VALUING FOREST HYDROLOGIC SERVICES IN COSTA RICAN FARMSCAPES:

A CONTINGENT VALUATION APPROACH IN TROPICAL MOUNTAINS

by

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(Under the Direction of Fausto O. Sarmiento)

ABSTRACT

I assessed the economic value of tropical mountain forests' hydrologic services in two localities of Costa Rica, Turrialba and Guácimo, using the Contingent Valuation Method. The survey elicited the willingness–to–pay (WTP) of various water consumers to fund a local Payment for Environmental Services Program (PES), for hydrologic protection, through a water conservation fee. Results indicate that the mean WTP is US$11.69 to the logit model, and US$7.54 to the linear model. Value estimates about the benefits of hydrologic services conservation provides information to design policy instruments and programs to halt the rapid loss of environmental services. A cost–benefit approach determined that the adoption of a local PES program to finance the conservation of hydrologic services is feasible; however, it may not necessarily result in Pareto improvement. For rural communities in the tropical mountains, hydrologic services require urgent protection. Therefore, it is necessary to find alternative mechanisms to finance conservation and promote equity.

INDEX WORDS: Costa Rica, Contingent Valuation, farmscape conservation, hydrologic services, Payment for Environmental Services.

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CHAPTER 1

INTRODUCTION

Deforestation has been one of the most serious environmental problems in the recent history of Costa Rica (Fig. 1.1). Its main cause has been forest conversion into agriculture and grassland for cattle ranching (Rosero–Bixby & Palloni, 1998; Sánchez–Azofeifa *et al.*, 2001; Montagnini & Finney, 2011). Earlier deforestation studies estimated that, between 1940 and 1984, 50% of forest cover was lost (Sader & Joyce, 1988; Sánchez–Azofeifa *et al*., 2001). Between 1976 and 1980, the deforestation rate was 3.2 % $year^{-1}$ (FAO, 1990), whereas between 1986 and199, annual deforestation rate was 4.2 % $year^{-1}$ (Sánchez–Azofeifa *et al*., 2001), one of the highest deforestation rates in the world at that time. However, Costa Rica is the only country in Central America that reported a negative forest area change rate (−0.8%) in the period 1990−2000, and then an increase in forest cover (0.9%) in the period 2000−2010 (FAO, 2011). However, it is not clear to what extent this turnaround is related to a reduction in agricultural land driven by changes in the global economy, or to conservation policies implemented in the country (FAO, 2007). Nevertheless, there is no doubt that the implementation of the Payment for Environmental Services Program (PES) has been positive for forest conservation in Costa Rica. In fact, the application of this policy instrument reduces deforestation and increases the protection of many environmental services. In 2010, Costa Rica had $2.6x10^6$ ha of forest cover representing 51% of the country's total land (FAO, 2011). Forty six percent of these forests are located in conservation areas whereas 54% are located in private lands (PEN, 2010). Today, 598,433 ha (43%) of private forests remain protected especially under the PES Program (PEN, 2010). However, regarding the protection of hydrologic services the PES Program has not been successful as expected. For example, the number of hectares participating in watershed protection is low. Therefore, the PES Program requires more targeting efforts and merits a reworking of its narrative applicable to hydrologic services conservation in tropical mountains (Zimmerer, 2000; Miranda *et al*., 2007; Pagiola, 2007) (Fig. 1.2).

The Payment for Environmental Service Program (PES)

The PES Program is a strategy adopted by the Government of Costa Rica to prevent environmental degradation derived from deforestation (Russo & Candela, 2006). It is a financial recognition from the government towards land and forest owners for the environmental services that their properties produce (FONAFIFO, 2011). The program functions like a funds transfer system from those who benefit from the use of environmental services towards those who provide such environmental services (Russo & Candela, 2006). The legal framework that legitimates the system is established in the Forestry Law 7575 (1996). Under this law, four major environmental services are protected: a) mitigation of climate change; b) hydrologic services; c) biodiversity protection; and, d) provision of recreational services. The PES Program has received significant recognition around the world as a conservation instrument. However, it is not exempt from weaknesses. For example, mitigation of climate change seems to receive more attention from the government, NGOs, the international community, and other prominent stakeholders (Montagnini & Finney, 2011). However, those environmental services with higher relevance for the local context, such as hydrologic services, receive less attention increasing their vulnerability to depletion (Miranda *et al*., 2007).

Financing the Program

Funding for the PES Program comes from various sources such as voluntary payments, direct payments for environmental services, allocation of funds by the Costa Rican government, and international donations and credits. The National Fund for Forest Financing (FONAFIFO), a governmental institution created in 1991, administers the budget (FONAFIFO, 2011). The most significant financing mechanisms are the following:

Deposits through CES

The Certificates for Environmental Services (CES) are financial instruments designed to promote national and international markets for environmental services. Through CES, FONAFIFO captures funds from businesses and institutions that benefit from environmental services. These funds are used to pay land and forest owners for the provision of those environmental services (FONAFIFO, 2011). CES are given to the private sector in recognition for their voluntary contributions to sustainable development. Therefore, they encourage environmental responsibility and provide good corporate image. Around US$ 1.35 x106 year^{-1} is obtained from this modality in Costa Rica (Russo & Candela, 2006).

Payments for mitigation of climate change

Based on 'The Polluters Pay' principle, and supported by the Law 8114, Art.5 (PEN, 2010), fuel consumers pay a hydrocarbon tax (ecotax) for every gas purchase they make, from which 3.5% is canalized to the PES Program. Revenues from this financing mechanism make approximately US$ 3.5 x 106 year^{-1} (Russo & Candela, 2006). However, the revenue in 2003 reached US$ 6.4 x 106 (Pagiola, 2007). More than 86 % of the PES revenues come from this tax

(Russo & Candela, 2006). Interestingly, most fossil fuel consumers in Costa Rica do not know that they are making such payments.

In Costa Rica, although important funding from sales of Certified Tradable Offsets (CTO's) (carbon bonds) was expected since 1998, no significant markets for carbon abatement have emerged (Gilbertson & Reyes, 2009). However, some transactions have already taken place. The first sale was for Norway, which consisted of US$ 2 million in 1997 for 200 million tons of carbon sequestration (Pagiola, 2007). In 1998, the Dutch government received a carbon bond equivalent to US $673,000 (Benavides & Veenstra, 2009). It paid for projects aimed to reducing methane emissions. The next year it paid for another $334,000 for carbon fixation (Benavides & Veenstra, 2009). Twenty–year carbon storage certificates issued by Costa Rica were valued in 2000 between US$ 40 and US$ 80 millions, and they were marketed at the Chicago Mercantile Exchange (Ramírez, 2000). However, under the Bonn Agreement, signed in July 2001, only reforestation and afforestation are considered eligible under the Kyoto Protocol's Clean Development Mechanism (CDM) (Smith, 2002; Pagiola, 2007). Because in Costa Rica, contribution to mitigation of climate change comes primarily from avoided deforestation rather than reforestation or afforestation, CTO's sales have been low. With the Kyoto Protocol now ratified, Costa Rica is returning to the carbon market as well as exploring the potential for non–Kyoto sales of emissions reductions (Pagiola, 2007). Meanwhile, Costa Rica is continuously working on carbon sequestration that can be traded in the future. Up to 70% of the benefits from forest preservation in Costa Rica accrue to the global community through carbon sequestration (Brockett & Gottfried, 2002).

Payments for hydrologic services

Most water payments are made by hydropower producers, who through voluntary contracts reimburse FONAFIFO for payments given to individual landowners who protect upstream watersheds. Some contracts include bottlers, municipal water supply systems, irrigation water users, and hotels (Pagiola, 2007). However, these private agreements have generated only about $100,000 to finance about 2,400 ha of PES contracts, which typically last 5 years (Miranda *et al*., 2007). Therefore, regarding the protection of hydrologic services, the PES Program is not as successful as it is with the protection of other environmental services.

Biodiversity payments

Based on Ecomarket Law No.8640, a thirty–million dollars credit from the World Bank is destined exclusively for the PES Program for a period of 5 years up to 2013 (PEN, 2010). The World Bank, the Global Environmental Facility, and the Government of Costa Rica, through the Ecomarket Project, have oriented the PES program towards global and regional biodiversity conservation priorities, as well as towards national social goals (Hartshorn *et al*., 2005).

The PES Program has also attracted significant co–financing from international donors, including the German *Kreditanstalt für Wiederaufbau* (*KfW Bankengruppe*) (Reconstruction Credit Institute), the Norwegian Agency for Development Cooperation (NORAD), and the Government of Japan (Hartshorn *et al*., 2005).

Paying to environmental services providers

The PES program relies on agreements with private land owners, for whom a sustainable forest management plan has to be elaborated by a licensed forester. After the plan's approval, landowners adopt sustainable practices, and they receive payments. The compliance of the plan is constantly monitored and verified by FONAFIFO (Pagiola, 2007).

Because landowners are not obligated to participate, the PES program relies on their willingness to participate in the program as 'providers of environmental services'. Consequently, the amount of payments that landowners will receive has to be more attractive than the revenue they can obtain from using their lands in other activities or their cost of opportunity. Therefore, as the opportunity cost increases, the risk of deforestation becomes critical (Muñoz–Piña *et al*., 2008).

The participation of land and forest owners has been vital to achieve forests' protection and reforestation goals. However, in the case of watershed protection, landowners' participation has been low (Miranda *et al*., 2007). In fact, from 2004 to 2010 the number of hectares of protected forests in watersheds was lower than 5,000 per year. This is an evident weakness of the PES Program (Fig. 1.3).

Conservation of hydrologic services

Costa Rica lies in the tropics between 8°2'N and 11°13'N (Kohlmann *et al*., 2008). The eastern trade winds, the Inter–Tropical Convergence Zone (ITCZ), and the effects of the Pacific and Atlantic Oceans influence the Costa Rican climate. The four mountain ranges: Guanacaste, Tillarán, Central, and Talamanca also play a pivotal role in creating microclimates (Obando *et al*., 2000).

Due to its geographical location, humid tropical climate, and rainfall ranging between 1,300 and 7,500 mm per year, Costa Rica is considered as one of the wettest country in the world. The Pacific Institute for Studies and Development, Environment and Security in 'The Biennial Report on Freshwater Resources 2006–2007' ranked Costa Rica as the third richest country in regard to supply of water within the Central American region, with 170 km^3 of annual renewable water resources (AyA & OPS/OMS, 2000; FAO, 2000a). It also has the greatest *per capita* access to water. With all these factors in mind, it is clear that the primary concern in Costa Rica regarding water is over its quality as quantity is rarely a limitation in a country that receives enough volume of water annually (except in lowlands of northwestern Costa Rica), but consumes about 6 $km^3 year^{-1}$ (AyA &OPS/OMS, 2000; FAO, 2000a; PEN, 2010).

Degradation and reduction of fresh and ground water has become alarming in the last decades. For example, Thrupp (1990) reported that nation's streams were highly contaminated from organic matter and industrial and domestic effluents, and key aquifers were polluted by garbage dumps and lack of sewer systems. Likewise, indiscriminate pesticides use threatened human health by contaminating food, water, and soil. Two decades later, the situation does not seem to have changed much. Today, these problems are still visible.

Between 1955 and 1999, *per capita* availability of fresh water diminished (Sandoval, 2001). Today, several Costa Rican cities face severe water supply problems during the dry season. Likewise, in the center of the country, 75% of the water supply sources have been qualified as particularly vulnerable (Miranda *et al*., 2007). With all these problems becoming critical year by year, Costa Rica requires to re–design its water policy and management to achieve sustainable development.

The sustainability of hydrologic benefits depends on a variety of factors, such as the level of precipitation, type of soil, vegetation, and topography. However, anthropogenic factors alter forests' ability to catch, recharge, retain, and regulate water fluxes through the ecosystem (OEA, 2005). Although, the relationship between forest cover and water production is not well understood yet, regarding to water quality it is clear: forest cover, in particular in riparian ecosystems and buffers, can maintain the quality of streams, for example, filtering sediments and nutrients from agricultural runoff (Bruijnzeel, 2004; Lorion & Kennedy, 2009). This comprehension about ecosystem functions over quality of water plays in favor of current policy instruments. For example, the strategy established in the Forestry Law 7575 to protect forests' hydrologic services, is beneficial to protect 'water quality' and favorable to achieve sustainable development in tropical mountains (Menhard & Sarmiento, 2010).

Costa Rica has acquired a good knowledge to succeed in developing carbon markets to finance forest conservation. Nevertheless, this achievement primarily responds to global concerns upon climate change whereas local environmental concerns, such as water protection, seem to have received less attention. For example, payments for water conservation are not sufficient to protect threatened watersheds. Indeed, current payments are only made through voluntary contracts with the private sector or consumers who have clear capacity to pay for the protection of environmental services from which they directly benefit. However, in the case of domestic consumers, their social welfare remains threatened by environmental degradation and the lack of conservation programs specifically designed to protect environmental services in their localities. A local PES program appears as an option to solve this problem, although as a policy instrument for watershed protection and management, PES based programs need to be improved to obtain the desired results (Miranda *et al*., 2007). The key to succeed in this type of projects may just require adjusting the models to the social, economic, and environmental characteristics of local scenarios. Therefore, this study attempts, amongst other goals, to obtain valuable information to improve the current PES models.

A brief history of water management in Costa Rica

Deforestation and degradation of hydrologic services are consequences of inadequate land and water management techniques and population growth. However, land–use transformation and water depletion are old environmental problems in Costa Rica. They have roots in historical processes (Thrupp, 1990).

