Cost-benefit distribution of ecosystem services and contracting under a PES scheme: the case of the Güisayote Biological Reserve, Honduras

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Abstract

This thesis assessed the costs and benefits distribution of improving drinking water quality through a land set-aside payment for ecosystem services (PES) scheme in a watershed of Honduras. The benefits of improving drinking water quality were determined using a contingent valuation survey for a stated willingness-to-pay (WTP) for improved drinking water quality through a PES scheme; and a revealed WTP was determined as the sum of averting expenditure and illness damage costs. Likewise, the costs of water conservation were determined through two approaches, the flow and rent opportunity costs of upstream landholders.

Both WTP measures evidenced that beneficiaries could afford and were willing to pay for improved drinking water quality. The two WTP measures were not correlated, but this could be due to biased estimates or context-dependent preferences for each approach. Conversely, the cost of water conservation came to an overall flow net return of US$ 1,410 ha^{-1}, with coffee exhibiting the highest returns. However, the median positive returns without coffee, US$ 140, are used and they are correlated to the rent opportunity costs. Identifying a reliable, accurate and cost-effective method to determine opportunity costs is challenging, but the two methods employed provided valid estimates. This study identifies and discusses several distributional issues for PES schemes; these are the upstream-downstream externality framework, peoples' perceptions, unequal water governance, and fair targeting of payments to service providers.

The WTP for improved drinking water quality is not sufficient to compensate the opportunity costs of landholders. The WTP would only cover 6% to 10% of the estimated cost of the water conservation. Thus, a user-based PES scheme at the study site is not feasible. Water conservation is more likely to be possible if substantial external support is obtained or through a sustainable land management-based scheme.

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Chapter 1: Introduction

This chapter outlines the motivation, aim, objectives, and structure of this research. The research motivation section (1.1) briefly introduces the importance and gaps being addressed by this study on costs and benefits distribution of ecosystem services through payment for ecosystem services schemes. Section 1.2 outlines the aim and objectives, developed from an academic and policy-oriented focus described in the research motivation section and in the literature review (chapter 2). Finally section 1.3 outlines the general structure of this thesis.

1.1 Research Motivation

There is a long-standing debate about how to achieve conservation and at the same time maintain or even improve the livelihoods of local communities (Adams et al., 2004). This is due to human activities progressively reducing the planet's life-supporting ecosystem services, while unprecedented rising human consumption makes increasing demands on them (Wells, 1992). This threat is particularly experienced in developing countries, where there is an obvious drive for economic development through increased investments and more intensive use of ecosystem services (Kramer et al., 1997). Protected and rural areas, and the ecosystem services they provide, are especially under mounting pressure as they are expected to directly contribute to both development and poverty reduction (Adams et al., 2004; Coad et al., 2008).

Reducing poverty or more generally inequity, is one of the main challenges in determining the impact and long-term success of conservation interventions (MEA, 2005; Goldman and Tallis, 2009). The provision of ecosystem services through protected areas generally has resulted in a lack of equity because these areas often don't take account of local communities and have reinforced existing conflicts and unfairness in access and control of ecosystem services (Arrow et al., 2000). Equity has been defined as a measure of the fairness of distribution (Brown and Corbera, 2003; Corbera et al., 2007a; Fisher et al., 2008). Rarely have studies analysed both costs and benefits in conservation and it is still unclear how they are distributed within and among different stakeholder groups (Landell-Mills and Porras, 2002; Chan et al., 2007). Factors affecting distributional issues can include the nature of the ecosystem service, its governance, and property rights, among others (Sommerville et al., 2010a). Inequity in distribution is a problem that is yet to be adequately addressed in protected area and ecosystem service management (Coad et al., 2008; Balvanera et al., 2012).

