

“EVALUATING THE ECONOMIC BASIS FOR PAYMENTS-FOR-WATERSHED-SERVICES AROUND AMBORÓ NATIONAL PARK, BOLIVIA”

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Abstract

Using economy theory and the contingent valuation method, I applied a survey in the summer of 2003 to measure the willingness to pay for water stabilization and water quality in two communities that share the Los Negros watershed, south of Amboró National Park, Santa Cruz Department, Bolivia. Interviews were undertaken in upstream Santa Rosa and downstream Los Negros. Initial results suggest that the agricultural downstream community (LN) is willing to pay for water conservation, although the amount revealed on the survey is not high when compared with local incomes or land values with or without water. However, any willingness to pay for a public good in this part of Bolivia is a surprise, as many locals believe that water is “a gift from god” that can be neither bought nor sold.

Traditional and important socioeconomic variables seem to play an important role driving farmers' willingness to pay (WTP). Age, education, and income are powerful explanatory variables of differences in the WTP between farmers. However, policymakers should be careful when setting up payment systems based on income. Measuring income can be a tricky business, because community members are often not open to talking about their financial situation. Indirect methods of calculating income may be more appropriate. It is interesting that the farmers who produce high water demanding crops, in combination with high market value, tend to be willing to pay more for watershed conservation. In order to implement a water fee, managers should focus first on young, well-educated farmers with high incomes who grow high value crops.

I. Introduction

Problem definition

Most of Bolivian agriculture depends on a capacity to access and use water for irrigation. This is especially true for the small farmers who normally cultivate the most marginal lands. Water is getting scarcer, as the population grows, migration to the lowlands increases, deforestation expands and water tables lower. Deforestation and land use changes seriously threaten the watershed services provided by forest, which impact directly ecological and human ecosystems. Empirical studies have shown that deforestation, especially of cloud forest, may diminish stream flow (Calder 1998). Tree removal can take away moisture leading to potential losses of groundwater and reduced or at least changed water table. However, these studies are based on a few examples and most of them are watershed specific.

As an example of the apparent deforestation of cloud forest and its impacts on the watershed can be seen in the buffer zone of Amboró National Park, where the welfare of the communities of downstream Los Negros (LN ~1200 families) and upstream Santa Rosa (SR~ 94 families) is threatened. These two agricultural communities depend on their ability to access water for irrigation to cultivate a range of vegetable crops. Dependence of irrigation water is particularly severe for LN community, which has been recently suffering serious difficulties in water access during the annual June to November dry season. At the peak of the annual drought, downstream farmers receive water for only ~3 hours/week for irrigation purposes. Losses of agricultural production have and continue to increase. Competition for irrigation water has escalated to the point where communities have suffered intense confrontations, and some farmers' lives have even been threatened.

In spite of these increasing tensions, the communities of SR and LN recently began talking to find a way to solve the problem. One way could be to apply the polluter pays principle and ask SR, the community up stream to pay for the agricultural losses down stream in LN. However, this option is unlikely because farmers up stream own the land and the property rights. Each individual upstream farmer faces an opportunity cost of leaving his forest resources in place and not cutting trees today. Given that the opportunity cost of conservation may be high, voluntary conservation may not be an option.

Given that upstream farmers have land use rights, an alternative potential solution may be to compensate these farmer for the forest based waters services that their land provides. Such compensation would create an added value to *in situ* upstream forests, and perhaps prevent future

losses for the LN community, which appears to have an efficient (albeit water limited) agricultural production system¹.

The goal of this study was to calculate the economic value of high quality irrigation water the farmers of LN, in order to assess how much these farmers would be willing and able to pay to secure their water supplies. In addition, this study aimed to provide local authorities, policy makers and researchers with information about the variables that influence or constrain the willingness to pay for water conservation in the LN and SR communities.

Area of the study

The study was carry on in two communities of Los Negros and Santa Rosa, located in the geographical region of the valleys of Santa Cruz -Bolivia, a mid-elevation transitional zone, part of which borders the Amboró National Park. Los Negros (LN, downstream) and Santa Rosa (SR, 35 km upstream) share the Rio Los Negros watershed (roughly 150 km²), the headwaters of which lie both inside Amboró and inside the cloud forests and transitional dry forests of Santa Rosa (see map). The main income of both these towns comes from agricultural production, which depends heavily on irrigation. However, the level of production and intensity is not equal across the communities; downstream Los Negros (population ~3000) has better irrigation infrastructure than Santa Rosa (population ~500), and depends more on water flow than any other community in the watershed.

Local perception in that water supplies in LN have diminished over time, due to deforestation in the upper watershed caused by new settlements and the expansion of the local community. According to local residents, the main water problems are erosion, diminished water flow in the dry season, sedimentation and salinization.

Ecology of the region

Santa Rosa and Los Negros communities are located in the buffer zone of one of Bolivia's most important conservation areas. Amboró National Park, covering over 637,000 hectares between 275 and 2700 meters altitude, is one of the most biologically diverse areas in the world. The park is situated at an important biogeographic transition zone and contains elements from three priority ecoregions: the Central Andean Yungas Forests (Global 200 Priority # 46) Southwestern

¹ LN is located in a productive valley with good transport connections. From LN to the markets of Santa Cruz and Cochabamba takes about 5 hours, while from SR the journey takes an additional 3.5 hours in ideal weather.

Amazonian Moist Forests (Priority #47) and the Chiquitano Dry Forests (Priority #58). Amboró protects the upper watersheds of many rivers, including the Piray, Ichilo and Yapacani that provide critically important water supplies to the cities and agricultural centers of the department of Santa Cruz. The park hosts an incredible variety of flora and fauna: at least 145 species of mammals, 105 species of reptiles, 73 amphibian species and more than 800 bird species.