There is archaeological evidence that suggests that the Turrialba Valley was one of the first places in Costa Rica to be inhabited. The first native inhabitants probably populated this region because of the high fertility of soils and abundance of water. The Reventazón River constituted a vital water resource for the development of these first societies. Between 500 A.D. and 1,550 A.D., native communities of the Guayabo culture, for example, developed several hydrologic infrastructures with store works in their dispersed villages such as small reservoirs, channels, and aqueducts. Therefore, water played a decisive role for the development of agriculture, domestic consumption, and provision of various forms of ecosystems services, including cultural and spiritual–related services (Vargas, 2001).

At the beginning of the sixteen century, the first Spanish settlers changed the prevailing patterns of water use. Most Spanish villages were established in the proximity of navigable rivers. It was the beginning of an extensive agriculture, deforestation and mining activity that modified water availability and its quality in the entire country.

During the seventeen century, the number of inhabitants increased especially in Barva, Aserrí and Pacaca regions, within the Central Valley, where San José and Heredia are located today. The increase of water demand led to the first water disputes. For example, the North Pacific region experienced an increase of haciendas dedicated to cattle ranching and they required large amounts of water to maintain the pastures, feed the animals and other related activities. It affected water availability for other consumers (Vargas, 2001). Since then, land value has depended inseparably from water. Water began to be valued as a commodity that increases the economic value of lands.

In 1776, tobacco production started in the Northern San José. It was a successful venture until 1821. Its production brought economic and political benefits to the city. One reason of this success was the abundance of precipitations, fertile volcanic soils, and numerous rivers and ravines. In 1779, coffee production gained relevance for economic development in the country, but its massive production became responsible of the first serious deforestation episode in the country and the loss of several ecosystem services including hydrologic services (Rosero–Bixby & Palloni, 1998).

In the nineteen century, many public works were developed to allow people from the Central Valley to have better access to water and electricity. These improvements, together with the expansion of mining and banana production, increased demand for surface and groundwater. In 1846, several decades after the country's independence, a decree stating the prohibition to cut trees near some key waterways was proclaimed (Steinberg, 2001). This is one of the oldest regulations in regard to water protection. The lack of knowledge and interest in the protection of water quality was common during this period (Miranda *et al*., 2007). For example, although coffee production helped to the country's economic development, its intensive production polluted many water bodies with lixiviates and solid waste (*broza*) that were usually discharged into rivers and streams without any treatment. Also, the lack of sanitary measures and waste–water treatment provoked in 1856 more than 100,000 deaths due to the outbreak of cholera (Vargas, 2001).

Earlier water regulations appeared in the middle of the nineteen century. They were elaborated primarily to guarantee the availability of water in large haciendas for agriculture, cattle ranching, and regulation of navigation between Costa Rica and Nicaragua. The exploration, exploitation, distribution and protection of hydrologic resources were regulated through the 1884 Water Law. A new law was promulgated in 1941, and one year later, the Water Law and the General Law of Drinking Water was issued (Vargas, 2001).

However, the major deforestation in Costa Rica occurred during 1950 and 1980. It was driven primarily by the expansion of pastures to raise cattle especially on marginal lands cut from tropical dry and moist forests (Groom *et al*., 2006). Cattle ranching attempted to satisfy external beef markets, especially through supplying fast food chains in the United States, a phenomenon termed as 'the hamburger connection' (Myers, 1981; Rosero–Bixby & Palloni, 1998; Benavides & Venstra, 2007). During this period, local credit policies favored cattle ranching as well as banana and coffee plantations (Rosero–Bixby & Palloni, 1998). Financial instruments to protect hydrologic resources, such as subsidies to stimulate reforestation, appeared in the 1980s (Miranda *et al*., 2007) only when deforestation, soil degradation, and loss of environmental services became a key concern.

Water depletion became critical at the end of nineteen century when an increase of its demand obligated the society to find and exploit more water resources. The population growth, urbanization, and the advancement of the agricultural frontier affected the quantity and quality of water reducing the welfare of the entire society. Also, water distribution in many regions of Costa Rica was never equitable, especially because of their differences in geographical exposition to a higher level of precipitation such as the Atlantic, Northern, and Southern Pacific region. Most differences in water value and management systems are rooted in these geographical differences. For example, in places with abundant water, Costa Ricans believed that water resources were inexhaustible. This situation did not favor watershed protection. Rather, it created several water disputes throughout the history of Costa Rica (Vargas, 200; Miranda *et al*., 2007).

The rural democratic model

Because water plays a pivotal role in the development of any society, it is necessary to elaborate a social analysis of water to understand human–related factors that affect water management. One of the relevant aspects of the Costa Rican society is the development of a strong rural economy that led to a rural democracy. This is the so–called 'rural democratic model'. A rural democracy or village democracy can be defined as 'A form of direct democracy in which the masses can make their own decisions in matters of their own interests and welfare' (Baogang, 2007). This concept describes the Costa Rican case very well due to its prominent rural life style that has roots in the colonial period (Kohlmann *et al*., 2008).

During the colonial period, there were only large areas of unsettled lands. One of the reasons for this situation was the lack of interest of Spanish settlers in these lands due to the lack of gold and silver, the difficulty of logistics, and marginal production. For this reason, even the Spanish governor in 1719 described the country as 'the poorest and most miserable Spanish colony in all America' (Shafer, 1994). Thus, Costa Rica was largely unappreciated by the

Spanish Crown and left to develop on its own. Consequently, Costa Rica became a 'rural democracy'. However, the characteristics of the rural democratic model in Costa Rica became more evident during the pre–coffee and transitionary periods (Gudmundson, 1986; Kohlmann *et al.*, 2008).

Those characteristics are the following (Gudmundson, 1986):

- High rural dispersion.
- Predominance of small, private and landholding peasantry.
- Social division of labor.
- The birth of agro–export model.
- Egalitarian social order.

High rural dispersion

Prior to coffee culture, population settlements patterns were characterized by significant rural dispersion, with more or less separate and isolated series of peasant households living on the lands that they worked, having little physical or economic contact with their fellow small holders.

Predominance of small, private, landholding peasantry

During the colonial period, most of the new Costa Rican settlers had to work on their own lands, because indigenous people were decimated; consequently, there were no significant labor exploitation, which obligated most of the Costa Rican first settlers to develop their lands by themselves. It prevented the establishment of large haciendas and the exploitation of latinfudio–modeled commodities such as mines, textiles, or grains.

Social division of labor

Coffee, banana, and cattle ranching revolutionized life in Costa Rica, and they stimulated occupational differentiation. Laborer groups appeared, and rapid urbanization occurred.

The birth of the agro–export model

The rate of population growth rose rapidly increasing peasant prosperity with the agro–export model or the proletarization of that same peasantry. Migratory movements occurred with rapid appropriation of outlying areas and expansion of urban nuclei.

Egalitarian social order

Rural democracy created a more or less egalitarian social order. There were no oppressed mestizos, and the indigenous class was practically inexistent (Gudmundson, 1986). Regarding indigenous people, they were significantly decimated, and today, the only remaining groups are the *Chorotegas, Guatusos* or *Malekus, Huetares, Cabécares, Bribris, Terrabas* or *Teribes, Bruncas* or *Borucas* and *Ngöbe–buglé or Guaymies* (BCCR, 2010). It was only after the promulgation of the Costa Rican Indigenous Law No. 6172, in 1977, that their cultural–related rights were officially recognized. In 2000, they represented around 64,000 individuals or 1.5 % of the national population (Solano, 2000).

The characteristics of the 'rural democratic model' are still present in modern Costa Rica in greater or lesser extent. Today, they configure the relationship between society and environment, and the political power that regulates this relationship. This human–environment relationship explains how people value and manage natural resources. Therefore, human dimensions of the environment are critical for an integrative approach to conservation. For example, in tropical mountains, there still exists the belief that valleys are for agriculture, pasturelands, or urban areas (Menhart & Sarmiento, 2010). Consequently, only those forests located in slope lands and remote areas are more likely to survive. However, even those lands in rural areas experience conversion into pasture, a phenomenon known as 'paramization' (Sarmiento, in press). Habitat shredding in these areas also configures irregular landscapes (Feinsinger, 2006). These elements of landscape transformation in tropical mountains require special attention within restoration projects because they are especially linked to anthropic processes with strong historical roots (Kapelle & Brown, 2001; Montagnini & Finney, 2011). Because water is strongly linked to land, any change in landscape configuration affects water resources.

Likewise, the fact that Costa Rica has historically experienced an egalitarian social order is perhaps the origin of the current 'political stability' (Thrupp, 1990) that has influenced the country's willingness to adopt virtually any and all conservation programs promoted by foreign experts (Evans, 1999) without significant dissent from the civil society. This political stability has been critical for foreign countries, NGOs, and scientists to create a long–term relationship and mutual trust with the country. Likewise, the lack of a military structure implies saving a large amount of funds which otherwise would be destined to armament and other army expenditures. Therefore, an image of peaceful democracy in Costa Rica has contributed to the success of conservation efforts, for example, through securing long–term commitments to nature conservation and educational attainment, or attracting tourists looking for safe destinations (Hall *et al*., 2000; Basso & Newcomer, 2009; Gordon *et al*., 2010). Hence, the historical, social and political processes have configured viable paths for the country to adopt policies that have received international recognition for their success. For example, subsidies for conservation are recognized in Costa Rica as superior policies due to their technical applicability and political acceptability (Benavides & Veenstra, 2007). However, the Costa Rican legal system does not explicitly address the property rights over environmental services. Instead, property rights in natural entities are inferred from the elements of the civil code. For example, the owner of the land also owns the trees or forests that grow on the land and the carbon sequestered. Thus, the owner can negotiate the right to sell or manage carbon and can in return reap the resulting benefits (FAO, 2011). The PES program is based on this rationale.

In contrast, countries with similar ecological characteristics, but different historical, social and political structures, such as Ecuador, are still in the process of developing environmental markets; however, market–based approaches to conservation are considered as another way of privatization of natural resources. Consequently, in Ecuador, market–based policies are restricted at the constitutional level.

Institutions, laws and water governance

Costa Rica has enacted different ‘game rules’ regarding water management along its history. Nevertheless, the constantly changing society’s characteristics, in particular, the population growth and the emergence of new systems of natural resource management, have made the regulatory framework become obsolete (Aguilar & Iza, 2001). It is only during the 1980s when soil and water degradation become alarming due to development activities that conservation became a critical issue in the political agenda (Miranda *et al*., 2007). However, hydrologic resources are still regulated by a law enacted 68 years ago (Water Law No. 276 of August 26, 1942) which, despite its reforms, it is unenforceable today except to granting water concessions (Aguilar & Iza, 2001). This law was issued within a social and economic context remarkably different than today. For example, at that time, the population barely exceeded half a million people, and it concentrated primarily in the Central Valley. Today, the population exceeds four and a half million inhabitants (INEC, 2010) who live in dispersed settlements located in valleys, slope lands, and mountains around the country.

Water is still governed by a centralized scheme and vertical management. There exist several laws, regulations, and executive decrees, including water issues, designed by the central government and institutions in San José to address every problem in the country (e.g., Environmental Law 7554, 1995; Forestry Law 7575, 1996 Biodiversity Law 7788, 1998). As a consequence, the current legislation is ineffective for the proper management of surface and groundwater, aquifers, and watersheds (Aguilar & Iza 2001; Miranda *et al*., 2007; Benavides & Veenstra, 2009). The legislation is dispersed. Today, there are more than hundred regulations, amongst international conventions, laws, and decrees regulating water resources. Also, most laws distribute responsibilities about water management upon more than twenty different institutions (Aguilar & Iza 2001). Likewise, most of these laws focus on administrative processes rather than true mechanisms to implement conservation (Aguilar & Iza, 2001). Alternatively, the new Hydrologic Resources Law that is being discussed by the Costa Rican Congress encompasses integrative approaches to the conservation of hydrologic resources (Benavides & Veenstra, 2009). However, its approval is pending and depends on political consensus amongst stakeholders.

Some key institutions involved in water management are the following: the Ministry of Environment, Energy and Telecommunications (MINAET), the National Fund for Forest Financing (FONAFIFO), the National System of Conservation Areas (SINAC), the Costa Rican Institute of Electricity (ICE), the Costa Rican Water and Sewer Institute (AyA), the National

Ground Water, Irrigation and Drainage Service (SENARA), municipalities, Water & Sewer Communitarian Associations (ASADA), Water & Sewer Rural Committees (CAAR); and, the Heredia Public Service Company (ESPH). However, for the context of this study, the key players are described below.

National Fund for Forest Financing (FONAFIFO)

The PES program is managed by FONAFIFO, a governmental agency with a semi–autonomous management system (Pagiola, 2007; Ruso, 2010). The legal framework that regulates FONAFIFO is established in the Forestry Law 7575, Art.46. Specifically, FONAFIFO's responsibilities include financing forests' protection, afforestation, reforestation, tree nurseries, agro–forestry systems and any action that helps to restore forest ecosystems. This agency is in charge to collect the revenues generated by the payment of environmental services. FONAFIFO's governing board is composed by representatives from the Ministry of Environment and Energy, the Ministry of Agriculture, the National Banking System, and two representatives from the private forest sector (Russo & Candela, 2006; Pagiola, 2007; Russo, 2010; FONAFIFO, 2010). FONAFIFO enjoys a relative degree of autonomy managing funds. However, it is directly subject to governmental regulation. Its budget is arranged and approved by the Ministry of Finance, and payment levels are set annually by executive decree depending on the level of involvement of landowners in the PES Program (Pagiola, 2007).