One of the most vital and threatened ecosystem services is water provision, which supplies the benefit of drinking water quality for humankind. Currently 780 million people worldwide are said to be without access to an improved drinking water source (UNICEF and WHO, 2012). The most affected by contaminated water are the populations in developing countries, living in poverty, normally peri-urban dwellers or rural inhabitants (Alberini et al., 1996; Dwight et al., 2005). There are many waterborne diseases and the most common one, diarrhea, causes about 2 million deaths every year, most of them children less than 5 years of age (WHO and UNICEF, 2014). Although substantial gains have been made in the provision of drinking water supply and sanitation globally (UNICEF and WHO, 2012), many inequities are masked behind national statistics (Pullan et al., 2014) and binary categorisations (Yang et al., 2013). Inequities in drinking water quality have been found for social (e.g. rich-poor), generational (e.g. age cohorts), spatial (e.g. urban-rural) and gender attributes (Rangel Soares et al., 2002; Yang et al., 2013; Pullan et al., 2014). The literature contains an increasing number of developing country estimates of water services. However, the value of water quality improvements in developing country settings deserves much more study (Olmstead, 2010). Inequity between and within communities in allocation of water resources and the corresponding outputs also remains a serious challenge (UNICEF and WHO, 2012). A detailed study on the local costs and benefits distribution of drinking water quality in rural communities can provide important insights to address present and future equity issues.

To address distributional or fairness issues in conservation, incentive-based initiatives have been promoted within and outside protected areas to complement command and control actions. Currently, Payment for Ecosystem Services schemes are deemed to be cost-effective at providing ecosystem services and efficient at conservation (Miles and Kapos, 2008; Fisher et al., 2010), but debate still stands on if and how PES can best maintain and improve equity and livelihoods (Jack et al., 2008; Kosoy et al., 2008; Farley and Costanza, 2010; Fisher et al., 2010; Muradian et al., 2010; Nkhata et al., 2012). Payments for water services are the most developed across Latin America (Balvanera et al., 2012) in line with the persistent water provision challenges across the region. A study on how the distribution of local costs and benefits of water services can determine contracting in PES schemes can therefore provide insight on developing more equitable schemes and reducing future distributional issues.

Economic valuation is commonly used to determine the costs and benefits of ecosystem service use for PES scheme design and contracting. These methods are favoured because they allow protected areas and the services they provide to be valued in equal terms as other forms of land use (either direct or indirectly) and can reveal costs or benefits that might otherwise remain hidden (Troy and Wilson, 2006). However, there is still substantial debate in the application of these methods that requires further research, importantly the accuracy and robustness of estimations (e.g. Harrington and Portney, 1987; Pattanayak et al., 2005; Jalan and Somanathan, 2008; Wünscher et al., 2011). So, a study employing several approaches to estimate the benefits and the costs of water services can first of all, contribute more accurate estimates, and also enhance the understanding of their design and application.

Honduras is the poorest country in Latin America (ECLAC and UN, 2011) and has a long history of inequity, mainly affecting rural areas (Székely and Hilgert, 1999; Rangel Soares et al., 2002; Klasen et al., 2012); thus making it particularly vulnerable to water provision issues. Honduras has ample hydrological capacity (GWP-Centroamerica, 2011) but it is characterised by unsafe drinking water mainly due to domestic and agricultural activities, e.g. only 20% of the country's water sources are deemed safe to drink (Mejia Clara, 2005; CONASA, 2006; Leiva Castillo, 2010; Acosta, 2011). It seems that water provision problems will continue into the foreseeable future due to it being a developing country with a growing population and prevailing high levels of corruption and inequality (EC, 2010; TI, 2013; Casey, 2014). Deaths and illness due to waterborne diseases, and its accompanying effects on quality of life, are widespread in Honduras (Varela, 2011; Halder et al., 2013). The west of the country is particularly vulnerable, as the department of Ocotepeque has one of the highest poverty rates in the country (OPHI, 2011), is one of the areas with most water provision problems (GWP-Centroamerica, 2011) and highest incidences of diarrhea cases (Halder et al., 2013). Thus rural communities in the west of Honduras are particularly interesting for the study of local costs and benefits distribution of drinking water quality. The findings of such a study could also contribute to the understanding of inequity issues in other parts of the world with similar environmental and socio-economic conditions.