The National Park and its buffer zone are increasingly threatened by illegal land incursions and expansion agriculture and cattle range in the cloud forest. Encouraged by farmers' unions and local leaders, landless migrants from the Bolivian high land "*altiplano*" are frequently entering the buffer zone and the park to clear cloud forest and bird habitat for farming. The ecological and economics impact of the deforestation can be substantial, considering that cloud forest may is the only one, which has relation between forests cover and water production.

Objective of the Study

The study aimed to calculate the economic value of irrigation water for the Los Negros community. Specifically, I tried to respond to the following question:

- 1) What is the value of reliable irrigation water for downstream farmers?
- 2) How much are these farmers willing to pay (WTP) for improved water quantity and quality?
- 3) Does the willingness to pay vary between farmers?
- 4) How do income, education, age, land tenure, size of property and other variables affect a farmer's willingness to pay?

I used the widely used contingent valuation method to assess the WTP for water conservation in LN, in order to ensure that the results of the analysis are relevant to other communities facing the same policy issues.

II. Literature review and conceptual framework

Failures in natural resource management are widespread all over the world, from local to global levels. Deforestation, biodiversity loss, soil degradation, pollution, and over use and contamination of water resources, are common examples of the mismanagement of natural resources. Water is a classic example of resource degradation even though humans and ecosystems depend on water resource for their very survival.

Public goods such as water tend to be under supplied by the private sector because free markets for such goods would not be efficient and would be plagued by externalities, as public goods are both non-rival and non-exclusive. Thus arose the idea that public goods are better managed by central government which should act like social planner to provide environmental goods and services across the society. However, it must be recognized that “the public sector has generally performed miserably in all forms of water management (Perry et al. 1997)” —a result of rent seeking, inappropriate regulations and poor implementation, subsidies, imperfect knowledge, lack of financial resource, centralization, high administration cost and excessive bureaucracies tend to reduce the government efficiency and sustainability (Landell-Mills and Porras 2002, Pagiola et al. 2002).

Examples from around the world have shown neither market nor government has been efficient in the management and allocation of natural resources (Ostrom, 1990, 1994; Briscoe, 1996; Perry et al. 1997). As an alternative to the apparently intrinsic failures of pure market or government approaches, different types of initiatives have been undergoing around the world at different levels. In consequence there are many efforts to stop deforestation and preserve critical ecosystems. One growing initiative are “Payments for Environmental Services” (PES) a tool to internalize externalities that could potentially simultaneously generate additional income for rural communities and preserve critical ecosystem services.

In theory, direct payments can help promote biodiversity preservation, watershed protection, carbon sequestration and scenic views protection. Landell-Mills and Porras (2002) documented 258 cases of PES around the world from which 61 are related to watershed protection. Most of the water payment systems involved negotiations between downstream and upstream stakeholder such as representatives of hydroelectric facilities, water utilities, municipalities, industries, and farmers, with a little or no government intervention.

Perrot-Maitre and Davis (2001) also studied nine cases of payment for environmental water services and found that downstream farmer may be willing to pay compensation to upstream communities if water is critical resource for expensive crop production; such market connection or export oriented crops. Thus communities such as the Cauca River in Colombia and in the Philippines have voluntary self-organized and set up a payment schemes 200 or 300 percent

higher than government tariffs in order to finance watershed management². As Perry et al 1997 said, “water markets tend to operate locally allowing suppliers and consumers to include the opportunity cost of water in their management decisions.

But who should pay and who should receive the benefit from environmental services? From the economic perspective, people who receive the benefit of a good should pay for it. Thus, irrigators who receive direct benefits of water should pay for this service. Ferraro and Kist (2002) state that the easiest and cheapest way to, for example, protect rainforests or watersheds is to simply pay directly for it. This argument has tended to be true in the case of water conservation in Costa Rica, Ecuador and Colombia, where farmers upstream have received direct payments for watershed protection from farmer’s downstream or hydroelectric utilities. In the case of Columbia and Philippines, it seems that the irrigator associations are better off paying directly for the amenities that they want, rather than facing the loss of crop production.

However, payments for environmental services are not yet a widespread tool for conservation and development. Many issues are still unclear, such as the biophysical relation between forest cover/water, development and conservation. Communities may not want to pay somebody else just based on their geographical location. In addition, water is invariably perceived to be a public good, many potential user raise the question of why they personally, rather than society as a whole, should be paying for it. Is it moral that people should be asked to pay for water, a basic need? And what should be the price of such “a gift from god”? I follow Briscoe (1996) who sidesteps that moral question, asserting simply “the value of water is the maximum amount the user would be willing to pay for it”.

It seems that existing PES scheme depend on well-structured supply and demand (Pagiola et al 2002). Since the 1960s non-market valuation such as contingent valuation method (CVM) have been extensively used to identify buyers and sellers, especially in western societies and particularly for drinking water. Building the demand side and capturing a true WTP for environmental amenities has been the principal task of CV methodology. There are also a few examples of the use of CVM in developing countries and in agrarian societies, such as Whittington et al (1992), Shyamsundar et al (1995), Kramer et al. (1997) and Pattanakak (2001). Meanwhile, in Latin America a number of PES projects have been designed and prices set based

² According to this study the government set up payment \$ 0.50/liter/ second/ trimester for the right of water access. The association of irrigators voluntarily agreed to pay an additional fee of \$ 1.50 to \$ 2.00 per the same amount of water. This could reflect the opportunity cost water and scarcity of resources (Perrot-Maitre and Davis 2001)

on the result of such CV studies. The use of CVM is thus rapidly expanding to evaluate the WTP for water conservation. Based on a CV study the Heredia Public Water utility in Costa Rica has adjusted its tariff. Consumers are willing to transfer part of their benefit to small landowners in order to conserve the watershed. Similar studies that explore the WTP for watershed conservation using CVM have been developed recently in Salvador, Honduras and Nicaragua³.