The Costa Rican Water & Sewer Institute (AyA)

The AyA is a governmental institution created by the Law No. 2766 on April 14, 1961. The AyA establishes the policies related to the administration, planning, and financing water and sewer systems. Therefore, it has the authority to approve, regulate, and monitor the quantity, quality, and price of public water services. The AyA directly administers water systems in urban areas, or delegates its responsibility to local governments. It provides drinking water to 2'257,400 users (half of the nation's population) and administers 178 aqueducts. Ninety eight percent of this service is potable water (Mora & Portuguez, 2010; Astorga, 2010).

Rural Water & Sewer Administrators

In rural areas, Water & Sewer Communitarian Associations (ASADA) and Water & Sewer Rural Committees (CAAR) are groups of operators or committees that manage local water and sewer systems. The difference between them is that, unlike ASADAs, CAARs have no delegation agreement with the AyA. However, all CAARs are in the process of becoming ASADAs. ASADAs and CAARs provide water to 27.5% of the nation's consumers and administer 1,864 aqueducts (81% of total aqueducts) (Mora & Portuguez, 2010; Astorga, 2010). Municipalities also provide water to 16.7% of consumers and administer 248 aqueducts. However, around 30.3% of water provided by ASADAs and CAARs, and 20.6% by Municipalities is not potable water (Mora & Portuguez, 2010).

Heredia's Public Services Company (ESPH)–PROCUENCAS

Heredia's Public Services Company (ESPH) is a joint–stock company that provides drinking water to three municipalities: Heredia, San Rafael, and San Isidro within the

PROCUENCAS Project (9°59’47”N; 84°7’0”W) (Redondo–Brenes & Welsh, 2006). Today, PROCUENCAS is considered as a case of success of a PES program for hydrologic services protection locally–funded by an imposed water conservation fee and administered by a joint–stock company. This project protects the existing natural forests, promotes natural recovery of forests, and support reforestation in upper micro–basins including the Ciruelas, Segundo, Bermúdez, Tibás and Pará rivers (Bolaños, 2003). Currently, the ESPH serves 50,000 water consumers and delivers 15.5 x 10^6 m^3 year $^{-1}$ of water for household consumption. The average use of water by a four–members Costa Rican family is 1,000 L day^{-1}, or two thirds the amount of water used by a four–members American family (1500 L day^{-1}) (EPA, 2010). Current demand for water from agro–industrial sectors (e.g., coffee, dairy farms and flower cultivation) amounts to 76.24 x 10^6 m^3 $year^{-1}$. Although water is not scarce in the area, its demand is growing (Porras & Neves, 2006). In total, hundred percent of consumers receive potable water, and 1,000 hectares of land with hydrologic importance are protected under the PROCUENCAS Program.

According to Redondo–Brenes & Welsh (2006), the success of PROCUENCAS is attributed to its efficient management by the joint–stock company (ESPH). The ESPH’s management strategy implies prioritizing conservation areas at a local scale, avoiding bureaucratic requirements for land and forest owners to participate in the program, focusing on local and direct benefits, and reducing administrative costs (Bolaños, 2003). The success of this program has been crucial for future proposals of PES schemes that are seeking to finance conservation of hydrologic services through a water conservation fee. Nevertheless, more studies on ecological economics are necessary to assess the viability of these types of policies in other regions with different scenarios.

Problem Statement

Although environmental services markets are gaining momentum and increasing awareness amongst academics and policy–makers, the lack of economic analysis is becoming more critical (Landell–Mills & Porras, 2002). Lack of economic information leads to inadequate ecosystem management techniques. However, the primary reason why ecosystem management does not succeed is that markets fail to value ecosystems' benefits (Bond, 2007). Current markets are characterized by unsophisticated payment mechanisms, low levels of price discovery, high–transaction costs, and low trading (Landell–Mills & Porras, 2002). The PES Program in Costa Rica is not exempt from these weaknesses especially regarding the protection of hydrologic services at local scales. Therefore, it is imperative to find innovative and efficient mechanisms to sustain environmental services markets consistent with the social and economic reality of localities. Water has multiple uses and values; therefore, changes in supply and quality could have different economic effects on households, farms, communities, and firms (Young, 2005). Therefore, a water conservation policy should consider all economic aspects of water, including its human dimension. Benefits of environmental services should not be overvalued nor underestimated.

In addition, there are differences between how developed and developing countries value their forests and environmental services. For example, while developed countries are paying more attention to carbon capture and climate change mitigation, developing countries are still facing problems of poverty and equity. Thus, environmental concerns in developing nations have different social dimensions. In Costa Rica, for example, the PES Program responds remarkably well to the needs of developed countries that focus their attention on global carbon markets (Castro &Tattenmach, 2000). However, local users of environmental services are more concerned about issues that affect them in the short run, such as water availability and quality. For cases like this, in which local needs require urgent attention, conservation programs are scarce.

This study attempts to measure the economic value of hydrologic services generated by tropical mountain forests and related ecosystems in two localities of Costa Rica. By using the Contingent Valuation Method, I assessed how people value water and what their willingness–to–pay is to protect forests' hydrologic services. Results can be used to assess the viability to implement a local PES Program to protect hydrologic services from anthropogenic stressors and maintain social welfare.

Objectives

1. To estimate the mean willingness–to–pay (WTP) of water users for the conservation of hydrological services.
2. To determine the cost and benefits of a conservation program of forests' hydrologic services.
3. To assess the viability to finance a conservation program through a 'water conservation fee'.

Study Sites

Two cantons in Costa Rica, Turrialba (9° 54' 0" North; 83° 41' 0" W) in Cartago Province (1,604 km^2); and, Guácimo (10° 13' 0" N; 83° 41' 0" W) in Limón Province (576 km^2) were considered for the economic valuation. The approximate number of inhabitants in both cantons for 2010 was 118,188 (INEC, 2010). Both are rural localities characterized by intensive cultivation of coffee, sugar cane, pineapple, and pasture for cattle ranching. Therefore, there is a strong land–cover change rate that impacts forests' hydrologic services. Life zones are tropical moist forest, tropical wet forest, and tropical pre–montane wet forest (Sawyer & Lindsey, 1971). Precipitation at this region varies from 2,500 to 3,500 mm year^{-1} (Kohlmann *et al*., 2008). The study sites are located in the 'Volcánica Central' Mountain Range, close to the Turrialba Volcano (3,340 m.a.s.l.). Predominant geological materials are sedimentary rocks from the Tertiary period. The geomorphology in Turrialba is irregular with deep slopes and abrupt changes of gradients. In contrast, Guácimo presents more regular terrains. Altitude in Turrialba City is 640 m., whereas in Guácimo is 114 m. (IFAM/IGN, 1985). The area of the study is located in the Reventazón Parismina River Basin. Costa Rica ranks about 20th among nations in the world in term of its biodiversity, and it possesses about 5% of the world's total species, many of which are endemic (Kohlmann *et al*., 2008).

The survey was developed during June 2010 in twelve localities: San Rafael, La Margot, Tres Equis, El Veroliz and La Suiza, in Turrialba Canton; and, Guácimo Centro, Los Geraneos, Santa Paula, Pocora, Palmitas, Aralias and Los Colegios, in Guácimo Canton. These rural villages are dispersed around the principal urbanized villages, but the entire region is rural (Fig. 1.1).

CHAPTER 2

THEORY AND METHODOLOGY

The Contingent Valuation Method (CVM) is a survey–based methodology for eliciting values people place on goods, services and amenities (Mitchell & Carson, 1989; Boyle, 2003). It involves asking people that they will be willing to pay contingent on some hypothetical change in the future state of the world (Young, 2005). Over the past two decades, the use of CVM to measure willingness–to–pay (WTP) has been well accepted in social science research. It has also been widely used in developing countries (Tapvong & Kruavan, 1999).

I used the CVM to determine the willingness–to–pay (WTP) of water users for the conservation of forests and their hydrological services within a hypothetical market of environmental services. The application of this methodology was adjusted to the characteristics of the developing country, especially by constructing CV scenarios consistent with the local context and considering all ethical issues in conducting the study. In particular, issues related to the informed consent, confidentiality and avoidance of risks related to human subject research were carefully treated (Whittington, 1998). I followed the guidelines of the NOAA Panel on Contingent Valuation to design, conduct, and develop reliable estimates of non–use values (Arrow *et al*., 1993; Haab & McConnell, 2003). The steps in conducting the CV study were those described by Boyle (2003):

1. Identify the change (s) in quantity or quality to be valued.
2. Identify whose values are to be estimated.
3. Select a data collection mode.
4. Choose a sample size.
5. Design the information component on the survey instrument.
6. Design the contingent–valuation question.
7. Develop auxiliary questions for inclusion in the survey instrument.
8. Pretest and implement the survey.
9. Develop data analysis procedures and conduct statistical analyses.
10. Report value estimates.

Description of alternatives: *status quo* and alternative situation

The Payment for Environmental Services Program in Costa Rica is designed, amongst other objectives, to protect forests' ability to catch, recharge, retain, and regulate water flows (hydrologic services). Water provides multiple consumptive and non–consumptive uses. However, to analyze the effect of a policy instrument over hydrologic services, I focused on the consumptive use of water, in which its quantity and quality are attributes of ecosystem's components and functions. The current condition of hydrologic services, or *status quo*, is determined by the current ecosystem's status (e.g., deforested, fragmented, or degraded). In the subsequent situation, or the alternative situation (after application of a policy), the condition of hydrologic services is determined by the subsequent ecosystem's status (e.g., restored through conservation programs, such as the PES, or policy instruments). Therefore, the change in hydrologic services status, after the application of a policy, can be assessed by measuring the changes in one of the attributes of ecosystem's components and functions, quantity or quality. For example, increased water quality is an expected result after the application of a conservation policy (Fig. 2.1).

Determination of individual welfare change measure

For simplicity, I use quantity as a measurement of quality. In the *status quo*, a consumer needs to pay a certain amount of money to the administrators of the water supply system, through an imposed water tariff, to bring water from the forests into household's faucets. It implies that the consumer will experience a certain level of utility that is related to the quantity of water that he or she receives monthly, the cost of the public service, and the consumer's income. However, the quality of this service is vulnerable to degradation of hydrologic services. Therefore, the *status quo* can be defined by:

$U^0 = v(P^0, Q^0, M^0)$

where:

$U^0 =$ Initial level of utility, P^0 = initial price of the service, Q^0 = initial quantity of the service; and, M^0 = initial level of income.

In the alternative (subsequent) situation, reforestation and conservation efforts will result in an increase of Q:

$U^1 = v(P^0, Q^1, M^0)$

Therefore, the application of a policy instrument will result in an increase in welfare:

$v(P^0, Q^1, M^0) > v(P^0, Q^0, M^0)$

With an increase in Q, we can take away Compensating Surplus (CS) in order to bring the consumer back down to his or her initial level of utility, U^0:

$v(P^0, Q^1, M^0 - CS) = v(P^0, Q^0, M^0) = U^0$

In Fig. 2.2, CS is the distance between Y^0–Y^1

CS can also be defined in terms of the expenditure function (Fig. 2.2). Here, quantity of water is in the horizontal axis and price in the vertical axis. CS is the area bellow the inverse Hicksian demand function at initial utility level U^0 (the consumer's right) or the marginal willingness–to–pay (*WTP*) function $WQ=b(P, Q, U^0)$, and between Q^0 and Q^1 (shaded area).

CS is found by integrating the inverse Hicksian demand function (*WQ*) with respect to Q (water quantity):

$$\left| \int_{Q_0}^{Q_1} b(P, Q, U^0) dQ \right| = \left| E(P, Q, U^0) \right]_{Q_0}^{Q_1} \right| = \left| E(P, Q^1, U^0) - E(P, Q^0, U^0) \right| = CS = WTP$$

Where,

$$\frac{dE(P, Q, U^0)}{dQ} = b(P, Q, U^0)$$

In conclusion, the theoretically appropriate individual welfare change measure for this study is 'compensating surplus for a quantity increase'. We could also use willingness–to–accept (WTA) compensation for a decrease in Q, after making the corresponding assumptions; however, the NOAA Panel recommends the use of the WTP format instead of WTA because the former is the conservative choice (Arrow *et al*., 1993; Haab & McConnell, 2003).

Relevant population

Mitchell and Carson (1989) assert that payments for most public goods are made at the household level. Therefore, in this study 'household' is considered the response unit. The relevant population is constituted by all water users; although, agricultural, industrial, and recreational uses are not a priority for 98% of respondents for whom domestic consumption is more important.

Data Collection Mode

The data was collected on–site through individual, structured, and standardized interviews, between 5 and 25 of June, 2010, in various communities selected randomly. All households were visited without previous announcement. Prior to the individual interview, the researcher explained to the household's spokesperson what the purpose of the study is, and proceeded with the CV questionnaire only after the respondent understood the study and agreed to continue with the interview. From a total of 358 attempted interviews, 47 individuals (13%) declined to participate.

Sample size

In the 70s and 80s, one–hundred observations were well accepted in CV studies. Today, there are no problems to publish results with 300, 400 or 500 observations. Samples of 800, 1,000 and 1,200 are large; 2,000 and 3,000 observations are exceptional. Large–scale surveys, for example, have 20,000 observations, but almost no CV study uses such sample size (Riera, 2000). Champ (2003) suggests 380 observations for a typical non–market valuation. However, the survey was developed according to the budget and time available. A total sample of 311 responses (including protest–zero and non–protest–zero) was finally obtained. The software 'Optimizing System for Sample Size' (SOTAM) (Manzano, 1996) indicated that 311 observations give a 0.05 level of significance level and a 0.05 level of sampling error. Therefore, 311 is a reliable sample size for statistical analysis. Also, the mode of sampling (in–person survey) requires smaller sample size than those of less expensive and less intensive surveys such as mailed surveys.