In summary, despite considerable studies on poverty and inequity issues in protected and rural areas relating to ecosystem service, there hasn't been sufficient examination of both the costs and the benefits distribution of drinking water quality in rural, protected areas. As well as on how this distribution affects the design of PES schemes for water conservation. Furthermore, more understanding is needed on estimations derived from and the application of economic valuation methods. This thesis aims to contribute to an increased understanding of these issues and, in particular, on the situation in Honduras. Overall, based on empirical evidence this thesis contributes to current debates on equity in PES contracting and economic valuation methods by enhancing understanding on the costs and benefits distribution of water services, the factors affecting this distribution, the contracting opportunities and challenges in PES schemes, and the valuation methods for costs and benefits.

1.2 Research Aim and Objectives

The aim of this thesis is to assess the costs and benefits distribution of the water provision service for contracting in a Payment for Ecosystem Services scheme in a Honduran Reserve. To achieve this aim, the specific objectives are:

1. to determine the costs and benefits of drinking water quality use in fifteen rural communities, their distribution and the factors determining this distribution;
2. to analyse how the distribution of costs and benefits may influence contracting Payment for Ecosystem Services schemes; and
3. to contribute to the understanding of different economic valuation methods and their use to determine the costs and benefits of ecosystem services.

1.3 Thesis Structure

This thesis is divided into 8 chapters as set out in the table of contents. After this introductory chapter, Chapter 2 reviews the pertinent literature on the ecosystem services approach to conservation, the valuation of ecosystem services and Payment for Ecosystem Services schemes. Chapter 2 also highlights the literature existent on equity in PES schemes, specifically focused on the distribution of costs and benefits. Chapter 3 describes the research design and methodology, including the methods used to collect data and the data analyses followed.

Chapter 4 applies a stated preference method – contingent valuation – to obtain a measure of the benefits of improving drinking water quality. This method is used to capture users' stated willingness-to-pay for improved drinking water. In Chapter 5, a revealed preference method – averting expenditure plus illness damage costs – to assess the benefits of improving drinking water quality is applied. This method is used to identify the household expenditure to avoid and treat the effects of contaminated drinking water. These two chapters also analyse factors that determine the distribution of benefits among users according to each method.

In Chapter 6, opportunity costs of landowners and farmers are estimated using both the flow and the rent-based approach. This chapter also assesses the farmer, plot and land characteristics that may influence the level of opportunity costs obtained per hectare of land. Chapter 7 provides a synthesis of the key findings in the empirical chapters and evaluates the implications of the findings in the context of the externalities framework, imperfect information, disparate water governance and fairness in targeting payments to providers. Chapter 8 summarises the main conclusions and policy recommendations.

Chapter 2: Literature Review

This chapter provides a general review of the literature on four key areas, namely the ecosystem services approach, cost-benefit distribution, valuation and payment for ecosystem services schemes; highlighting the state-of-art and the gaps and weaknesses in the literature, identifying the areas of contribution of this thesis. Section 2.1 outlines the trend for conservation through protected areas and the ecosystem services approach, and the challenges faced in these approaches. Section 2.1.1 defines and describes the characteristics of ecosystem services. Section 2.2 reviews the equity concerns that arise with ecosystem service use and section 2.2.1 discusses the gaps in cost and benefit distribution studies. Section 2.3 describes payment for ecosystem services (PES) schemes and section 2.3.1 discusses how PES schemes can be designed to improve equity. Section 2.4 reviews the different valuation methods used to value ecosystem services. Finally, section 2.5 concludes by summarising this chapter and identifying the research gaps that this thesis addresses.

This chapter presents the general baseline of relevant topics to the research as a whole but the more detailed aspects of the literature are presented in each of the three empirical chapters: 4, 5 and 6. This was done to facilitate readability, considering that this research applies several methods and covers different themes. At the same time it allows for the in-depth assessment of the specific themes of each empirical chapter.