However, application of CVM is a learning exercise more than conclusive studies for policy recommendation. This study explored the potential to use this valuation technique in a situation of high levels of illiteracy or low education levels, poor information flow, low incomes and a lack of a market function for water irrigation. Thus the study was undertaken by carefully developing a survey that reflected the local culture and characteristics of indigent farmers and their perceptions about local resource use.

III. METHODOLOGY

a) The Contingent Valuation Method

The demand curve for water conservation and improvements in Los Negros Watershed was measured applying the contingent valuation (CV) method and therefore carrying out a Cost Benefit Analysis. The CV method essentially measures the willingness to pay (WTP) or willing to accept (WTA) by asking direct questions whether respondents would be willing to pay certain hypothetical amounts for different degrees or changes in goods or services (Cummings et al. 1986, Cameron and James 1987, Mitchell et al. 1989, Hanemann 1994). CV methods have been widely used for calculating use value and non-use value of semi-private as well as public goods that do not have a clear market price. Despite the fact that CV methodologies are relatively new, in the economics literature they are broadly used to calculate the value of drinking and irrigation water as central component of environmental or ecosystem services schemes⁴ (Michelsen et al. 1999, Kramer et al. 1997, Whittington et al. 1991, 1992, World Bank 1999).

³ In Honduras Fernando Cruz implemented a CV study to explore the WTP of residents at Colan River. In Nicaragua Carlos Perez developed a similar study on evaluation of WTP in three Central American countries. In Salvador, Doribel Herrador and Leopoldo Dimas (2000) conducted a CV study to explore the WTP for drinking water in two districts (Rosa et al. 1999, 2003).

⁴ The Exxon Valdez oil spill in 1989 played an important role in the development of CV methods. The technique was used to assess the loss of non-use value from the oil spill, and ascertain how much respondents would be willing to pay to avoid another similar event. Later the National Oceanic and Atmospheric Administration (NOAA) endorsed this method as valid for assessing damage and the loss of passive use value (Carson et al. 1992)

There are many weaknesses associated with CV, which are well known, such as strategy behavior, designed bias, hypothetical bias, starting point, implementation bias and others. However, most of the drawbacks of CV are related to practical procedures, rather than the fundamental basis of the method. This study will not go into pros and cons of the CV methods⁵, but given the potential weakness of the CV method, it proved critical to develop and implement a survey that effectively elicited each individual's willingness to pay for environmental amenities.

The theoretical framework for CV studies has been entrenched by several authors and it is consistent with economic welfare theory (Cummings et al. 1986, Cameron and James 1987, Mitchell et al. 1989, Hanemann 1994). I adopted the Mitchell et al. (1989) theoretical base for the CV measurement of public goods. According to these authors, an individual's indirect utility function can be expressed as $e(Y, P, D, Q)$; where Y is monetary income, P is the vector price for other goods and services, D is demographic and socio-economic vectors, Q represents a vector for improving quantity and quality of water. All these vectors might affect a household's ability to pay or influence its behavior. Thus y_0, p_0, d_0, q_0 represents the initial level of public good or *status quo* situation and y_1, p_1, d_1, q_1 represents some level of improvement (Mitchell et al. 1989, pp 26).

$$WTP = e(y_1, p_1, d_1, q_1) - e(y_0, p_0, d_0, q_0) \quad (1)$$

A positive willingness-to-pay (WTP) implies that q_1 is preferable to q_0 , and that a consumer will be willing to reduce their income in order to preserve the quantity and quality of water until the point where he or she gets the same level of utility as before any water conservation scheme and no payment has been made. From this it can be inferred that consumers want to preserve water beyond the *status quo* condition. Following the equation (1) we derive the equation (2), where the dependant variable, WTP, is influenced by a number of independent variables such as income, the price of other goods and services, socio-economic conditions, location, type of crop and quantity and quality of services offer and other factors.

$$\text{Willingness to pay (WTP)} = e(y, p, d, q, \dots, x) \quad (2)$$

⁵ For further knowledge of different weakness inherent to CV see Boyle et al. 1986, Bergstrom et al. 1989, Diamond and Hausman 1994, Boyle et al 1989, Hoehn and Randall 1976, Randall et al. 1983, Cummings et al. 1986)

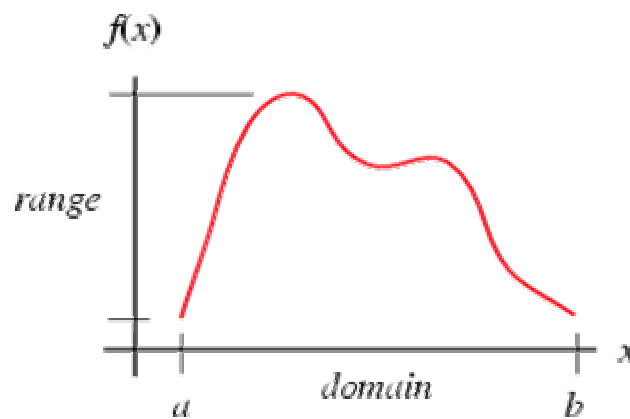
Transforming these variable into log-linear:

$$\text{Log (WTP)} = \beta_0 + \beta_1 y + \beta_2 p + \beta_3 d + \beta_4 q \dots \beta_n x + \mathbf{e} \quad (3)$$

where the β 's are coefficients are to be estimated.

By standardizing these values I assumed that all the parameters are normally distributed with a mean of 0 and a standard deviation of 1.