Method of provision and payment vehicle

Because there are various providers of water services (AyA, Municipalities, ASADAs and CAARs), interviewees were asked to identify which agency provides them with the service, and the current tariff that they pay for it. I made clear to interviewees that the administrative agency that currently provides them with the service would be in charge of the hypothetical change in the service. Also, I explained to them that the payment mechanism would be the existing water bill which would include a water conservation fee.

WTP elicitation format

For each interview, I used a Single Bounded Dichotomous–Choice (SBDC) bid, using a payment level randomly selected from a predetermined set of payment levels. It was followed by an open–ended question eliciting the maximum willingness–to–pay (Appendix A).

The dichotomous–choice approach (DC) is recommended by the NOAA Panel on Contingent Valuation because it is considered closer to a free market (Arrow *et al.,* 1993; Hanley, 2000). The standard dichotomous–choice method is based on Hanemann's (1984 & 1989) Random Utility Maximization (RUM) model. With RUM, economic agents provide 'yes' or 'no' responses if they are asked whether they would be willing to pay to finance a program to improve the environment (Jin *et al.*, 2008). However, other studies assert that dichotomous–choice questions tend to overestimate the WTP, especially for studies conducted in low–income countries (Bateman *et al.*, 1995; White & Lovett, 1999). One cause of such overestimation is that the DC format might result in symbolic votes in favor of the environmental program, not because the respondent would pay the hypothesized price for it, but rather to register his support for the program (Brown *et al.*, 1996). The DC format may also encourage 'yea saying', whereby the hypothesized bid is accepted as a cue of what is a reasonable payment (Mitchell & Carson, 1989; Kanninen, 1995). Therefore, to increase the reliability of statistical results of this format, a larger sample is required (Mitchell & Carson, 1989). However, due to time and budget constraints, especially related to the difficulty to develop a survey in rural communities characterized by highly–dispersed households, the DC and the open–ended format were combined. The open–ended format has the advantage to measure WTP directly, constituting a good check when it is used in conjunction with other formats such as the DC (Gunatilake *et al.*, 2007). However, neither format is superior on a *priori* grounds (Hanley, 2000) because both methods have advantages and disadvantages.

The questionnaire incorporated a section of socioeconomic characteristics of all respondents to assess the validity of responses as well as to know consumers' attitudes towards the proposed conservation program. Also, socioeconomic characteristics were used as explanatory variables in two regression models (OLS and logit). WTP values were obtained in local currency or colones (₡) (₡517.00 = US$; 1.00 as of June, 2010).

Statistical analysis

Most common best–fits for DC yes/no data with a WTP distribution censored at zero have been achieved with maximum likelihood estimation methods such as logit, probit or Tobit models (Ojeda *et al*., 2008; Jin *et al*., 2008). I applied the logit model to fit the yes/no answers. The observations that resulted from the open–ended question (maximum willingness–to–pay) were analyzed through Ordinary Least Square (OLS) regression. The OLS helped to determine the robustness of the model. To determine whether the mean WTP responses for a given independent variable were statistically significant or not, I used t–test and one–way analysis of variance (ANOVA). This information allowed to identifying which independent variables were determinants for the WTP. I used NLOGIT 4.0® and MINITAB 15® for data mining.

From a total of 311 observations, one was excluded because its income level was largely inconsistent with the rest of the sample. Likewise, 19.3% of observations were excluded from the analysis because the ratio of the revealed WTP to income exceeded 5% (FAO, 2000). Likewise, protest–zeros were rejected, and only true zeros were kept. Finally, 208 observations were considered for the analysis.

Measuring Mean WTP

The probability that the individual will accept an offer X can be expressed by the following logit model (Hanemann *et al*., 1991; Jin *et al*., 2008):

$$P_i\,(yes) = F_\varepsilon(\Delta V) = \frac{1}{1 + exp(-\Delta V)} = \frac{1}{1 + exp[-(\alpha + \beta X)]}$$

where α and β are coefficients to be estimated and X is the amount of money the respondent is asked to pay. At a minimum, the coefficients include the bid amount the individual is asked to pay. Additional coefficients are obtained from the respondent's demographic information (Giraud *et al*., 2002; Jin *et al*., 2008).

The logit model is estimated using the maximum likelihood estimation method. The log–likelihood function is (Jin *et al*., 2008):

$$Log\ L = \sum_{k=1}^{N} I_k\ ln\, F_\varepsilon\ (\Delta V_k) + (1 - I_k)\ ln(\ 1 - F_\varepsilon\ (\Delta V_k))$$

Where I_k is an indicator variable for observation. If the answer is yes, I_k =1; otherwise, I_k =0.

The mean WTP is determined using the following formula (Haneman, 1989):

$$Mean\ WTP = -\frac{\alpha}{\beta}$$

Where, β is the coefficient estimate on the bid amount and α is either the estimated constant (if not other independent variables are included) or the grand constant calculated as the sum of the estimated constant plus the product of the coefficient estimates on other independent variables and times their respective means (Haneman, 1989; Giraud *et al*., 2002; Jin *et al*., 2008).

The linear model gives the basic relationship to obtain the mean WTP directly:

$$Mean\ WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ \ ...\ \beta_n X_n$$

Where, β_i is the estimated coefficient and X_i is the mean value of the explanatory variable such as the respondent's demographic information (e.g., age, education, income, gender, family size, etc.) or attitudes towards the proposed conservation program or policy.

CHAPTER 3

EMPIRICAL RESULTS AND DISCUSSION

Individual and household characteristics

The survey revealed that 98% of the sampled population uses water for household consumption, followed by agricultural, industrial, commercial, and tourist consumption. This result is consistent with the fact of developing interviews in areas of agglomeration of urban and rural settlements where household consumption is usually high. However, most interviewees do not own lands even though they live near farmlands and forests (around 1km). Therefore, valuation of forest's hydrologic services for uses other than household consumption is underestimated in this study.

Water users receive the service from the following systems: Municipal Water Systems 54.98%, ASADAs 17.68%, and AyA 15.75%. The remaining 11.56% do not receive the service and obtain water from alternative sources (e.g., spring, tank, water well) (Fig. 3.1). This result is consistent with the national data reported by Astorga (2010), in which 83.4 % of Costa Ricans receive treated potable water.

Despite this important service coverage (and relative abundance of water), consumers have a perception of 'decreasing water availability'. Possible reasons of this perception are the increase of water consumers, the high level of water leakage, waste of water, and depletion of water quality. In Turrialba, for example, aqueducts are 50–70 years old, made of iron, and vulnerable to leakages. Likewise, most households lack water meters, which makes people to waste water making difficult to determine the real demand of water. Only 12% of respondents had an idea about how much water they are using per month. In regard to depletion of water quality, the most notable cases close to the sampling areas are El Cairo, Milano and Luisiana de Siquirres aqueducts, which since 2003 have suffered contamination with pesticides, such as Bromacil and Diuron, commonly used in pineapple plantations (Astorga, 2010). This situation has made people look for new drinkable water sources upstream where water quality can still be found. Therefore, consumers recognize the protective value of forest cover for enhanced water quality (Bruijnzeel, 2004; Pagiola, 2007). These anthropogenic factors influence the economic value of environmental services. Likewise, the levels of efficiency of agencies, in charge of water management, affect the economic value of water. This could be one of the reasons why a significant number of observations resulted in protest–zero responses such as ‘I do not trust in the government’ or ‘private companies should pay for it’, when interviewees were asked whether they will be willing to pay for a conservation program. However, 98% of respondents considered necessary to develop a conservation program although there were disagreements about who should pay for it.

Respondents’ attitudes towards environmental services and PES program

Environmental services provided by forest ecosystems have different levels of importance for local people. Hydrologic services represent 44.1%, oxygen production 19,3%, biodiversity protection 14.1%, microclimate regulation 10%, timber production 1.6%, carbon capture 1.3%, erosion control, 1.6%, recreational services 1%; and, other environmental services 2.3% (flood and pollution control, and food) (Fig. 3.2).

The vast majority of the population was capable to link forest cover with the maintenance of at least two environmental services. This result indicates that Costa Ricans are conscious about the importance of protecting forests. It also suggests that environmental education and conservation promotion have influenced positively in Costa Rican's perceptions about conservation. In contrast, information about the PES Program does not seem to have been widely socialized. For example, 87% of interviewees declared not being familiar with the PES Program, whereas 13% declared to have some information. However, those who declared to know the PES Program were unable to identify its goals, in any case. Though, this result is not surprising. For example, Del Camino *et al.*, (2000) indicated that PES Program is not well understood by most Costa Ricans, including members of government, and bilateral and multilateral organizations. Moreover, information about the PES Program seems to be provided only by request from those people interested in participating in the program (land and forests owners). There is no proactive campaign to socialize and promote the PES Program not even to inform its conservation achievements. For example, many people do not know that, for every purchase of gas, they are paying an eco–tax which finances most part of the PES Program. As a result, people do not pressure the government to allocate the full revenues from this tax to forests' protection (Del Camino *et al*., 2000; Russo & Candela, 2006).

Demographic information

According to the survey results, an average family is constituted by 4 members, with a mean age of 42 years. The average income is ₡19,877.00 month^{-1} (US$ 383.13). The average educational level is between elementary school and high school. Specifically, 47.11% has elementary education and 27.40 % secondary education. The mean number of years that respondent has lived in the sampled area is 25 years. Each household pays for the water service an average of ₡ 4,301.28 (US$ 8.32) month^{-1}. Seventy–one percent of respondents were women.

The socioeconomic characteristics of the respondents and variables used in the study are presented in Table 3.1:

Outliers and Protest–Zero Bidders (PZ)

From a total of 311 observations, one was excluded because its income level was largely inconsistent with the rest of the sample. Likewise, some observations were excluded from the analysis if the value of the ratio of the revealed WTP to income exceeded 5% (FAO, 2000). In the raw data, 19.3% were unrealistic WTP values. Also, protest–zeros were rejected, and only true zeros were kept.

There exists no well–established or standard method for identifying protest bidders, and it is typically done using an *ad–hoc* approach (Jorgensen *et al*., 1999; Boyle & Bergstrom, 1999). In the survey, the PZ bidders were identified by asking them the reason why they were not willing to pay. Most common reasons for choosing the *status quo* were 'private companies should pay for it', 'I do not trust in the government', 'current tariff is fine', 'I would pay once, but not all the time', and, 'I do not know'. Only those negative responses related to the financial situation of interviewees (e.g., I cannot afford to pay the extra expense), were considered true zeros, genuine zero–bids or non–protest–zero. In the initial raw data, 13.5 % were protest–zero bidders.

Dichotomous–choice and open–ended answers

After eliminating outliers (observations in which WTP values were greater than 5% of corresponding income) and protest–zeros responses, a total of 208 observations were considered for the analysis. The DC approach resulted in 92 'YES' responses, and 116 'NO' responses. The follow–up open–ended approach revealed that from a total of 92 'YES' responses 64 accepted the originally proposed bid amount as the maximum WTP, and 28 were even able to increase the WTP. Whereas, from a total of 116 'NO' responses 84 were lower WTP values (in comparison with the originally proposed bid–amount), and 32 were non–protest–zeros or true zeros (Fig. 3.3). The important number of 'NO' responses suggests that there is no starting point bias, although the effect can go in either direction (Carson *et al.*, 1985).

The average WTP from the dichotomous–choice is ₡ 2,395.19 (US$ 4.63) per month. It was calculated as:

$$\frac{1}{N}\sum_{i=1}^{N} X_i Y_i$$

where N is the total number of responses (N=208), X_i is the bid level, and Y_i is the number of 'yes' responses to that bid level (Ojeda *et al*., 2008).

WTP distribution

The results of the open–ended question indicate that the average WTP is ₡ 3,903.17 (US$ 7.54) per month. The mean WTP from the open–ended question is notably higher than the mean WTP calculated from the dichotomous choice question. It happens because some respondents who accepted the initial bids were also able to extend their maximum WTP, whereas a large proportion of respondents, who did not accept the initial bid, chose a lower WTP than the initial bid. The distribution of WTP obtained from the follow–up open–ended question is shown in Fig. 3.4, and it appears to be normally distributed. However, the Kolmogorov–Smirnov normality test indicates that p value is lower than the selected α level. Therefore, I rejected the null hypothesis and concluded that the sample does not follow a normal distribution (Fig. 3.5). However, it is pertinent to mention that due to the consumer's random preferences, if we draw another sample from the same population, we would obtain another WTP average (Haab & McConnell, 2003).

Statistical and bid curve analysis

Multivariate linear and logit regressions of WTP versus eight explanatory variables were fitted for the analysis of the maximum WTP and DC responses. Two hundred eight observations, including non–protest zeros, were used for both models.

The t–test and the one–way ANOVA test showed that the *p* values of five out of eight explanatory variables were lower than the critical *p* values, at least at 0.05 level of significance, including AGE, TARRIF, BIDAMOUNT, INCOME, and YEARSLIVE. Therefore, the null hypothesis that mean WTP is equal across different groups for these variables was rejected. Consequently, these variables have a significant influence in the WTP response. In contrast, variables GENDER, FAMYMEM, and EDUCATION do not seem to affect the WTP response (Table 3.2).

Variable AGE was expected to have a positive influence in the WTP, however, its negative sign in the models' coefficients indicates that respondents were more likely to give a lower WTP value as the their age increased.