2.1 Conservation and the Ecosystem Services Approach

Protected areas (PAs) now cover over 14% of the world's land area (WB, 2013) and they form the cornerstone of conservation and the supply of ecosystem services (Balmford et al., 2002; MEA, 2005). The effect of protected areas on their human inhabitants is arguably the most controversial debate in conservation policy (Andam et al., 2010). In most developing countries, large numbers of people live within PAs (Gadgil and Guha, 1995; Cunningham, 2001). For example, 50% of Latin American national parks have human occupation (Amend and Amend, 1995). Until relatively recently protected area management has changed from focusing on protectionist approaches (Wells, 1992; Amend and Amend, 1995; Brockington, 2004; Cernea and Schmidt-Soltau, 2006), to recognising the rights and needs of local communities. Currently the rapidly growing conservation planning literature indicates that protected areas are not only expected to protect the environment but to directly contribute to development and poverty reduction (Margules and Pressey, 2000; Coad et al., 2008; Naidoo et al., 2008; Ferraro and Hanauer, 2011). So much so that reaching the most equitable design, along with economic and environmental benefits, is considered a requirement and the ideal outcome of conservation (Blaustein, 2007; Ehrlich et al., 2012).

Matching the need for conservation, through protected areas, with equity concerns is a compelling challenge. Many authors have employed different focuses and methods to study equity issues in PAs. For instance, Halpern et al., 2013) assessed different types of equity in three marine protected areas using the Gini coefficient. Munthali, 2007) discussed how transfrontier conservation areas in southern Africa contribute to both biodiversity conservation and poverty alleviation. Andam et al., 2010) evaluated how protected areas reduced poverty in Costa Rica and Thailand by using matching methods to estimate the effect of protected areas on poverty in communities near protected area. Despite the rising number of publications on this topic many aspects of equity or fairness in protected areas are only partly understood and considerable problems persist.

Currently, policy and research are increasingly oriented towards internalizing ecosystem service concerns into conservation and land use planning (Cowling et al., 2008; Jack et al., 2008). This is known as the ecosystem services approach or framework. This approach calls for an integrated view of nature's complexity and its problematic relationship with anthropogenic activities; thus, it can provide a useful argument for conservation (Vira and Adams, 2009) and communicate society's dependence on ecological life support systems (Daily, 1997; de Groot et al., 2002). So far, the development of the ecosystems services approach seems to have led to a better understanding and management of natural resources; unlike past conservation efforts focused on individual components of an ecosystem independent from human well-being. Nowadays, the ecosystem services approach is applied to many purposes, such as the development of environmental accounting and performance systems (Boyd and Banzhaf, 2007), education (MEA, 2005), economic valuation as an aid to environmental decision-making, landscape management, public policy and equity in human welfare (Wallace, 2007), or multiple purposes at once

(Fisher et al., 2009). In the case of protected areas, the approach can be useful as their boundaries were not designed to encompass the flows of ecosystem services across the landscape, such as water and organisms (Scott et al., 2001). Most protected areas have also been designed without taking full account of people's vital dependence on ecosystem services.

The concept of an ecosystem services approach is used here to address the issue of equity through cost and benefit distribution. This concept states that people are integral parts of ecosystems and that a dynamic interaction exists between them and parts of ecosystems. Furthermore, changing human actions drive, both directly and indirectly, changes in ecosystems and thereby cause changes in human well-being. Criticism of the ecosystem services approach has included its conceptual and methodological incompatibility with governance and management (i.e. with on the ground implementation; Cook and Spray, 2012; Baker et al., 2013). However, this approach is useful as it focuses on the indivisible linkages between ecosystems and human well-being; and in particular, the services or benefits that ecosystems provide to humans (MEA, 2005). Also, this approach already seems to have led to better conservation and management practices as it views people as potential partners in sustainable development strategies (Brown, 2002). However, as yet, the literature has scarce comprehensive studies assessing both costs and benefits applying an ecosystem services approach. There is still uncertainty about how to utilise this concept to enhance equity in different management and conservation practices.

2.1.1. What are Ecosystem Services?

Ecosystems constantly generate services: "the aspects of ecosystems utilized to produce human well-being" (Fisher et al., 2009). In general terms, ecosystem services are the benefits that nature provides to humans (MEA, 2005; Goldman and Tallis, 2009) and can be divided into provisioning (such as food and water), regulating (such as those affecting climate and water quality), cultural (such as those providing recreational and aesthetic benefits) and supporting services (such as nutrient cycling; MEA, 2005). Ecosystem service trade-offs can arise when the provision of one service is enhanced at the cost of reducing the provision of another service, and ecosystem service synergies can arise when multiple services are enhanced simultaneously (Raudsepp-Hearne et al., 2010). For instance, actions to enhance the supply of some ecosystem services, mainly provisioning services such as food and timber, have led to declines in other ecosystem services, including regulating services such as water provision (MEA, 2005; Fisher et al., 2009).