To identify the true WPT, I used CV and Cost Benefit Analysis (CBA). These two methods estimated the total WTP and compared the outcomes. In a scenario where there is not a price preference for water irrigation, Contingent Valuation might not capture the actual preference of the farmers. Therefore, the Cost Benefit Analysis lets us know the net benefit that each farmer makes from crop production. From that it can be inferred that part of his revenue can be allocated for water conservation. Farmers will not however, invest in water conservation more than the net benefit that they obtain from crop production. The concept of upper and lower bounds of the net benefit important to identified the threshold on those bounders. Farmers do not like to tell the exactly amount of profit that make, but they are willing to respond to a range with lower and upper bounds as we see in the following graph. So the true net benefit will be something in between these bounds.



b) Stratified Sampling and Survey designed

Based on a stratified systematic sample, I applied a survey to 168 farmers in the valley of the Los Negros watershed during the summer of 2003⁶. The results presented here are based on 155

⁶ The first stratified sample was base on location through measurements of distances from the main river. However, it became clear in the preliminary test that this particular variable was not relevant because the total farmed area in the valley had access to water. Thus I considered more important whether the respondents were members of one of the irrigation associations. There are six irrigation associations in LN with total member of 300 members, with the largest e irrigation association alone having 100 members. Through stratified random sampling I ensured that a representative group of farmers from each irrigation association were selected.

valid surveys applied to farmers from various irrigation associations. The stratified sample was designed to measure different location of the plot, but based on preliminary data I made some changes to the design, most importantly in dropping the measurement of distance from the main river. Almost all the LN valley has access to water through different channel owned by eight different irrigation associations. In consequence, the stratified sample was based on membership of a channel and the differentiation made between people who did or did not have access to irrigation water. Interviewees within each strata were randomly selected, thus every farmer had the same opportunity to be selected.

I paid special attentions to the survey considering that the success of CV studies depends on how well people understood the study. During a preliminary test of the survey I rapidly assessed the social characteristics of Los Negros and Santa Rosa communities and collected all the information available about those towns. The preliminary survey information was useful to establish an appropriate cultural protocol, identify the sample population and introduce the study to the communities. Members of the Los Negros Environmental committed facilitated the work, in order to help them define future compensation mechanisms for water conservation.

The survey was developed base on theoretical framework, field data and secondary information. The initial survey was pre-tested with 15 farmers from the Los Negros community. Farmer also gave an important feedback to improve the survey in a focus group discussion. During the process of developing and applying the survey, staff of the Bolivian National Statistic Institute (INE-Bolivia) reviewed the questions and trained the interviewers. These exercises were important for adequately refining the survey to the local environment and culture.

The survey was applied over a two-week period by a four-person research team, aided by ~25 local teachers and students, who knew the agricultural and cultural aspects of the farmers. The interviewers received one day of training in CVM, including how to apply the survey and codes of behavior. The final version of the survey was significantly different from the original. The pre-test also indicated the need to make significant changes to some questions⁷. It also proved useful to shorten the survey, make it more comprehensive, develop the right amount of

⁷ As an example, during the question pre-test we discover that “market” is not acceptable word. Farmers have a high resistance to the word payment—in their view water is public good that cannot be sold in a market. Changes of the word “payment” to “compensation” for watershed conservation seems more appropriate, and makes it appear more as cooperation rather than an obligatory tariff.

hypothetical payments and redefine or simply avoid some questions. The final version of the survey was organized in four parts⁸:

- I. Socio-Economic situation of the farmer
- II. Perceptions about local organization, environment, and natural resources management
- III. Perceptions of irrigation water in the Los Negros Watershed
- IV. Questions about the willingness to pay for watershed conservation

With the first part of the survey I captured information about the respondent's socioeconomic situation, land tenure, price of land, access to water, type of crop production, family income, production cost and benefit. I wanted to know how much farmers make from agricultural production. This information was essential for calculating the net benefit of crop production. Additional information about differentiating between plots with or without water access was also included. The second and third part of the questionnaire was more qualitative and explored farmer's perceptions about environmental and social issues as well as changes in water flows.

In the fourth part of the questionnaire, interviewers conducted the WTP question. Using the card form with large range of numbers, started with value 0 up to 100, farmers were asked their WTP (or compensate) for water conservation by asking the following question:

How much is the maximum amount monthly that you are willing to pay or compensate for water stabilization and quality?

Stabilization was defined as continued water flow over the year, and quality as reduced sedimentation. For water management and policy implementation this differentiation is critical, and lets us know the relative importance between quantity and quality for those farmers. This differentiation is also important for establishing a payment for environmental Services (PES), where it is critical to identify the "commodity" for which payments will be made. Knowing whether farmers care more about water table regulation or water quality will help to define which service might be demanded, and will help the suppliers focus on providing that particular service.

However, the pre-test revealed that sedimentation was not considered to be important. More than 80% of the respondents considered that sedimentation was normal or very low. Farmers in LN care about water quantity and not much about water quality. Thus water quantity and quality

⁸ The original survey was developed in Spanish and then translated into English.

were not analyzed separately. During the study it became clear that salinization and contamination were more significant problems (for ~50 farmers). However, these concerns were not considered as independent variables in this study because salinization and contamination do have a direct relationship with deforestation.

Three questions about WTP were made reflecting small but potentially important differences in scenarios. In the first WTP question, a small range of payments were proposed, ranging from Bs 0 to 100, and the municipality was proposed as the vehicle for payment through setting up a monthly fee to support conservation program of forests in the headwaters of the watershed. In the second question, values was proposed from Bs 0 to 500; the payment vehicle was the same and the payment itself was to directly protect the areas that supply the water.

The main modification in the third WTP question was the vehicle of payment. Instead of municipally the irrigation association was proposed, but the scale of payments was the same as first WTP i.e. Bs 0 to 100 for the monthly tariff. Not surprisingly, farmers who already have in place a very strong organization trusted more in the irrigation association than the municipally.

A few farmers respond with zero bids. In some cases this was a clear protest against the vehicle of payment. It is perhaps not surprising that when the local municipality was proposed to implement this charges, some farmers asserted that they “won’t pay anything if the municipality is in charge”. Protest responses were included in the final analysis. Around 30% of those surveyed also responded with zero WTP, but in those cases it is more difficult to understand if these respondent are really unwilling to pay for water stabilization and water quality, or if in fact they are protesting. The zero WTP was considered in the data analysis and these responses was correlated with factors such as income, demography information, education, age, land tenure, plot size, etc. that may influence the WTP of those farmers.