Variable TARIFF has a negative sign as expected for both models, implying that those who pay a higher tariff of water would be willing to pay less for a conservation program than those who pay a lower tariff of water or pay nothing. For policy makers, this result highlights the importance to design a water tariff consistent with the type and quality of the public service and coherent with the local economic characteristics. Therefore, water tariff determination should not be based on studies made in places with different socioeconomic characteristics or imposed nationally by a centralized political decision. WTP may vary between places with different water tariff, and different socioeconomic characteristics such as in a rural or urban environment. Likewise, in many rural aqueducts, tariff of water is established by consensus through local assemblies sometimes based on inaccurate economic assessments. Despite its legitimacy, the established water tariff may not be economically adequate. For example, in many rural areas, consumers pay an expensive water tariff comparable to San José, despite their incomes are relatively low in contrast to urban consumers. For the economic valuation, water tariff is a potential source of bias because consumers can consider it as the referential value of their WTP. However, variable TARIFF appears significant only in the linear model ($p<0.1$).

Variable BIDAMOUNT has a negative sign, as expected. WTP decreases as the bid amount increases. Bid values were designed in such way that they were consistent with the local economy; however, the high level of negative responses suggests that proposed bids were high. Nevertheless, through the open–ended question the majority of interviewees were able to state a lower value of WTP although it is not possible to know to what extent respondents still used the bid value as a referential WTP value.

As in many CV studies, variable INCOME has a positive sign and significant influence in the WTP in both models, showing that results are consistent with economic theory ($p<0.000$) (Fig. 3.6). However, it is necessary to mention that prior to the analysis, around 19.3% of WTP observations in the raw data were considered unrealistically high; therefore, they were dropped

Variable YEARSLIVE, the number of years a respondent has lived in the area, significantly influences the WTP. Individuals who have lived several years in the area may have witnessed the long–term impacts of land–cover change, recognizing the relationship between loss of environmental services and loss of welfare. In fact, many respondents had anecdotal information about the loss of forests, biodiversity, and water resources, linking these problems to the development of agriculture. They recognize the importance to develop a conservation program.

Variable GENDER has no influence on the WTP. Although 71% of respondents were women, there is no evidence to assert that there are differences in mean WTP between men and women. This result suggests that men and women benefit equally from hydrologic services; although a gender approach should be used to study more deeply this assertion. EDUCATION and FAMYMEM (number of family members) have no effect on the WTP. The mean WTP, across groups of different educational levels and family size, respectively, are not significantly different.

The Hosmer−Lemeshow test for goodness of fit for logistic regression indicated that there is insufficient evidence to claim that the model does not fit the data adequately (the null hypothesis of an adequate fit is not rejected) ($X^2_{.95}$=11.48; df=8; p=0.178). The adjusted R^2 of the linear and logit models are 0.233 and 0.342 respectively. According to Mitchell & Carson (1989) ‘the reliability of a CV study which fails to show an R^2 at least 0.15, using only a few key variables, is open to question’. Therefore, I conclude that, in this study, both models are reliable. Also, the similarity between these two models indicates that the WTP–determinant relationships are robust (Table 3.2).

Measuring mean WTP

The estimated coefficients obtained from the multivariate linear and logit regressions and the mean values of explanatory variables were used to determine the expected value of individual WTP E(WTP). Results indicate that the mean WTP is ₡ 6,044.16 (US$ 11.69) to the logit model, and ₡3,902.14 (US$7.54) to the linear model. The mean WTP of the logit model is greater than the mean WTP of the linear model.

The mean WTP value obtained through the logit model is consistent with common findings of CV studies based on DC approach. For example, published CV studies comparing open–ended to DC questions have shown that values from the dichotomous choice method equal or exceed those of the open–ended method in every case (Balistreri *et al*., 2001).

Relation of the mean WTP with the current tariff and water

The mean WTP values from the multiple linear regression and binary logit regression represent, respectively, 56.48% and 87.49% of the current water tariff, and 2.6% and 4.0 % of median income (₡150,000.00; US$ 290.13). The water tariff used in this study is ₡ 6,908 (US$13.36). This is a fixed price for monthly household consumption (Table 3.3). Ortega *et al.*, (2009) used a probit analysis in a CV study to measure households' willingness–to–pay higher water bills for a local PES program to adjust upstream land use practices to protect downstream water quality, close to the area of this study. His results indicate a mean WTP of ₡ 2,300 per month per household, equivalent to 227% of the tariff of water (₡ 1,015) or 2% of the median income (₡ 115,000.00) in 2006.

Cost–Benefit Analysis (CBA)

Payments for environmental services are based either on their value to consumers or on the opportunity cost of providing them (Muñoz–Piña *et al*., 2008). Payment levels to providers of environmental services, within the PES Program, are based on the opportunity cost of not developing the land and using it in conservation alternatives. However, these values can vary depending on location, type of land, land–use practices, and fluctuations of the economy. For example, the opportunity cost of cattle ranching varies between US$ 8.00 and US$ 158.68 ha^{-1} $year^{-1}$ (Cordero, 2001; Arroyo–Mora *et al*., 2005). Agriculture opportunity cost is around US$ 662.00 ha^{-1} $year^{-1}$ and forestry opportunity cost is around US$ 55.00 ha^{-1} $year^{-1}$ (Barton *et al*., 2009). However, the main competing land use, relative to conservation, is cattle ranching (Miranda *et al*., 2003; Sánchez–Azofeifa *et al*., 2007; Benavides & Veenstra, 2009; Montagnini & Finney, 2011). Opportunity cost of cattle ranching has been commonly used to establish the payment levels for beneficiaries of the PES Program. For example, the Heredia's Public Services Company (ESPH) included the cost of opportunity of cattle ranching into the cost–benefit analysis that determined the tariff and payment level for the protection of watershed services in the Province of Heredia (Cordero, 2001; Montagnini & Finney, 2011). Hitherto, this is the only project in Costa Rica in which a municipal water supplier system is privately administered. The ESPH charges a water conservation fee to its consumers within a PES scheme. However, nationwide, payment levels and priorities regarding the PES Program are set annually by executive decree (Pagiola, 2007). For example, at the beginning of the PES Program, payments for forest conservation were about US$43 ha^{-1} $year^{-1}$, while payments for timber plantations were US $550 ha^{-1} during 5 years. In 2006, payments for forest conservation increased to US$64 ha^{-1} $year^{-1}$, and US$816 ha^{-1} for plantations, during 5 years. By 2010, payments for forest conservation increased to US$ 87 ha^{-1} $year^{-1}$, and US$ 980 ha^{-1} for plantations, during 5 years (Table 3.4). For contracts beginning in 2010, a presidential decree was issued to incorporate 23,244 hectares of land to the PES program distributed in the following categories: reforestation, natural regeneration under Clean Development Mechanism (CDM), natural regeneration (non–CDM), forest protection (including forests with hydrologic importance), and agroforestry systems. Therefore, for contracts signed in 2010, an investment of US$ 10’880,140 is necessary, during a five–year period, to make forests and landowners stop developing their lands and participate in the PES Program (Table 3.4). According to the Executive Decree Nº 35762–MINAET, published in February 2010, one thousand hectares of forests with hydrologic importance, nationwide, were approved to be protected by the PES program (FONAFIFO, 2010). Beneficiaries of the program, forest owners who decided to participate in the conservation program instead of developing their lands, are receiving an annual payment of US$ 80.00 per hectare during five years. This is the referential cost of conservation used in this study (Table 3.4).

An estimate of the total value of the welfare change for the population from which the sample was drawn (economic benefit) can be obtained by calculating the mean WTP and multiplying it by the total population (Freeman, 2003). Thus, in this study, the linear and logit model gives an annual approximate estimate of 2.3 and 3.6 million dollars respectively (relevant population adjusted to the percentage of valid responses and households constituted by 4 members). Theoretically, financing a program to protect hydrologic services through a water conservation fee is feasible. This result is similar to the findings by Ortega *et al.*, (2009) who assert that local demand for conservation is not an obstacle for using locally financed PES approaches as a mechanism for the protection of watershed and associated ecological services.

Environmental, social, and ethical considerations

Competing land uses have not favored forests conservation in Costa Rica during the last several decades; therefore, effective public policy instruments are necessary to stop forest loss and depletion of environmental services (Sánchez–Azofeifa *et al*., 2007; Benavides & Veenstra, 2009). In the case of hydrologic services protection, PES programs need targeting efforts as well as the resources generated be spent within the same watershed where they are produced (Pagiola, 2007). In the hypothetical scenario in which the proposed policy is implemented within the area of study, the PES Program would obtain sufficient funding. Funding is vital to achieve conservation goals. However, conservation programs alone may not influence the social and economic roots of environmental problems. Then, complementary policies must be applied in conjunction. For example, urban sprawl, pollution of aquifers, uncontrolled expansion of agriculture, and lack of sanitation systems also reduce social welfare. Those problems must be considered in the formulation of an integral policy (Fig. 3.7, 3.8, 3.9, 3.10 & 3.11). However, PES programs are designed to protect ecosystems, not to address socially driven problems, although their outcomes are socially desirable *per se*.

PES programs can suffer from various kinds of inefficiencies related to the social benefits (Pagiola, 2007); therefore, the structure of a PES program need to be engineered in such way that benefits exceed the cost and achieve financial efficiency (Benavides &Veenstra, 2009). However, CBA should not be the ultimate resource for decision making. A standard CBA does not distinguish between the sections of society that receive benefits and that endure costs as a result of a project, especially if the those suffering the costs all live in the same geographical area or belong to the same social group (Edwards–Jones, 2006). For example, sixty one percent of interviewees belong to the lowest income quintile (<₡190,804 month−1) (INEC, 2010). Therefore, if a local PES Program for hydrologic protection is applied, potential ‘buyers’ would be represented by poor people who will have to finance a program to overcome environmental problems that are not directly caused by them. For instance, most serious environmental impacts on hydrologic services are caused by industrial plantations (not by small farmers), through invasion of aquifers' buffer zones and riparian ecosystems, deviation or over draughts of water bodies, surface and ground water contamination with pesticides, sediments and wastewater, filling of wetlands, and deforestation of primary and secondary forests (Astorga, 2010) (Fig. 3.10 & 3.11). These environmental impacts reduce people's welfare by restricting their access to quality water. These are externalities of development that markets do not account for (Rosero-Bixby & Palloni 1998).

On the other hand, people that are willing to participate in conservation programs are often better–off landowners. It happens because 'in order to achieve operative efficiency conservation programs have to rely on large properties that normally belong to the wealthy' (Rosero-Bixby & Palloni, 1998). Thus, policy and decision–making processes have to incorporate these ethical issues. For example, whether the poor should finance or not the conservation of hydrologic services to give better–off land owners an opportunity to become more sustainable in their land–use practices. Conservation programs may not necessarily result in Pareto improvement even if they accomplish their environmental goals. Still, conservation programs using well designed PES schemes can enhance rural development and create economic opportunities for the poor (Montagnini & Finney, 2011).

The role of institutions related to water management and their efficiency is critical for the success of conservation programs. Nevertheless, the AyA still suffers from administrative weaknesses, such as failing to provide drinking water to many rural and indigenous communities and failing to build or improve sewer systems (Astorga, 2010). In fact, in rural areas, only 28.3% of aqueducts operated by ASADAs/CAARs provide potable water (Astorga, 2010), whereas the rest of aqueducts provides piped water. In 2007, the AyA attempted to impose a 35% increase in the water tariff. However, the Public Service Regulatory Authority (ASEREP) did not approve the proposal because it found that the AyA had not met the required efficiency and quality levels in providing potable water. Likewise, it found that 52% of drinking water is lost by leakages due to the obsolete infrastructure, built 50 or 70 years ago, resulting in financial losses that are compensated by higher tariffs of water. Because tariff of water influences the WTP, it is recommendable that the agency responsible for the water management uses optimal water tariff values to minimize its effect upon the value that consumers give to hydrologic services. Because the quality of the hydrologic service is perceived through the quality of the service provided by the water agency, the economic valuation of that environmental service is affected by the levels of institutional efficiency over water management. Consequently, all these problems should be addressed before the adoption of a 'conservation fee' that will increase the water bill.

Imposing a payment for hydrological services would also require an analysis of its legal viability. The Costa Rican Forest Law No.7575 recognizes the role of forests in providing hydrological services, but it does not establish that beneficiaries pay for those services (Pagiola, 2007). This is the reason why most water payments are based on agreements. For example, current 'buyers' of hydrologic services are hydroelectric companies, bottlers, the ESPH, irrigation water users, and hotels. However, the new Law of Hydrologic Resources that is being discussed by the Costa Rican Congress proposes to augment the funds for subsidizing forest conservation through a tax on the consumption of potable water (Benavides & Veenstra, 2009). However, any increase in water tariff could harm the most disadvantaged consumers, especially because in poor countries, changes in access to natural resources can induce large changes in income (Haab & McConnell, 2002). This is the case of Turrialba and Guácimo. The vast majority of the population is under the poverty line. To solve this type of problems, Benavides & Veenstra (2009) suggest payment exemptions for the first several liters consumed per month.

Nonetheless, at least in the area of study, the vast majority of households lacks water meters. Hence, this is a potential obstacle to apply payment exceptions.

Therefore, it is necessary to continue seeking for alternative policies to finance the conservation of hydrologic services and protect the most vulnerable people within the society. A PES program applied to the tourism sector is an option. The tourism sector uses biodiversity and recreational services from the forests to profit. Ecotourism, in particular, emerged during the 1990s as one of the major beneficiaries of conservation. For example, in 1994 tourism was the major earner of foreign exchange. Today, the sector represents 5% of Costa Rica’s gross domestic product, employs about 12% of its labor force, and generates 20% of the country’s foreign income (Benavides & Veenstra, 2009). In 2007, the nature–based tourism industry generated US$ 1895 million, almost 34% more than the total benefits of banana (US$ 255 million), coffee (US$ 674 million) and pineapple (US$ 484 million) production together (Kohlmann, 2008). However, despite being profiting handsomely from Costa Rica’s reputation as the ‘Green Republic’ (Evans, 1999) tourism industry is not paying as expected for the use of forests’ recreational services (Pagiola, 2007). This example of free riding on conservation shows that there exist alternatives to finance conservation which are not yet developed by the government. These alternative financing mechanisms may constitute ‘measures’ to protect the poor, promote equity, and protect the environment.