Ecosystem services are anthropocentric, benefit-dependent, heterogeneous in space, evolving through time, and associated with (or hindered by) a variety of property rights and other institutional arrangements (Costanza et al., 1997; de Groot et al., 2002; Fisher et al., 2008; Turner and Daily, 2008; Fisher et al., 2009). Their benefit-dependency means the benefits of interest will dictate what is understood as an ecosystem service (Boyd and Banzhaf, 2007). For example, water regulation services can provide the service of clean water provision or fish production. Since different stakeholders perceive different benefits from the same ecosystem processes they can at times be conflicting (Turner et al., 2003; Hein et al., 2006).

Ecosystem services provide a benefit when human welfare is directly affected and where other forms of capital (built, human, and social) are likely to be needed to realize the gain in welfare (Boyd, 2007; Boyd and Banzhaf, 2007; Turner and Daily, 2008; Fisher et al., 2009). How an ecosystem service is conceptualized and valued is very important, as this will influence beneficiaries understanding and decisions. Humans measure their wellbeing either in terms of tangible benefits, such as food, water, property; or in terms of abstract benefits such as a sense of being loved or contentment. If a wide range of people are to be engaged in decisions relating to ecosystem services, then the measures used to evaluate options must be overtly relevant to the daily lives of people. Ultimately, the relative weighting of services is a socio-political assessment shaped by the specific context in which a particular decision is made (Wallace, 2007).

A key characteristic of ecosystem services is their excludability and rivalness, also known as the public-private good aspect. A rival service is one for which consumption by one person reduces the amount of service available to others. An exclusive service is one from which consumers can be excluded unless they meet the conditions prescribed by the party controlling the service. A non-exclusive service can be regulated or provided by the government, as is the case with ecosystem services (Brown et al., 2007; Fisher et al., 2009).

Some ecosystem services may have a variety of agents with entitlements to different aspects of the service simultaneously (Paavola, 2007). The public-private good aspect can determine how the main types of property rights that affect ecosystem service provision can be classified.

Private goods are goods with rival consumption and low exclusion costs (Engel et al., 2008; Paavola, 2009). Common property refers to a regime that determines rules under which the members of a community may access and use a common pool resource (Brink et al., 2009). Common-pool resources are of rival consumption and high exclusion costs, e.g. fisheries, aquifers (Paavola, 2009). If there is no regime it becomes an open-access resource with absence of property, because of low benefits or high exclusion costs (Paavola, 2007; Lant et al., 2008). Pure public goods are jointly consumed goods with high exclusion costs. Consequently, public goods tend to be underprovided because the producer is unable to take full advantage of their value by charging for them and it is hard to identify and delimit the users (Engel et al., 2008). If nothing is done to constrain free-riding, receiving benefits without paying for them or investing in their long-term availability, nobody will make an effort to provide the good. Ecosystem services fit all of these property rights categories (Arrow et al., 2000; Lant et al., 2008; Paavola, 2009).

The spatial characteristics of ecosystem services, that determine heterogeneity and patterns, are to some extent subjective but conceptually important. Spatial categories can describe relationships, between service production and where the benefits are realised (in situ, omni-directional and directional), their scale (local, regional, global or multiple), or a combination of categories. Ecosystem services scarcity, substitutes and complements likewise are spatially differentiated (Boyd and Banzhaf, 2007). These characteristics recognize the spatio-temporal dynamics of ecosystems, further explain the public-private good aspect and the benefit-dependence of services, and can also highlight potential PES schemes. For instance, water provision has generally been referred to as a rival service that can be exclusive or non-exclusive and it has specific directional benefits accruing at a local level. However, services may not fit neatly into these spatial categories and the above mentioned property rights, as they do not accommodate all formal governance solutions that are used in practice (Paavola, 2007).