This amount of zero responses is not surprising at all and may represent the honest response from farmers who have a negative attitude towards paying for a resource that they have always received for free. Thus I was expecting large number of zeros because farmers historically have never paid for water irrigation, and also because there are no reference prices for this kind of services.

In the LN community irrigation water is not competing with other uses (domestic, industrial, commercial) and the survey was strictly directed to farmers. Farmers with a second economic activity were also interviewed. If no farmer was available in the household or plot, an alternative farmer was selected.

As a final check of the model I implemented a factor analysis. Factor analysis helps to discriminate between variables and ascertain which of them are driving the model. It is also a good technique to reduce the numbers of predicting variables. Given my total number of observations, the original range of variables—of which 3 were dependent and 14 were independent—was too large to establish linear relationships between the variables. Given that I expected that many of these variables co vary, underlying factors (for example, psychological factors, economical factors, etc.) may better predict people's willingness to pay. Factor analysis was a useful tool to test such hypotheses and identify underlying factors.

Results

From the analysis of the farmer data, the average family size in Los Negros community is ~ 3.8 persons and around 84% of the respondents concentrate in range between 20 to 60 years old. The illiteracy rate is very low; most of the respondents at least have a primary education (66.7 percent primary, 29.5 percent secondary). Only 2.6% of the farmers interviewed never attended the formal education system, and these tended to be older farmers. Only two respondents have technical education and though their main income still comes from crop production, they also have a secondary income source. Thus for statistical purposes, education was organized in two groups; primary and secondary education. The majority of the respondents were male (85%). It seems that woman are more engaged in household duties and only participate in the harvesting of vegetables and not in the other steps of crop production.

The responses patterns were influenced by socioeconomic differences and beliefs. It seems that income, family size, age, education and the perception that water flows have diminished over time influence the WTP of those farmers. The survey provided good information to estimate the net benefit (NB) of crop production in Los Negros (see below Table 1). The analysis showed that the average agricultural profit per family is ~ 11,438 Bolivians peso (\$us. 1462) per year. However, there is a possibility that the NB was over estimated: the number was derived from the total benefit of crop production minus the total cost, and while the cost estimation considered labor, transportation, and machinery, inputs such as pesticide and fertilizer were not included. It may also be that some people did not talk honestly about income. This is especially likely in rural areas where people associate such questions as the precursors for new taxes or fees.

However, the results of the Cost Benefit Analysis are consistent with previous studies in LN that shown annual average net income of \$US 2300 from agricultural production and cattle grazing (Pampagrande Municipal Government 2003, page 135-136). In the linear regression analysis I used separately the three measures of income, namely agricultural income, family income and net benefit. The net benefit appears to be the most powerful indicator to ascertain the WTP.

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	\$US.	Std. Deviation
FYINC	153	1000	25000	5846,41	760	5859,45
AGINC	147	250	30000	5190,82	675	5541,60
NETBENEF	143	207	48225	11438,11	1490	12126,35
Valid N	136					

No hydrological data were included in the survey. There is no information about changes in water table and irrigation water consumption per family, precipitation, etc. The only information available was the number of hectares each farmers has water access. Thus, instead of using milliliters per second I used as a base line, the number of hectares with water access.

On average, farmers are willing to pay monthly around to 2% of their income for watershed protections. Even though this value seems low compared with the value of the land with water access, it can also be viewed as significant considering that there is no history of payment for watershed services in LN. However the average WTP seems really small compare with rent cost or land value of in that valley (see below table 2). From the surveys I ascertained that one hectare of land without water is worth only \$900, while a similar hectare with a reliable water supply is worth an average of \$4700⁹.

Two hypotheses can explain this difference between the WTP expressed in the survey and market land values. One is the historical absence of fees for water irrigation and the belief that water should be free for every farmer. Second, the added value of water is directly connected with the infrastructure rather than the water itself. Thus in the valuation of a plot with water access, farmers take into account the cost associated the channel construction, the fees paid to be part of the irrigation association (\$US 1000 –1500) depending of number hectares that will have water access, and the type of crop and number of harvests per year that can be made with water.

⁹ Other factors such as location and soil quality can also influence land values. However in the LN valley these variables are similar for all the plots. Thus the important differentiating factor is access to water.

Table: 2 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Amount in Bs Bolivians					
WTP1	155	0	55	6,10	8,41
WTP2	155	0	50	6,61	8,22
WTP3	155	0	100,0	7,274	10,539
Amount in \$US dollar					
Rent with Water\$	150	100	600	356,13	145,79
Rent NOT Water\$	148	30	300	124,93	70,47
Buy NOT Water	150	150	2500	933,00	498,95
Buy with water	152	800	8000	4715,79	1372,29

Estimation of the WTP

What is the commodity that is being offered? Before describing the WTP results, I defined the commodity as “stabilize the flow of water and reduce the deforestation and maintain the areas under irrigation and reduce sedimentation”. Three questions assessed the WTP with reference to the value of both the maintenance of water flows and improvements in quality. The payment vehicle was a monthly tariff charged by the municipality or by the irrigation association.

What determined the WTP in Los Negros community for watershed conservation? Many variables were tested to see if they explained the changes on the dependant variables (see below table # 3). From the coefficient we read that marginal changes (Δ) in a particular variable at the farmer level will influence the WTP (Cameron and James 1987).