CHAPTER 4

CONCLUSION

Since its inception in 1996, the PES program has been successful to stop deforestation and enhance conservation of environmental services. In fact, Costa Rica is the first country in the Central American region that achieved such goal. To continue with this success, the PES Program requires sufficient and permanent funding. Currently, funding sources for the PES program are diverse and include the Costa Rican government, the international community, and NGOs committed to conservation. However, conservation programs continue to focus on carbon markets development. Although, the Forestry Law 7575 does not set priorities for the conservation of any particular environmental service, it is clear that the country has developed carbon markets to justify the PES Program, especially because this strategy attracts more funding from the international community. Although 'carbon capture' works as an umbrella for other environmental services, the lack of conservation programs targeting hydrologic services allows their rapid degradation. Therefore, local conservation programs are necessary to sustain the welfare of Costa Ricans to whom conservation of hydrologic services has a higher priority in contrast to the mitigation of climate change.

To assess the viability to implement a local PES Program for the protection of hydrologic services, financed by a water conservation fee, I measured the economic value of forests' hydrologic services in Turrialba and Guácimo using the Contingent Valuation Method. Results indicate that the mean WTP is US$11.69 to the logit model, and US$7.54 to the linear model. These findings provide value estimates about the benefits of conserving forests' hydrologic services in a scenario in which environmental degradation is high. For example, loss of hydrologic services and water pollution are severe, and most of these problems are the consequence of agricultural expansion. Consequently, there exists demand for a local conservation program specifically designed to protect hydrologic services. In such scenario, imposing a 'water conservation fee' is feasible. Likewise, a cost–benefit analysis determined that forests' conservation program, within the watershed relevant for the study population, is viable and can increase the social welfare. However, a conservation program that imposes a payment for environmental services may not necessarily result in Pareto improvement if the most disadvantaged people are not protected. For example, in the area of study, more than 60% of the population lives under the poverty line. For them, current water tariff is already expensive.

On the other hand, beneficiaries of the PES Program are often wealthy landowners. Therefore, policy and decision–making processes must incorporate ethical issues. For example, whether the poor should finance or not the conservation of hydrologic services to give better–off land owners an opportunity to become more sustainable in their land–use practices, or whether the poor should pay to stop the depletion of environmental services from which they are not directly responsible for.

The agency in charge of providing water services must improve its administrative efficiency levels and achieve water quality standards before planning an increase of the water tariff. Without these improvements, PES programs may lose legitimacy. However, there exist alternatives to finance conservation, which are not yet developed by the government, such as payments from the nature–based tourism industry. These alternatives may constitute measures to protect the poor and promote equity while protecting the environment.

The ESPH–PROCUENCAS Program is the first case in the country in which the conservation of hydrologic services is financed by its consumers through a water conservation fee. The PROCUENCAS program is a success; however, adopting similar approaches to conservation in other areas of the country with different economic, social, and environmental scenarios may be controversial. However, Costa Ricans are adaptable to any environmental policy implemented by the government due to their environmental openness.

There is no doubt that the PES Program has been successful for the conservation of environmental services in Costa Rica; however, due to its high dependence on international carbon markets it has given less attention to local necessities such as the protection of hydrologic services. Therefore, developing local markets and targeting conservation efforts can fulfill the expectations of local consumers. However, policy analysis has to go largely beyond only financial considerations, because the human–water relationship is more complex.

CHAPTER 5

RECOMENDATIONS

The main constraint for this study was the lack of information about the conservation goals in the study area. Therefore, future research should focus on determining the quantity of water that is required to satisfy the current demand for water and what are the ecological flow requirements to conserve the hydrological and ecological functions of the drainage networks. Unfortunately, for the first case, the vast majority of households do not have water meters and, in the second case the information is ambiguous. Knowing this information can help targeting conservation efforts and allocating funds efficiently.

Likewise, estimating benefits for long–run water investments (e.g., conservation of hydrologic services) or allocation decisions requires forecasting the behavior of a number of economic, technological and social variables for a period of years (Young, 2005). Therefore, it is necessary to reassess the economic value of what this study has assessed, by incorporating alternative methodologies to test the convergent validity of their results and identify trends. This information will help to obtain more accurate results and allow the transferability of benefit estimates to other locations requiring environmental protection (Boyle & Bergstrom, 1992; Boyle, 2003).

GLOSARY

Afforestation: Planting of trees or seeds in order to transform open land into forest or woodland.

Benefit transfer: The method used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context.

Carbon fixation: The process in plants and algae by which atmospheric carbon dioxide is converted into organic carbon compounds, such as carbohydrates, usually by photosynthesis.

Carbon sequestration: The active removal of CO_2 from the atmosphere to mitigate climate change. It uses a variety of means of artificial carbon capture and storage, as well as of enhanced natural sequestration processes. The most common carbon sequestration process is through forestry.

Compensating surplus: Change in income that would compensate for the change in environmental quality if it is implemented.

Deforestation rate: The average speed at which the forest is being cut, and expressed in unit area per year.

Ecosystem: A structural and functional unit of biosphere or segment of nature consisting of community of living beings and the physical environment, both interacting and exchanging materials between them.

Environmental services: A set of benefits generated for society by the existence and dynamic development of natural resources or ecosystems.

Farmscape: A landscape dominated by agriculture. Farmland is the main element in farmscape, though non-agricultural uses may be included.

Forest cover change rate: The annual rate of change in forest cover calculated by comparing the area under forest cover in the same region at two different times, and expressed in percentage of change.

Marginal land: In farming, poor–quality land that is likely to yield a poor return. It is the last land to be brought into production and the first land to be abandoned.

Pareto improvement: Any change in economic management that improves the situation of one or more members of the community without worsening the lot of anyone.

Rural democracy: A form of direct democracy in which the rural masses can make their own decisions in matters of their own interests and welfare.

Single Bounded Dichotomous−Choice: A WTP elicitation format in which respondents are allotted a single bid and enquired whether, for the proposed program, he or she is willing to pay the amount.

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TABLES

Table 3.1: Description of variables and demographic information

Variable	Description	Sample average		Min	Max
		Mean	S.D.		
AGE	Age of respondents.	42.34	16.33	18	88
TARIFF	The current tariff of water in colones/month.	4,301.28	3,568.30	0	25,000
YEARSLIVE	The number of years that respondent has lived in the sampled area.	25.00	19.16	1	75
BID AMOUNT	The bid used.	8,315.87	9,593.96	1,000	12,000
INCOME	The respondent's income elicited in the open-ended question through income ranges for those who were not able to reveal their exact income.	19,8077.00	121,866.00	50,000	900,000
GENDER	Dummy variable. 1= man, 0= woman	0.29	0.46	0	1
EDUCATION	Dummy variable. 0=Never went to school; 1=Elementary; 2=High School; 3=College; 4=Graduate.	1.58	0.91	0	4
FAMYMEM	Number of family members.	4.05	1.67	1	9
WTP	Dependent variable obtained with the open-ended question: maximum willingness to pay.	3,903.17	2,874.45	0	12,000
Yes/No	Dependent variable obtained with the DC question: Yes =1, No =0.	0.44	0.50	0	1

Table 3.2: Bid curve analysis: estimated WTP model

Variables	Linear model			Logit model		
	Estimated Coefficient	t	*p*	Estimated Coefficient	b/St.Er	*p*
CONSTANT	4801.230	6.335	0.000***	3.616	3.510	0.000***
AGE	-53.659	-3.792	0.000***	-4.722×10^{-2}	-2.881	0.004***
TARIFF	-0.09648	-1.915	0.057*	-3.660×10^{-5}	-0.653	0.514
YEARSLIVE	24.13	2.042	0.043**	2.797×10^{-2}	2.125	0.034**
BIDAMOUNT	-0.04476	-2.43	0.016**	-5.691×10^{-4}	-5.513	0.000***
INCOME	0.009474	5.69	0.000***	7.785×10^{-6}	3.768	0.000***
GENDER	44.40867	0.111	0.912	-2.866×10^{-1}	-0.697	0.486
EDUCATION	-209.667	-0.914	0.362	-9.777×10^{-2}	-0.412	0.680
FAMYMEM	-0.1075	-0.059	0.953	-5.227×10^{-3}	-0.516	0.606
Adjusted R^2		0.233			0.342[a]	
Number of observations		208			206	
MeanWTP	3,902.14			6,044.16		

*** Significant at $p<0.01$, ** Significant at $p<0.05$, *Significant at $p<0.1$
[a] McFadden's Pseudo R^2

Table 3.3: Aqueduct tariff for fixed and metered service

Type of Tariff	Household	Business	Preferential	Government
Metered price*				
Basic tariff 0 - 15 m^3	3454	13643	5699	13643
16 - 25 m^3	380	910	380	910
26 - 40 m^3	380	”	”	”
41 - 60 m^3	495	”	”	”
61 - 80 m^3	910	”	”	”
81 - 100 m^3	”	”	”	”
101 - 120 m^3	”	”	”	”
> 120 m^3	956	956	”	956
Fixed price				
Colones/month	6908	38656	22797	109147

Effective from December 12/2009 to December/2010.
*Colones per cubic meter per month
Source: AYA, 2010. Adapted: David Cotacachi

Table 3.4: Payment for environmental services during period 2010-2015

PES modality	2010 requested contracts (has)	Payment amounts US$ per ha per 5 year	Total Funding Required (US$/5year)
Reforestation	3,916	980 (196)	3'837,680
Natural regeneration CDM*	1,000	320 (64)	320,000
Natural regeneration (Non-	500	205 (41)	102,500
Forest protection	15,828	320 (64)	5'064,960
Forest protection (Watersheds)	1000	400 (80)	400,000
Forest protection in areas without conservation programs	1000	375 (75)	375,000
Managed forest	-	250 (50)	-
Agroforestry	600,000 (plants)	1.30 (per plant per 3 years)	780,000
Total	23,244		10'880,140

Source: Presidential decree No. 35762-MINAET. February, 2010
*Clean Development Mechanism.
Number in parenthesis are US$ per hectare per year.
Elaboration: David Cotacachi

FIGURES

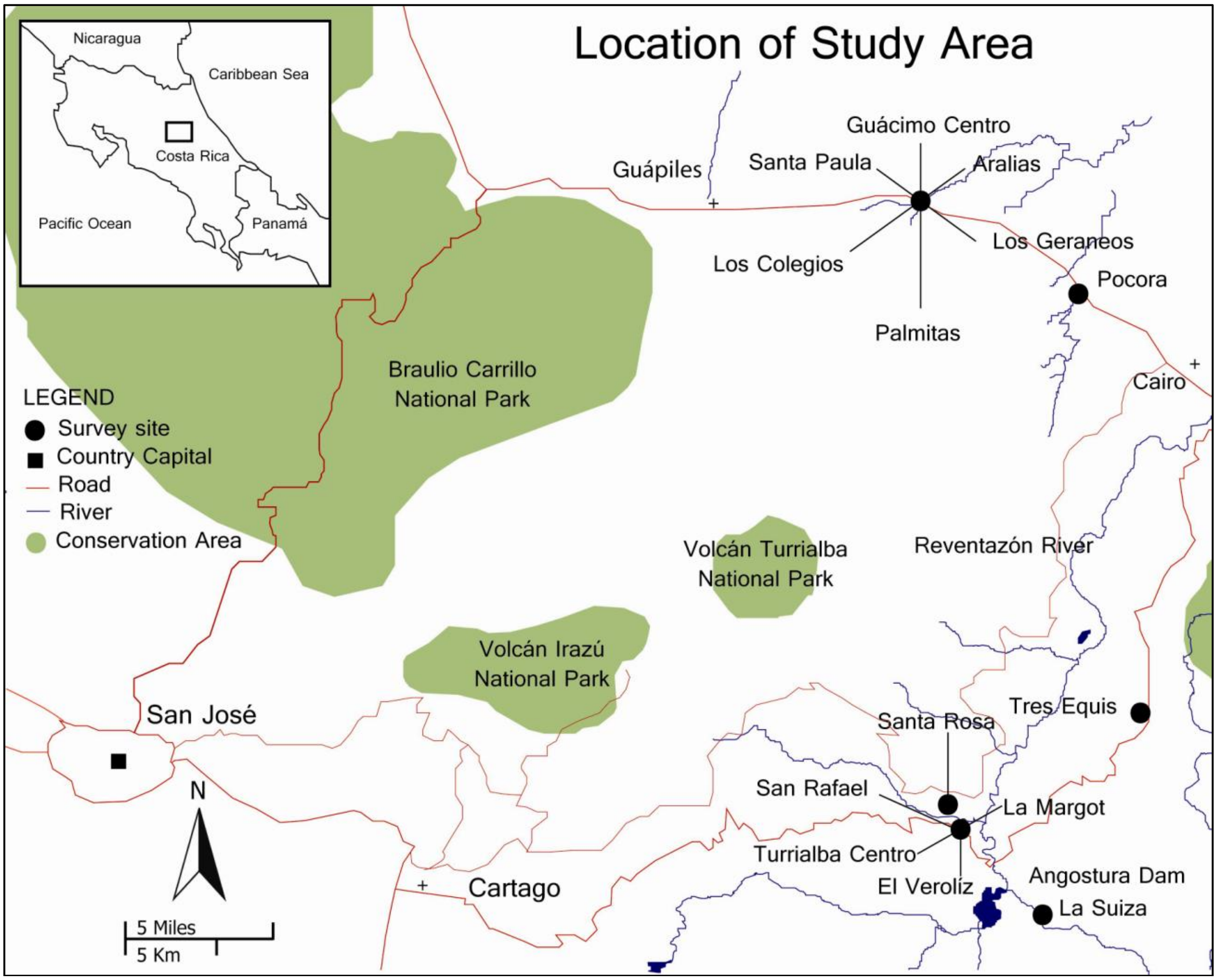

Figure 1.1: Location of study area
Elaboration: David Cotacachi.

