** significant at 95%, *** significant at 99%, Ns not significant. Standard deviations in parenthesis.

and this proportion would in the hypothetical scenario increase to maximum 0.60%. Given the differences between smallholders and recreational households, we observed that the “origin” variable captures a significant share of the difference in income and education of these two groups. The second model attempts to include the income variable. Given the high correlation between income and expenses, we use the latter variable, since non-responses to income questions in the survey would significantly reduce sample size.

Results from these two models are presented in Table 5. The first finding is that the amounts proposed in the hypothetical scenario reconfirmed the expected downward sloping demand curve in both models: as the proposed bid increases, the probability of acceptance is reduced, even when a series of other variables are controlled for. An increase of one dollar in the proposed bid reduces the probability of acceptance 43%.

The proxy for income, monthly household expenses, seems 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. Given the similarity between models 1 and 2, for the remaining analysis we use the results from model 1, which has more observations, exhibits better goodness of fit and more prediction ability.

Spatial variables are important explicative variables for explaining acceptance of the bid. In particular, distance to the urban center, our wealth proxy, affected negatively and significantly the probability of accepting the payment. A household living 1 km farther from town had, ceteris paribus, a 19% lower probability of accepting the bid. As mentioned before, several factors associated to distance act together for creating this behavior. After testing different approaches, we found that distance to the water distribution point has a parabolic effect on acceptance of the bid, and therefore a quadratic specification is used. Both coefficients are significant and generate a U-shape in the probability of accepting the bid. Ceteris paribus, an average household will have a decreasing probability of accepting the bid for the first 7 km from the distribution point, showing the effect of receiving fewer benefits from the ES—in terms of less quantity or worse quality of water—as better water is being serviced to household close to the point. However, after 7 km, the probability starts to grow maybe because—as suggested by one reviewer—such users would have the most to gain if a better PSA scheme resulted in more water availability.

Table 6
Estimated willingness to pay across type water of users.

Statistic	Smallholders	Recreational-house owners	Total
Mean	0.91	2.11	1.39
Standard deviation	0.51	0.45	0.76
95% confidence interval	0.82–1.01	2.01–2.21	1.28–1.49
Median	0.92	2.23	1.32
Min	0	0.70	0
Max	2.68	2.91	2.91

Agreement with the ongoing PES program strongly increases the probability of paying a differentiated fee (42%), showing that users who know about and are satisfied with the program perceived a potential for further improvement, thus stimulating their WTP. Demographic variables, such as the respondent's sex, age and family size, seemed to have no impact on WTP, and were therefore dropped from the regression. A significant difference between smallholder peasants and recreational households was, unsurprisingly, confirmed. Smallholders are around 40% less likely to accept a given proposed bid, compared to recreational households, when other factors of difference are controlled for. Under the assumption that households have the possibility of substituting or complementing the lack of water from the aqueduct with water from other sources, we tested for the effect of buying bottled water because of quantity or quality reasons. Those that buy bottled water because of scarcity issues are more willing to pay than those that do not, and this variable increases the probability of accepting a given bid in 45%. The effect of having to buy bottled water because of quality issues is not significant, though. From this model, and following the standard procedure to estimate WTP (Haab and McConnell, 2002), we obtain an estimated average WTP of around US$1.39, which is $0.90 more than the current flat fee (US$0.5). As shown in Table 6, estimated WTP for recreational households (US$2.11) is more than double that for smallholders (US $0.91). This WTP was estimated for all of the households from the sample, not only for those that accepted the referendum question, in order to avoid over estimation of this value.

Based on a set of socioeconomic, demographic, and spatial variables, our findings confirm that socioeconomic heterogeneity significantly affects the willingness to increase the current ES fee. Moreover, our findings open the door for a discussion about whether differentiation of ES fees, particularly of hydrological services fees, is a viable and suitable way for increasing efficiency and providing equity in PES programs, when ES users exhibit high heterogeneity. In the next section we briefly explore this issue as part of the discussion.