Table 3: Variables considered in the model

	N	Minimum	Maximum	Mean	Std. Deviation
Categorical Variables					
AGE Dummy Young=1 Older=0	155	0	1	,88	,32
EDU Dummy Pri Edu=1 Sec Edu=0	155	1	2	1,30	,46
WHHIGH Dummy Crop high water demand and market value crop =1 Other wise=0	155	,00	1,00	,3935	,4901
WHHIGHES Dummy Crop high water demand and highest market value crop =1 Other wise =0	155	,00	1,00	8,387E-02	,2781
WHLOWEST Dummy Crop high water demand and lowest market value crop =1 Other wise =0	155	,00	1,00	,1226	,3290
WLHIGH Dummy Crop low water demand and high market value crop =1 Other wise =0	155	,00	1,00	,1097	,3135
WLOW Dummy Crop low water demand and low market value crop =1	155	,00	1,00	,2258	,4195

Other wise =0					
WLOWEST Dummy	155	,00	1,00	5,806E	,2346
Crop low water demand and lowest market value crop =1				-02	
Other wise =0					
Landtenure	155	1	4	1,89	1,22
Owner= 1					
Rent=2					
Borrow=3					
Joint Venture=4					

Continuous Variables

FLMYSIZE	155	1	8	3,79	2,11
Family Size					
LNAGRINC	147	5,52	10,31	8,0825	,9856
Log Agriculture Income					
LNFYINC	153	6,91	10,13	8,2667	,8728
Log Family Income					
LNNETBET	143	5,33	10,78	8,7452	1,2130
Log Net Benefit					
LNVALPRO	117	6,21	11,29	8,7788	,7943
Log Value Property					
LNZPLOT	155	-1,39	2,71	,2212	,6957
Log Size of the Plot					
LNZPROP	155	-1,39	4,09	,5046	1,0421
Log Size of Property					
LOGWTP1	155	-,69	4,02	1,1577	1,3480
LOGWTP2	155	-,69	3,92	1,2684	1,3612
LOGWTP3	155	-,69	4,61	1,2963	1,3979

To do a Linear Regression Analysis (LRA) all the variables must have normal distribution. It could be seen from the box plots that the variables of **WTP1, WTP2, WTP3, FYINC, AGINC, NETBENEF, VALPROP\$, SIZEPROP, and SIZEPOT** are heavily skewed. Meanwhile, it also could be seen from quantile plots that these variables were not normal distributed. In order to achieve normality for these variables, they were transformed by taking their natural log. Although most quantile plots with transformed variables are not perfect straight lines, they were significantly improved over the quantile plots of non-transformed variables. Thus, in the following analysis, we used natural log transformed variables. For the variables of **FLYMSIZE, DIFRENT** and **DIFBUY**, no transformation was necessary. Thus, original data for these three variables were used in the following analysis. Also categorical variables as education and age were aggregated as two level dummy variables.

The age category expressed a clear difference between young and old people. Three of the original categories of young people—0-20, 21-40 and 41-65—shared almost the same mean and standard deviation, except people >65 year old. In terms of the education variables, the number of observation in the extreme categories was so small that it would not represent the true

population mean. There were only three observations with technical training and four observations that never attended school. I ran the regression including all categorical variables in the original data form and then, again with these variables in dummy form. No changes were observed in the result of the regression analysis, so these variables were kept as dummies.

On the regression analysis I used the method StepWise (SW). This method selected the variables that high significant level between 99 and 95 confidence intervals. The result of SW method was contracted with normal Ordinary Least Square regression, no changes was evidence in the coefficient or significant level. Variables that are excluding of the model also are reported (see annex: 1: table 7)

Consistent with economic theory the coefficient the log Flyinc, Agrinc or net-benefit are significant. Farmers with high income were willing to pay more. From the different scenarios of WTP it can be derived that a one percent (1%) increase in income levels leads to a 33-39% increase in the willingness to pay for water stabilization and quality. In real terms, the average willingness to pay goes up from Bs. 6.10 (.79 \$US) to 8.11 (1.05\$US). However, at the margin it seems that the utility for small farmers is higher than for those farmer who already have water and big land property. Age also seems to be another good indicator of the WTP. Young people show a greater WTP than old people at level of significant 99% interval.

Education levels also seem to be significant variables almost for all the WTP tested. WTP increases with increased education—perhaps because the better educated people may better understand the relation between forest cover and water. Educated people may also better perceive the future risk of reduced water flows on crop production, and hence may understand the importance of payments as a tool to improve forest conservation. Interesting, and coincident with the literature (Perrot-Maitre and Davis 2001, Pattanayak 2001), the high water consumption crops (i.e. tomatos, green pepper and potatoes) normally have high market value even in rural areas. From the coefficient I could derive that for high value crops, farmers are willing to pay more (between 44% to 63%) at significant level of 0.01 to 0.05. In contrast, production of high water demanding and low value crops (i.e. cucumber, cauliflower) has an inverse correlation with the willingness to pay.

Every time farmers produce one unit low market value crop, their WTP for water decreases by 63%. In general, the level of change for log WTP3 was bigger and more significant than the other two scenarios. This can be explained by the fact that people are more willing to pay in scenarios were they control the use of the resources, such as through payments to the irrigation

association rather than the municipality. The coefficient and level significant was quite similar for the other two scenarios of WTP. This shows that the model is robust and these numbers may express the true WTP of those farmers.

Table 4: Estimation for WTP1, WTP2, WT3 for waster stabilization and quality, Stepwise method, base on Log Net Benefit

Dependent Variable: LOGWTP1 Vehicle: Municipality Tariff The same scale				Dependent Variable: LOGWTP2 Vehicle payment: Municipality Tariff Change in scale			Dependent Variable: LOGWTP3 Vehicle Payment: Irrigation Association The same scale			
Variables	Coefficients		t	Coefficients			Coefficients			
	B	Std. Error		B	Std. Error	t	B	Std. Error	t	
(Constant)	-3,681(000)	,816	-4,509	-3,068(000)	,845	-3,630	-3,847(000)	,858	-4,485	
AGE	1,131(000)	,317	3,567	1,058(002)	,328	3,228	,822(015)	,333	2,468	
LNNETBET	,332(000)	,082	4,065	,302(000)	,084	3,593	,399 (000)	,086	4,648	
EDU	,576(008)	,215	2,680	,520(021)	,223	2,330	,540(018)	,226	2,388	
WHHIGH	,515(012)	,203	2,532	,446(044)	,219	2,036	,633(004)	,214	2,964	
WHLOWEST				-,6359(058)	,332	-1,914				