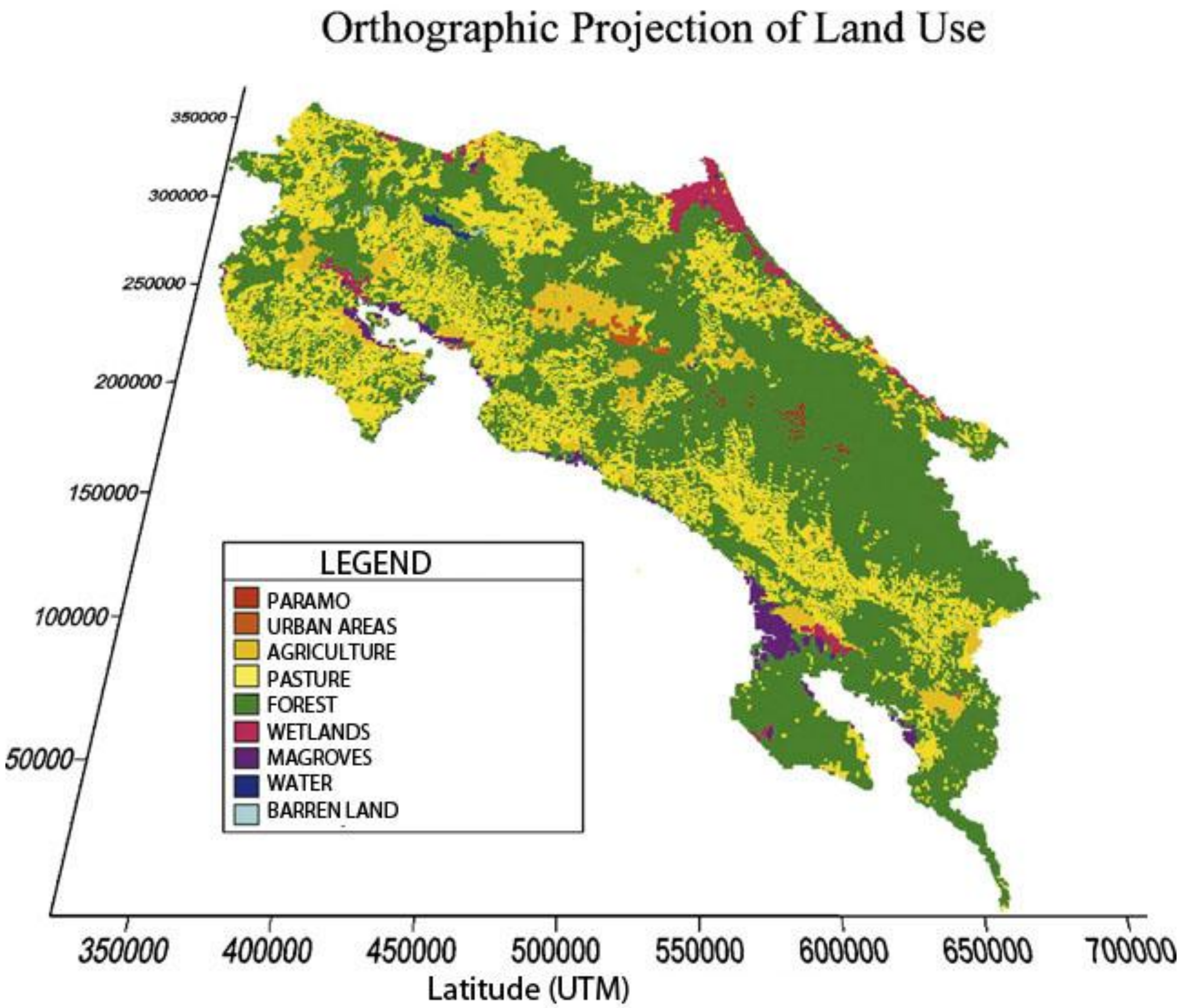

Figure 1.2: Land Use in Costa Rica.
Source: Kohlmann *et al.*, 2002.

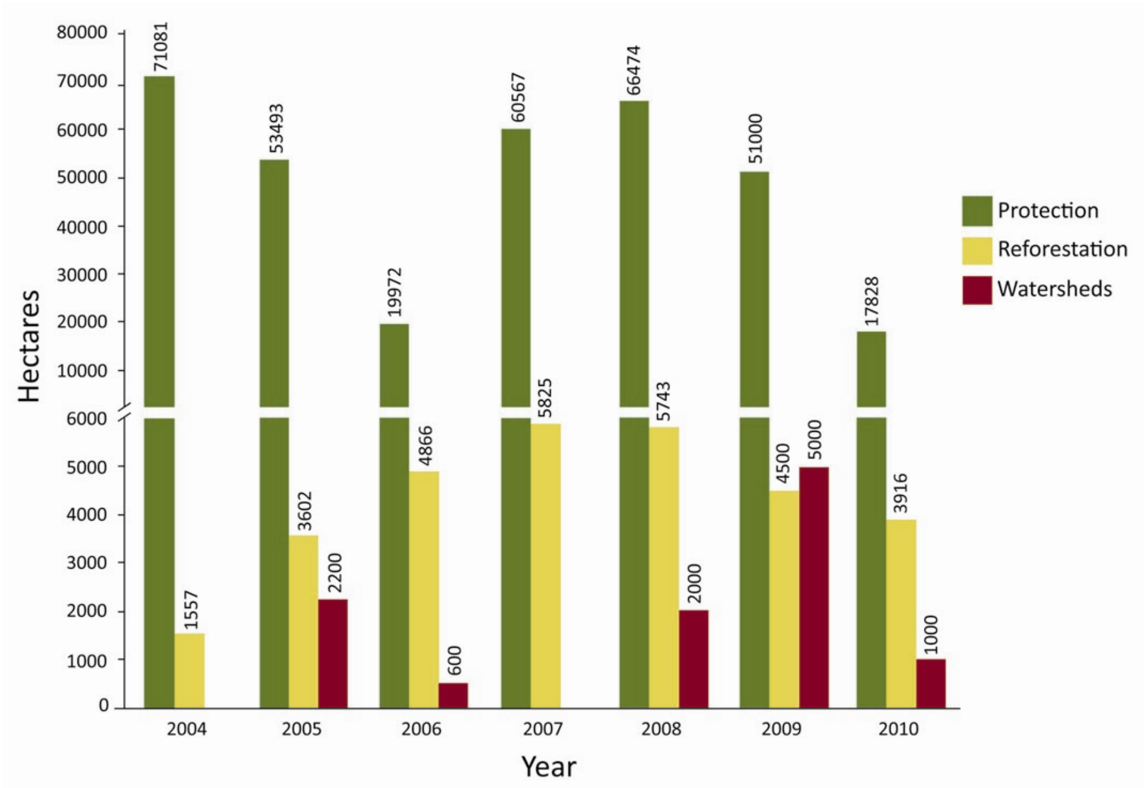

Figure 1.3: Number of hectares participating in the PES program

Source: 2004-2008: PEN, 2010; 2009: Executive Decree No. 35159-MINAET 02-19-2009; 2010: Executive Decree No.35762-MINAET 02-22-2010

Elaboration: David Cotacachi.

Environmental Service	***Status-quo*** $S^O = f(E^O)$	**Alternative** $S^1 = f(E^1)$	**Change in Service** $S^1 - S^O$	**Qualitative Change Goal-End**
Hydrologic services	‘Degradation’ (e.g., Reduced forest ability to capture, recharge, retain, and filtrate water).	‘Restoration’ (e.g., Restored forest ability to capture, recharge, retain, and filtrate water).	‘Improvement’ Change in quantity and quality of environmental services	Quality of the environmental service. **(Q)** Water

Figure 2.1: Description of Alternatives

Note: Based on ‘Setting up the Policy Analysis Scenario’ by John C. Bergstrom, 2010.

Adaptation: David Cotacachi.