5. Conclusion and discussion

We analyzed a pre-existing user-driven PES initiative in a small watershed in the Colombian Andes, where about 900 ES-buying households pay to upstream landholders for pursuing land uses that are assumed to generate hydrological services. To date, a monthly flat ES fee of US$0.5 is paid by all ES buyers. Despite the small scale of the watershed, environmental service-users exhibit high heterogeneity between two types: smallholder peasants and owners of recreational houses. Our findings confirm that ES users in the Chaina watershed differ significantly not only in socioeconomic and demographic characteristics, but also in their water-consumption patterns and spatial distribution. Surprisingly, almost half of all households declared not to know the PES program or the monthly fee they were currently paying, and yet most of them agreed to hypothetically paying a higher ES fee for improved services, once the PES program was explained to them.

Our results about willingness to pay for the environmental service of improved water provision show that both smallholder farmers and recreational households perceive a positive effect from implementing the PES program, and they were willing to pay a significant amount above the current fee: US$1.39 compared to the current US$0.50. This suggests that water users value hydrological services more than is expressed by the fee they are currently paying. Also, user type matters: owners of recreational houses are willing to pay on average more than one dollar 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., 2009), Bolivia (Shultz and Soliz, 2007) and Mexico (Mendoza et al., 2007). Spatial variables exhibit important effects on WTP, which might be reflecting that people receive differential benefits depending on their location. For instance, perceptions about the effect of the water distribution point exhibited a U-shape. Likewise, distance to the urban center proved significant, as an observable proxy for wealth that may better capture socioeconomic differences than self-reported household income and consumption. Designers may thus also want to consider spatial variations when ES quantity and/or quality vary in space.

Many respondents agreed to differentiate current ES fee either by consumption or by income levels (85%), most of them declaring preferences for consumption. Currently, the flat fee (US$0.50) does not vary with consumption or income level, making high-consumption households pay a smaller per-volume equivalent fee. If ES benefits increase monotonically with water-consumption levels, a simple differentiation by water consumption would imply that households consuming more water should progressively pay more. But were surveyed households in their behavior consistent with the proposal of discriminating payments by own consumption? That is, did those who declared preferences for fees differentiated by water consumption and exhibit high levels of water consumption, also willing to pay more? Similarly, have households who declared preferences for fees differentiated by income, and exhibit high income, also a higher WTP?

To have some insights on this issue, we explore these two questions by testing whether for water consumers preferring a fee differentiated by consumption, the estimated WTP would be an increasing function of the declared consumption level; and for consumers preferring a fee differentiated by income, the estimated WTP would be an increasing function of their declared income. To test these hypotheses, we run a regression where the dependent variable is the estimated WTP for each household. Explanatory variables are declared water consumption and reported household expenditures (as a proxy for income); these variables were also included in interaction with their declared preferences about differentiating by consumption or by income, (respectively). Interacting terms allow us to test the hypothesis that WTP would be positively related with consumption (or income) levels.[2] In addition we controlled by WMB, origin and their interaction.

[2] The hypothesis that WTP would be positively related with consumption (or income) levels should be tested evaluating the joint significance of two coefficients: i) the coefficient corresponding to consumption (income) variable alone and ii) the coefficient corresponding to consumption (income) interacting with preferences about differentiation by consumption (by income). For example, for a household that *does not agree* on consumption differentiation the test would be on the coefficient for consumption alone. The same logic applies for testing differentiation by income. Now, if the household *agrees* that fee should be differentiated by income, the test must be performed for the joint significance of coefficients, from both expenditure and the interacting term between expenditure and preferences.