Table 5: Estimation for WTP1, WTP2, WT3 for waster stabilization and quality, Stepwise method, base on Log Agricultural Income

Dependent Variable: LOGWTP1 Vehicle: Municipality Tariff The same scale				Dependent Variable: LOGWTP2 Vehicle payment: Municipality Tariff Change in scale			Dependent Variable: LOGWTP3 Vehicle Payment: Irrigation Association The same scale			
Variables	Coefficients		t	Coefficients			Coefficients			
	B	Std. Error		B	Std. Error	t	B	Std. Error	t	
(Constant)	-3,519(000)	,908	-3,875	-2,391(012)	,941	-2,542	-3,125(001)	,961	-3,250	
AGE	1,052(001)	,324	3,242	1,006(003)	,336	2,997	,760(029)	,343	2,213	
LNAGRINC	,357(001)	,101	3,525	,284(008)	,105	2,710	,360(001)	,107	3,356	
EDU	,547(015)	,222	2,466	,478 (040)	,231	2,070	,512(031)	,235	2,180	
WHHIGH	,498(015)	,202	2,462				,583(007)	,214	2,724	
WHLOWEST				-,707(024)	,310	-2,284				
FLMYSIZE	-,129(089)	,052	-1,710	-,120(123)	,053	-1,552	-,120 (121)	,055	-1,560	
OWN	-,142(072)	,291	-1,813	-,147(070)	,297	-1,824	-,156(054)	,308	-1,943	
BORROW	,140(064)	,473	1,865	,151(062)	505	1,882	,113 (145)	,524	1,464	

Significant at 0.05*

Significant at 0.01 **

In blue variables that were exclude in the stepwise methods

It is surprising to note that landowners are unwilling to pay in any scenarios at a 90% significant level. In contrast, people who do not have land (they rent or borrow) are 11-15% more likely to be willing to pay for water stabilization, but only at a significance level of 85 to 90%. This may be because people who have title to their land often have big properties, and often have a good water supply infrastructure, such as irrigation channels. Farmers with such

amenities may be less willing to pay forest protection for water supply because they have already spent part of their income to resolve the water scarcity problem. The opposite may be true for people who do not have land.

It may also be that landowners do not believe that forest conservation is related to water stabilization and less sedimentation. More analysis is needed to find deeper explanation about the relation between those variables and WTP.

Other socioeconomic characteristic such as gender, and plot and property size were statistically uncorrelated with WTP. It seems that most of the agriculture in Los Negros is carried out by males (85%), so the influence of females was not significant in any of the WTP scenarios. Size of the plot and size of property were tested as proxy of wealth, and in different ways (log, quadratic, etc.), but they were not significant in any WTP scenario. It is possible that these variables are related to each other or with other variables, so I checked, but found no evidence for correlation.

To ascertain if some underlying factor may be driving the model, I also implemented a factor analysis. From this technique I derived four sets of factors. For factor 1, the indicators of LNZPROP, LNZPLOT and LNVALPRO have high factor loadings. These three indicators are thus related to permanent assets and could act as a proxy for wealth. Thus, I defined factor 1 as “permanent assets” factor. Factor 2 was clearly indicated by LNFYINC, LNAGRINC and LNNETBET, each of which had high factor loadings. These indicators are related to income, thus I defined factor 2 as the “income” factor. Only the indicator of DIFBUYW had high loadings for factor 3. This indicator was related to the difference between the cost of buying one ha of land without water and the cost of buying one ha of land with water, so I defined factor 3 as the “water” factor. For factor 4, the indicators of LNNETBET, and FLMYSIZE had relatively high loadings. Considering that LNNETBET also had a high loading for factor 2, it may mean that this indicator is not well determined. I defined factor 4 as the “family” factor.

Loadings for AGE, EDU and DIFRENT were low for all four factors. This suggests that either they are not related to the extracted factors, or there is a third factor (i.e. the borderline eigenvalue of 0.973). Meanwhile, 3 larger than 0.1 non-redundant residuals from residual correlation matrix also remind us of the possibility of the presence of another factor. I suggest that further research efforts are made to find variables related to other possible factors.

Table : 7 factor analysis

	Factor			
	1	2	3	4
LNFYINC	.214	.881	.117	.155
LNAGRINC	.208	.892	9.740E-02	-3.70E-02
LNNETBET	6.390E-02	.520	-6.09E-02	-.453
FLMYSIZE	.114	4.702E-02	.117	.478
AGE	-.264	2.208E-02	.149	-.309
EDU	-.178	1.033E-02	5.494E-02	-6.84E-02
LNZPROP	.855	.217	-6.61E-02	4.287E-03
LNZPLOT	.813	.346	.198	-2.87E-02
LNVALPRO	.707	.140	.103	.243
DIFRENT	-2.22E-02	.125	.249	1.884E-02
DIFBUYW	2.318E-02	-7.58E-02	.687	4.540E-02

Extraction Method: Principal Axis Factoring.
 Rotation Method: Varimax with Kaiser

a. Rotation converged in 6

The linear regression analysis was run with these four factors but only two factors –factor 1 and four- came up as significant predictors of the WTP.

Table 8: Parameter Estimates in the Factor Analysis

Dependent	Parame	B	Std.	t	Sig.	95% Confidence	
						Lower	Upper
LNWT	Interc	1.30	.11	11.2	.00	1.07	1.53
	FAC2	.49	.12	4.04	.00	.25	.74
	FAC4	-	.16	-	.00	-	-
LNWT	Interc	1.41	.12	11.3	.00	1.16	1.66
	FAC2	.43	.13	3.27	.00	.17	.69
	FAC4	-	.17	-	.01	-	-
LNWT	Interc	1.48	.12	12.0	.00	1.23	1.72
	FAC2	.49	.13	3.78	.00	.23	.75
	FAC4	-	.17	-	.00	-	-

As result the following model was constructed

$$\underset{n \times p}{\mathbf{Y}} = \underset{n \times (r+1)}{\mathbf{X}} \underset{(r+1) \times p}{\mathbf{\beta}} + \underset{n \times p}{\mathbf{e}} \Rightarrow \underset{10 \times 3}{\mathbf{Y}} = \underset{10 \times 3}{\mathbf{X}} * \underset{3 \times 3}{\mathbf{b}} + \underset{10 \times 3}{\mathbf{e}}$$

Where:

Y is predicted dependent variable matrix for LNWT1, LNWT2, and LNWT3.