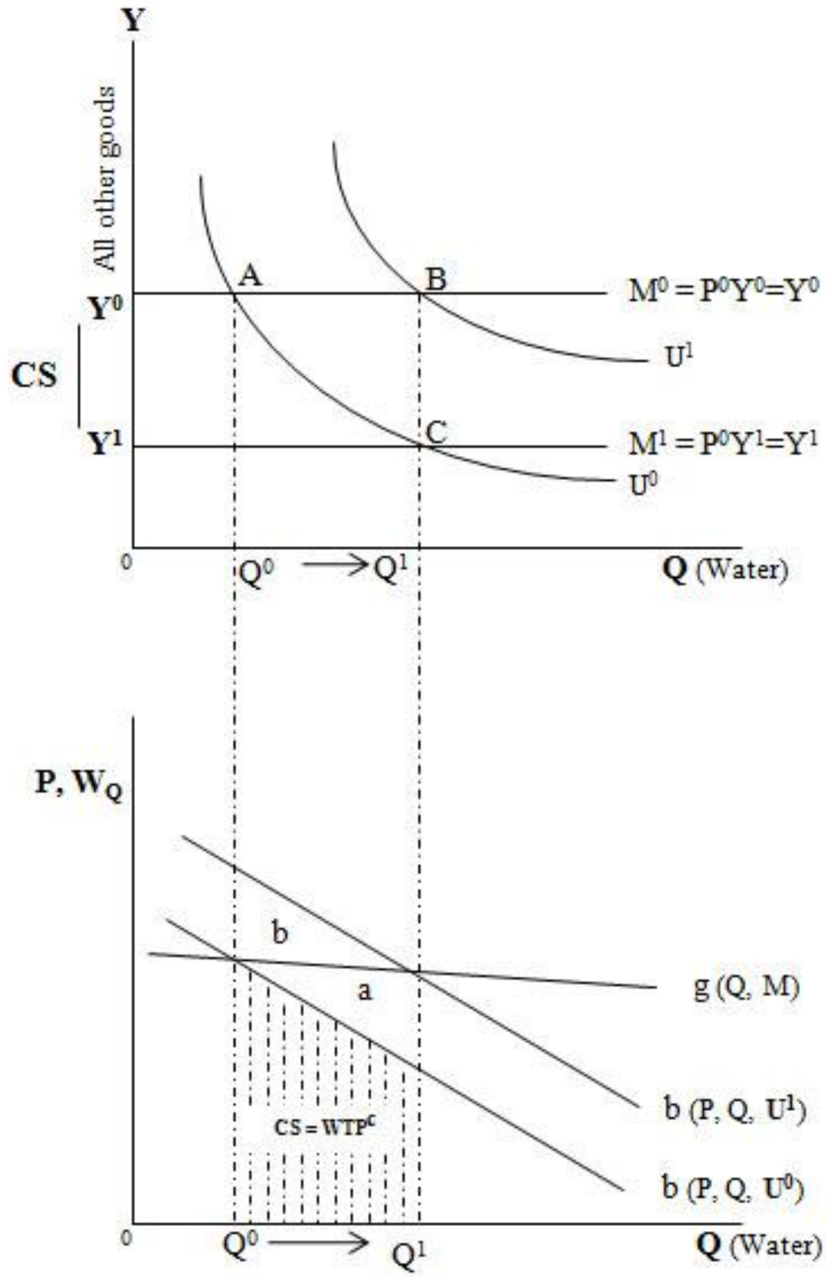

Figure 2.2: Individual welfare change for a quantity increase

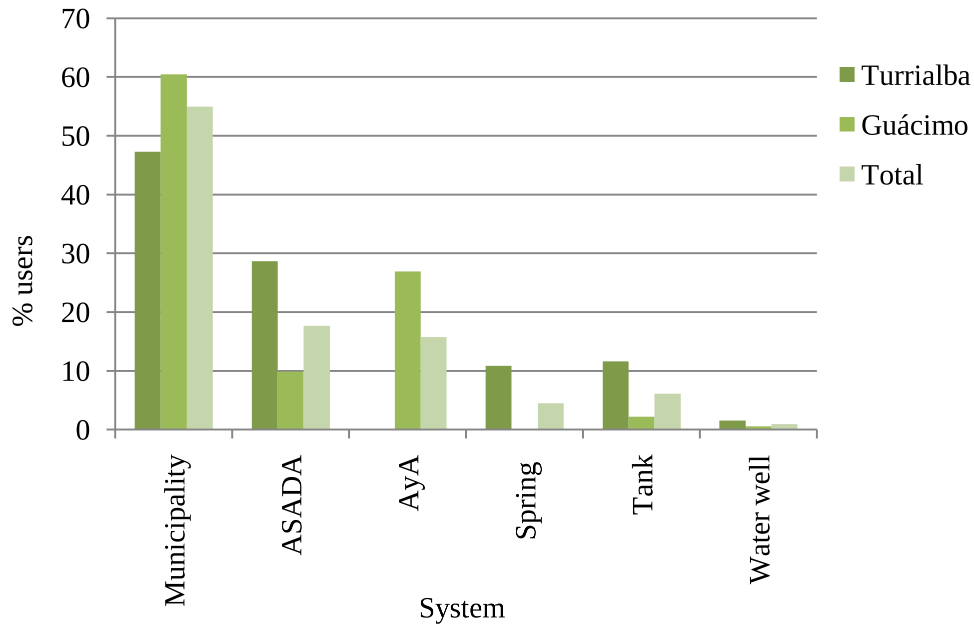

Figure 3.1: Systems of water provision in Turrialba and Guácimo

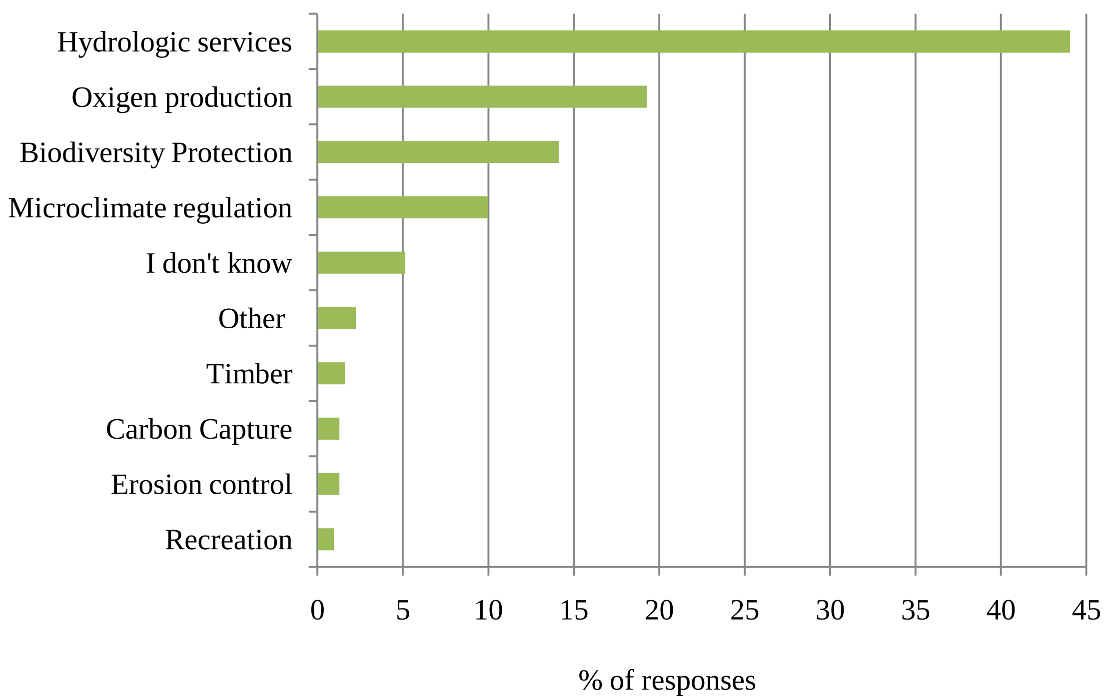

Figure 3.2: Most important environmental goods and services for local people

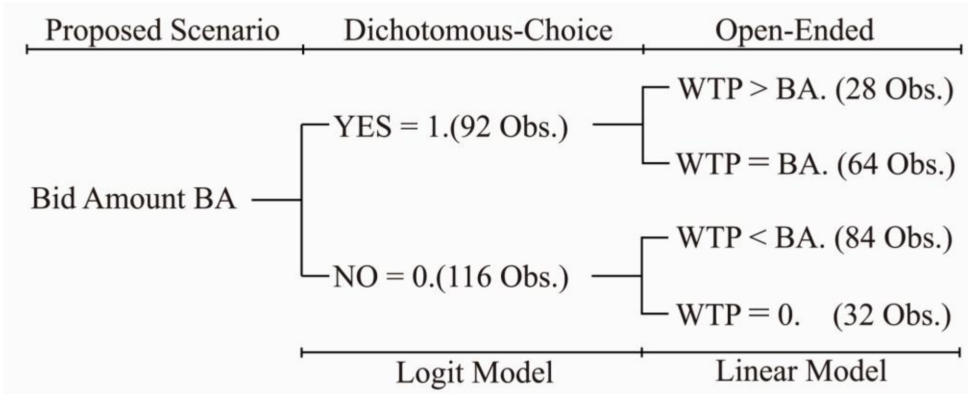

Figure 3.3: Responses to the Willingness-to-Pay questionnaire. WTP elicitation formats and regression models.

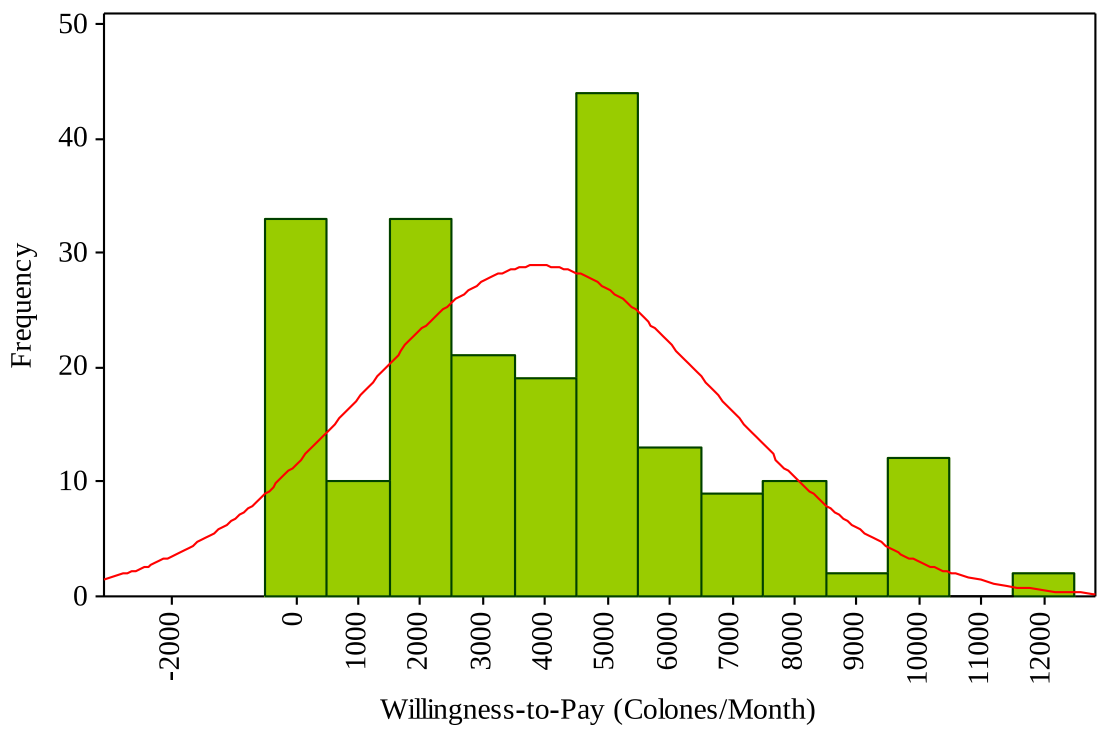

Figure 3.4: Distribution of WTP

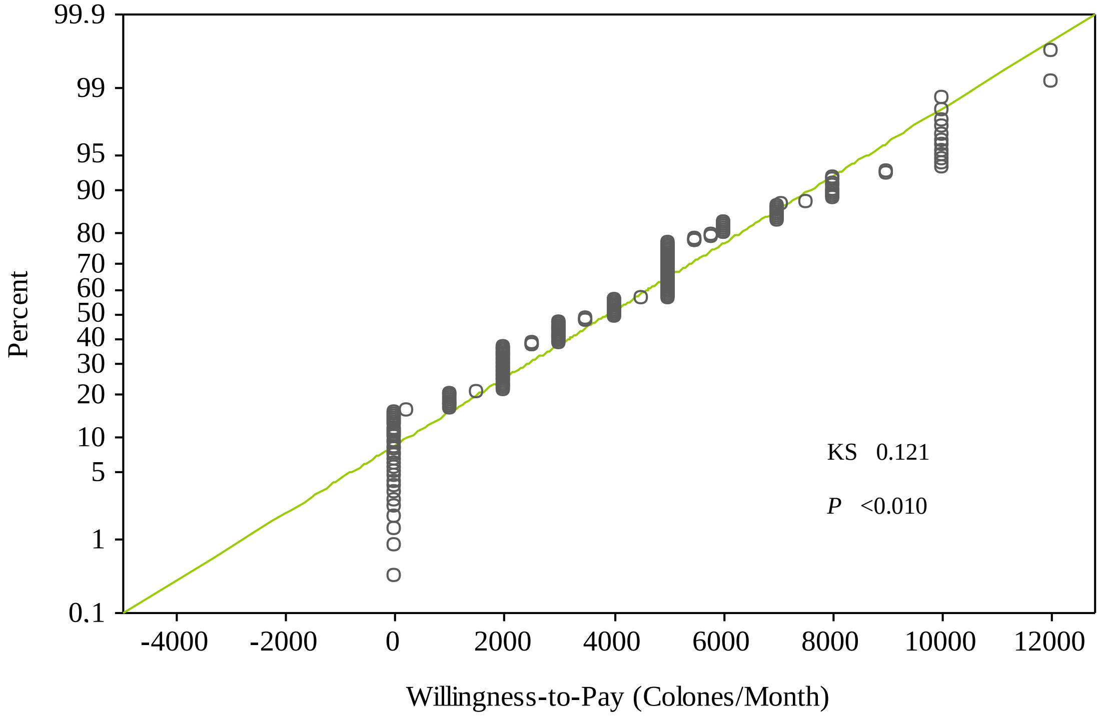

Figure 3.5: Kolmogorov-Smirnov normality test

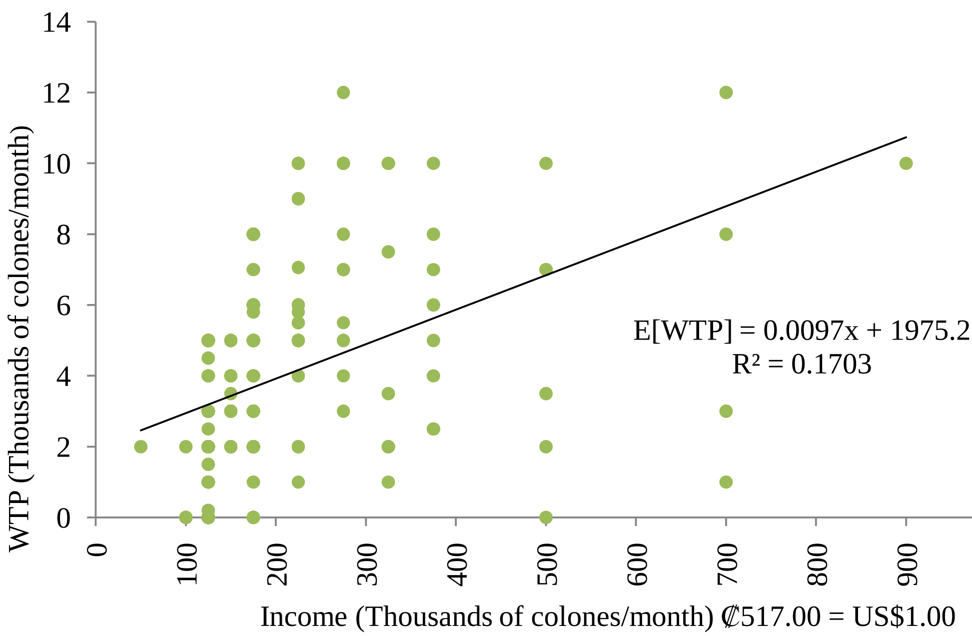

Figure 3.6: WTP as function of income

Figure 3.7: Invasion of aquifers' buffer zones and riparian ecosystems. La Suiza Community, Turrialba.
Photo: David Cotacachi, 2010.

Figure 3.8: Invasion of riparian ecosystems and land-cover change.
La Suiza Community, Turrialba.
David Cotacachi, 2010.

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Figure 3.9: Water pollution. Municipal wastewater is discharged into rivers and streams without previous treatment. Colorado River, Center of Turrialba.
David Cotacachi, 2010.

Figure 3.10: Water contamination with pesticides and sediments.
Pineapple plantation in Guácimo.
Photo: David Cotacachi, 2010.

Figure 3.11: A typical farmscape in Guácimo. Pineapple plantation.
Photo: David Cotacachi, 2010.

APPENDICES

APPENDIX A. WTP ELICITATION QUESTIONNAIRE

Considering that you benefit from mountain forests' hydrologic services, would you be willing to pay ₡ _______, charged in your monthly water bill, to support a conservation program of such forests?

YES	NO
What is the **maximum** amount of money that you would be willing to pay in support of a program to conserve forests' water services? ₡____	What is the **minimum** amount of money that you would be willing to pay in support of a program to conserve forest's water services? ₡____ *If answer is protest-zero (0):* Why are you not willing to pay? ____________________

APPENDIX B. LIST OF ACRONYMS AND ABBREVIATIONS

ASADAS	*Asociaciones Administradoras de Acueductos y Alcantarillados Comunales*–Water & Sewer Communitarian Associations
AyA	*Instituto Costarricense de Acueductos y Alcantarillados*–Costa Rican Water and Sewer Institute
CAAR	*Comités de Acueductos y Alcantarillados Rurales*–Water & Sewer Rural Committees.
CVM	Contingent Valuation Method
DC	Dichotomous–Choice
ESPH	*Empresa de Servicios Públicos de Heredia*-Heredia's Public Services Company
FAO	Food and Agriculture Organization of the United Nations
FONAFIFO	*Fondo Nacional de Financiamiento Forestal*–National Fund for Forest Financing
NGO	Non-governmental organization
NOAA	The National Oceanic and Atmospheric Administration
INEC	*Instituto Nacional de Estadística y Censos de Costa Rica*–Costa Rica National Institute of Statistics and Censuses
PES	Payment for Environmental Services
WTP	Willingness–to–Pay