All these key ecosystem service characteristics (anthropocentricism, benefit-dependence, spatial dynamics, and property rights), and other potential factors, will significantly influence what is considered equitable and how equity issues are dealt with in the use of an ecosystem service. This is particularly the case for non-market services, those that are not properly regulated by markets (Freeman III, 2003); which is often the case of the vital service of water provision.

2.2 Equity issues in Ecosystem Service Use

It is widely accepted that achieving a balance between conservation of ecosystem services and development is far from realised (Oldekop et al., 2010; Ferraro et al., 2011; Martin-Lopez et al., 2011; Gross-Camp et al., 2012; Halpern et al., 2013; Krause and Loft, 2013). The many challenges this aim faces can be grouped into the three commonly used evaluation criteria of efficiency, effectiveness and equity (Bardhan, 1996; van Wilgen et al., 1998; Adger et al., 2005; Angelsen, 2008; Angelsen and Brockhaus, 2009; Kasterine and Vanzetti, 2010). Issues pertaining to the efficiency and effectiveness of ecosystem service use have been substantially studied, providing considerable understanding on them (Ferraro and Simpson, 2002; Drechsler et al., 2007; Wunder, 2007; Barton et al., 2009; Morse et al., 2009; Chen et al., 2010; Gauvin et al., 2010; Groom and Palmer, 2010; OECD; Narloch et al., 2011). These studies have made significant contributions to understanding how cost-efficient PES schemes can be achieved, such as through targeting discriminate payments to service providers. However, the study of equity issues arising for ecosystem service use is more limited and is still a compelling challenge fraught with conflict, trade-offs and incomplete understanding (Blaustein, 2007).

There has been quite a debate about what equity is in different settings, who defines it and how it is implemented in practice. According to several authors (Daly, 1992; Gleick, 1998; Costanza, 2000; Brown and Corbera, 2003; Corbera et al., 2007a; Fisher et al., 2008) equity is a measure of the fairness of the distribution or at least when inequity is limited within some acceptable range. These two definitions arise in the context of social welfare policy, were equity can be proportional - resources should be distributed according to people’s efforts or deservedness - or egalitarian - everyone should be treated equally (Syme et al., 1999). For example, if proportionality is considered, service providers would be compensated based on their contribution to service provision or their opportunity costs; and, if egalitarianism is considered, all service providers would be compensated the same amount irrespective of service provision or opportunity costs. On the whole, equity is perceived differently according to varying bargaining positions or values which are dynamic, linked to time and the larger environment (Savas, 1978; Wegerich, 2007). This study makes no claims on which approach to equity is pre-eminent, but provides insight into the application of both approaches described above.

Ignoring issues of equity in conservation planning can produce suboptimal social outcomes, and risk failure in prioritization efforts and durability of actions (Halpern et al., 2013). Many equity or fairness issues have been reported in the conservation literature, such as the perpetuation or exacerbation of poverty traps (Gilson et al., 2000; Coad et al., 2008; Krause and Loft, 2013), unequal distribution of payments or outcomes (Ghazoul et al., 2009; Narloch et al., 2011; Matthews et al., 2013; Narloch et al., 2013), loss of livelihoods and income (Börner et al., 2007; Corbera and Brown, 2010; Kosoy and Corbera, 2010; Mahanty et al., 2013), reproduction of power asymmetries (Kosoy et al., 2008), exclusion of the poorest (Grieg-Gran et al., 2005; Corbera et al., 2007a), among others. Furthermore, perceived or real inequity can create opponents to conservation efforts, leading to noncompliance or destructive actions. Thus, equity can be a critical component of ecosystem service management and conservation success (Halpern et al., 2013). To date, the issue of equity has largely been addressed indirectly, through implicit assumptions about spreading costs or benefits, or as a secondary concern, as with post hoc comparisons of the equity of outcomes (White et al., 2012). Thus, further study and understanding of equity issues related to ecosystem service use is warranted.