Results are shown in Table 7. For the case of consumption, neither declared consumption alone nor in interaction with preferences for differentiation for consumption exhibit significant effects on estimated WTP. As a reviewer noted, WTP in fees differentiated by consumption might require, in addition of knowing own consumption levels, awareness of others' consumption levels. So, even if respondents agree with differentiation by consumption, they do not know others' consumption in order to relate more precisely their WTP to relative consumption.

Using the same regression, we also test for the effects of income. We observe that there is a positive relation between declared income level (expenditures used as a proxy) and estimated WTP. However, the marginal effect for the joint coefficients is not significant, showing that again, there is no evidence that estimated WTP is correlated with income level, even for respondents who agreed on fees differentiated by income.

The differentiation scenario we presented to respondents may explain these results. A specific differentiation scenario might have produced different outcomes; for example, a CV design in which several bid options, for particular ranges of consumption an income, were randomly and explicitly offered among respondents. Another way to analyze ES fees differentiation scenarios would be through choice experiments where specific changes in the ES are accompanied by several ranges of water consumption and income levels.

How could the results in this article be applied to the specific implemented PES scheme? If we assume that water-user associations in their PES design generally pursue objectives of efficiency (low-cost provision of high-level services) and fairness (equitable contributions from different users), then we can conjecture 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 restoring riparian areas, costs of establishing a tree nursery, necessity to buy selected land areas), one can make a strong argument that current payments are too low and that, on efficiency grounds, currently environmental services are being undersupplied—to the detriment of both service users and providers. Second, if more payments are needed from a heterogeneous set of users, payment differentiation is a pragmatic way of raising revenues: if water users 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 is done in practice?

Water-consumption levels would be one possible pricing discriminator: those who consume most water should also receive more benefit

Table 7
Explaining WTP through current water consumption and expenditures levels.

Variables	Coefficient	
Declared water consumption (m^3)	0.0038	Ns
Declared water consumption * differentiation by water consumption	0.0025	Ns
Household expenditures (USD)	0.0004	**
Household expenditures * differentiation by income	−0.0002	Ns
Smallholder (1 = yes; 0 = no)	−0.9372	***
WMB 1 (1 = yes; 0 = no)	−0.4613	**
WMB 1 * Smallholder (1 = yes; 0 = no)	−0.0422	Ns
WMB 2 (1 = yes; 0 = no)	−0.2843	Ns
WMB 2 * Smallholder (1 = yes; 0 = no)	−0.0374	Ns
WMB 3 (1 = yes; 0 = no)	0.3513	***
WMB 3 * Smallholder (1 = yes; 0 = no)	−0.5344	**
WMB 4 (1 = yes; 0 = no)	−0.0241	Ns
WMB 4 * Smallholder (1 = yes; 0 = no)	0.2504	Ns
Constant	2.0573	***
Observations	112	
R^2	0.675	

** significant at 95%, *** significant at 99%, Ns not significant.

from ES, 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 stated that, in principle, water consumption would be a desirable differentiation criterion, but in practice self-reported consumption might be misleading and direct measuring might increase administrative and transaction costs.

Household income was also perceived as a widely acceptable price discriminator. Unlike for water consumption, respondents were in some way consistent in that those with higher stated income did actually state higher WTP figures. Having the rich contribute more than the poor would imply a progressive user fee, which from an equity viewpoint could be desirable. One practical problem is that household income information is not easily available—and having it disclosed for the specific public purpose may lead to significant non-response and biased estimates. Proxies, such as distance to urban center, or socioeconomic strata defined by municipality, may help solve the issue. In addition to water consumption and income, other variables surfaced from our analysis (Table 5), 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 adjust user fees. Perhaps, the variable that came out as the most 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 other factors related to conservation attitudes, tradition, etc. Is 'native origin' an objectively verifiable variable that could justify a binary distinction into low and high-user payments? It seems so; however, at the very least, there would seem to be non-trivial obstacles in operationalization, 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'.

Finally, peasant households state a lower WTP *inter alia* maybe because they have already been long-term subsidized, at least in terms of water bills and 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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