X is our observation matrix for different independent variables.

b is coefficient matrix as it is shown below.

$n = 101$, which is the number of our total observations.

$g = 2$, which is the number of independent variables

$p = 3$, which is the number of dependent variables.

$$\mathbf{b} = \begin{matrix} 1.304 & 1.413 & 1.480 \\ .496 & .431 & .493 \\ -.579 & -.442 & -.577 \end{matrix}$$

The coefficients for factor 2 were positive, which indicates that with more income, people are more willing to pay for watershed services. The coefficients for factor 4 are negative, which may mean that large families are not willing to pay, perhaps because of more urgent need to feed people in family rather than considering better water quality.

For example, if the factor 2 increases by 1 for LN WTP1, then

$$\ln(WTP1_1) - \ln(WTP1_0) = \ln\left(\frac{WTP1_1}{WTP1_0}\right) = 0.496 \Rightarrow \frac{WTP1_1}{WTP1_0} = 1.64214$$

Which means that with income factor increases by one, the WTP1 will increase by about 64.2%. Similar example was also made below for factor 4.

$$\ln(WTP1_1) - \ln(WTP1_0) = \ln\left(\frac{WTP1_1}{WTP1_0}\right) = -0.579 \Rightarrow \frac{WTP1_1}{WTP1_0} = 0.56046$$

Above example means that the WTP1 will decrease by 43.95% if factor 4 increases by 1.

Also, from the output of predicted values and residuals, it could be seen that the predicting residuals are relatively large, which means that further research to include more related variables is needed in order to more accurately predict the willingness to pay.

Even though CV studies do not look at the Adjusted R Squared values, in this case the RS for the three dependent variables are relative small, suggesting that other variables outside the model have an important influence on the WTP of farmers in the LN community.

An important finding is that in comparing both regression and factor analyses, I could show that the model to predicted WTP is robust. The variables that are driven the model seem to be the same in both the regression and the factor analysis.

The above results show each of the variables that influence a farmers' willingness to pay. This study also shows the average WTP per farmers. To develop the aggregated demand for water conservation, the average value per family was multiply by total number of families in Los Negros Community. Given that the WTP per farmers was ~ Bs. 6.66 (\$.86), multiplying the mean value per farmer, by the total number of families in Los Negros Community (~1200 families), multiplied by 12 months, the aggregate WTP of Los Negros Community is Bs. 95, 904 or \$12,487 per year.

The opportunity cost of the Santa Rosa community to leave forest in situ or to cut it is around ~\$ 3/ hectare/year (own data). \$12, 487 LN can thus help to protect around 4000 ha of forested watershed per year. This sum could allow the almost complete protection of the cloud forests in the jurisdiction of Santa Rosa community and thus protected the entire headwaters of Los Negros River. In a similar situation, the Municipality of Pimampiro in Ecuador, set up a payment for environmental services system costing ~ \$500 per year to pay 20 farmers to protect valuable forest cover and compensate upstream farmers for their opportunity cost (Echeverria 2003). Compared with Pimampiro, it seems that LN community has the potential to raise a lot more money per year and hence protect a bigger area of upland forests.

Conclusion

Contrary to common beliefs and perceptions, the results of the data analysis revealed that poor farmers in rural communities connected with markets, are willing to pay for environmental services and in doing so, may diminish their potential losses from stream flow reduction. Through the contingent valuation method, the survey showed that the majority of respondents (70%) were willing to pay for watershed conservation. However, the revealed amount is low compared with income and property values in LN. Farmers and their families were only willing to pay \$.86 per month, or \$10.32 per year). However this amount is significant, considering that in many communities, and particularly in farming cultures such as Los Negros, water is perceived as a public good.

For the policy perspective, local authorities should evaluate the possibility of setting up fees for water irrigation, and used these financial resources for watershed conservation. However, it seems that the farmers would be more comfortable if payments were set up and managed by their irrigation associations rather than the local municipality. When the association of irrigators was

proposed as the vehicle of payment, the monthly WTP increased on average by Bs. 4.43 per farmer. This meant a change from Bs. 6.10 to Bs. 10.53 (\$0.86 to \$1.37)/month/farmers.

Traditional and important socioeconomic variables seem to play an important role driving the WTP. Age, education, and income are powerful explanatory variables of differences in the WTP between farmers. However, policymakers should be careful when setting up payment systems based on income. Measuring income can be a tricky business, because community members are often not open to talking about their financial situation. Indirect methods of calculating income may be more appropriate. It is interesting that the farmers who produce high water demanding crops, in combination with high market value, tend to be willing to pay more for watershed conservation. In order to implement a water fee, managers should focus first on young, well-educated farmers with high incomes who grow high value crops.

However the result of this study should be considered with caution. Surveys are not always accurate and respondents tend to be lost despite the pre-test, training, careful design, and focus groups etc. Policies must also consider the respondents who claimed they were unwilling to pay anything for watershed protection, in this case accounting for 30% of the respondents. These negative responses may well imply that these people seriously oppose any kind of water tariff, or it may be that they simply didn't understand the question. Thus, further research needs to be done to identify other underlying factors that may affect the willingness to pay of these farmers.

Variables such as perception about the environment and trust and social values should be explored.

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Annexes... coming soon!!

Appendix: Survey Instrument

Map study area