Several approaches have been implemented to try to integrate equity and conservation goals into economic and social contexts at the local, regional and global scale (Brown, 2002). More recent approaches can include integrated conservation and development projects, community-based natural resource management, pro-poor conservation, as well as market-based approaches such as direct payment schemes (Adams et al., 2004). These approaches have evidenced mixed outcomes and many challenges still prevail. For instance, integrated conservation and development projects (ICDPs), have been commonly critiqued because conservation activities tend to be strongly overpowered by development activities (Browder, 2002; Baral et al., 2007). Sommerville et al., 2010b) found that a community-based PES scheme in Menabe, Madagascar was overall positive, but still presented a lack of adequate benefit distribution. A review of World Bank economic projects that had environment and natural resources management as a major theme, showed that relatively few (16%) had substantial gains in terms of their stated environmental and poverty alleviation outcomes (Tallis et al., 2008). Thus, the integration of equity and conservation, particularly regarding ecosystem service use, remains a challenge.

2.2.1 Distribution of Costs and Benefits

Although there are many studies looking at the impacts of conservation and ecosystem service use on the poor, this is a narrow view not comprising the broader quantitative distribution of costs and benefits (Grieg-Gran et al., 2005; Pagiola et al., 2005). An understanding of the local costs and benefits of ecosystem service use is particularly important to further equity in developing countries (Ferraro and Simpson, 2002). In most cases, these benefits and costs are both poorly understood and poorly quantified (Costanza, 2000), and they are not evenly spread over all people, places and time (Arrow et al., 2000; Chan et al., 2007). As Brockington, 2004) and Kramer and Sharma, 1997) have noted for conservation, just as the failure to measure benefits can lead to suboptimal policies, the failure to measure the local costs may lead to unworkable policies. There are a number of studies investigating the costs and benefits of diverse conservation strategies such as activities in protected areas (Ferraro, 2002; Ezebilo and Mattsson, 2010), community-based projects (Sommerville et al., 2010b), incentive-based programmes (Spiteri and Nepal, 2006), and market-based mechanisms like PES schemes (Naidoo and Ricketts, 2006). Despite these studies, there are many gaps in the knowledge and understanding of costs and benefits of ecosystem service use and conservation.

The costs of conserving ecosystem services range from economical transaction costs, opportunity costs, costs of implementing conservation actions, and monitoring costs; plus more indirect costs such as increased competition for land, social tension, reduced employment and food security, weakening of local community institutions, to name a few

(Grieg-Gran et al., 2005; Coad et al., 2008; Fisher et al., 2008). It has been found that most conservation costs are felt in terms of access to natural capital (Igoe, 2006) or restrictions on the use of forests and its resources (Grieg-Gran et al., 2005). For instance, although richer members of forest communities are often the biggest harvesters of forest products, the poor can be more dependent on these resources and thus suffer the most from restrictions (Coad et al., 2008). Knowledge on the costs of conservation will provide vital information on where to best allocate conservation funds and efforts (Balmford et al., 2003; Naidoo et al., 2006; Naidoo and Ricketts, 2006).

Conversely, conservation strategies have generally aimed for environmental and social benefits, or at least not to compromise or even increase poverty (Balmford et al., 2002; Adams et al., 2004). Benefits are frequently experienced in terms of financial and physical capital (Igoe, 2006); such as amounts of income, diversification and stabilization of income sources, capacity building, technical support for livelihood activities, community empowerment and of course, the maintenance of ecosystem services (Grieg-Gran et al., 2005; Coad et al., 2008). However, benefits of conservation are often difficult to identify, slow to materialize, diffuse, or discouraged by high transaction costs (Spiteri and Nepal, 2006; Chan et al., 2007). Also, some groups are better positioned to take advantage of benefits than others and these are often not the same groups who have borne the biggest costs of conservation (Wells, 1992; Igoe, 2006). According to the Millennium Ecosystem Assessment report (MEA, 2005), “ecosystem services are the benefits people obtain from ecosystems”. In this study benefits are defined as the economic value that humans derive from an ecosystem service. Knowledge of benefits will help estimate the economic value of lands and ecosystem services identified for conservation and to identify who may be willing to pay for these services (Balmford et al., 2003; Naidoo and Ricketts, 2006; Reid et al., 2006).

Both costs and benefits need to be understood to estimate the value of conservation lands and ecosystem services (Balmford et al., 2003; Naidoo and Ricketts, 2006; Jack et al., 2008). Many studies focus on one or the other, costs or benefits, seldom both and rarely on their distribution. Distribution refers to the relative division of the resource flow, as embodied in final goods and services, among alternative people (Daly, 1992; Haab and McConnell, 2003), considering both social and environmental concerns (Brink et al., 2009). The distribution of costs and benefits has been found to vary between male and female, providers and users of a service, intergenerational (current and future people) and intra-generationally (among and within communities and individuals) and between different time periods based on the extent of dependence on ecosystem services (Arrow et al., 2000; Coad et al., 2008; Farley and Costanza, 2010). So far studies looking at equity in ecosystem service use and conservation through the distribution of costs and benefits have been relatively limited and with varied methodologies (Igoe, 2006; Tallis et al., 2012). However, understanding the distribution of economic costs and benefits, and the factors affecting such distribution are important and need special attention (Spiteri and Nepal, 2006; He et al., 2008).

A few studies have looked at the costs and benefits of ecosystem services and suggest that unequal distribution is the trend (e.g. Briscoe et al., 1990; Wegerich, 2007; He et al., 2008). This trend in the distribution of costs and benefits is probably due to them accruing to beneficiaries and providers in different ways depending on several characteristics. The literature has already reported equity implications and trade-offs due to spatial location, poverty levels, opportunity costs, as well as many forms of market failure: externalities, insufficient knowledge and information, public goods nature, and imperfect property rights (Arrow et al., 2000; Chan et al., 2007; Corbera et al., 2007a; Jack et al., 2007; Engel et al., 2008; Jack et al., 2008; Lant et al., 2008; Brink et al., 2009; Paavola, 2009). Many of these factors are influenced by macro-scale issues usually out of stakeholders' control, but local scale factors are more flexible to change. Thus, how the local context determines the distribution of costs and benefits requires careful consideration, as well as the possible effect of conservation strategies on this distribution.

In this study, the focus on the distribution of economic costs and benefits is used as a characterisation of equity and to understand the factors influencing this distribution. This focus considers both costs and benefits with proportionate significance, and the way they relate to each other. An emphasis on a broader quantitative distribution of costs and benefits is needed as many studies have had a narrow view looking at the poor only (Grieg-Gran et al., 2005; Pagiola et al., 2005). This distribution needs to be understood and considered to better deal with inequity and to inform conservation policy design (e.g. Nyahongo et al., 2005; Berentsen et al., 2007; Hope and Castilla-Rubio, 2008).

2.3 Payment for Ecosystem Services Schemes

The management of ecosystem service use has been dealt with through numerous means, such as the public provision of ecosystem services, market or incentive-based mechanisms, voluntary efforts by firms and individuals, direct government regulation, and hybrid mechanisms. Market-based instruments are commonly referred to as the most effective way to conserve nature, and thus research has grown in their design (e.g. Daily, 1997; Heal, 2000; Landell-Mills and Porras, 2002; Pagiola et al., 2002; Engel et al., 2008; Boisvert et al., 2013). Market-based mechanisms work by creating or changing prices, making environmentally beneficial activities more profitable and environmentally harmful activities more costly (Sommerville et al., 2009; Muradian et al., 2013).

Market-based initiatives are important because they translate external, non-market values of the environment (correcting market failure) into real financial incentives for local actors to provide public good and common-pool type ecosystem services (Engel et al., 2008; Engel and Palmer, 2008; Lee and Mahanty, 2009; Farley and Costanza, 2010; Mohammed, 2012; To et al., 2012). The initiatives also change economic incentives towards conservation, change the behaviour of private actors involved in ecosystem service use, ensure that the beneficiaries of ecosystem services pay the full cost of service provision, and may facilitate environmental goals more efficiently than by regulation alone (Brink et al., 2009). Leading market-based instruments are markets for ecosystem services (regulatory or voluntary) and payment for ecosystem services (PES) schemes.

PES schemes have been defined broadly as voluntary and conditional transactions over well-defined ecosystem services between at least one supplier and one user (Wunder, 2005). The basic idea behind these mechanisms is that the beneficiaries of service provision compensate the providers. PES schemes have commonly covered carbon sequestration, provision of habitat for endangered species, protection of landscapes and various hydrological functions (Gómez-Baggethun et al., 2010). These schemes can increase local people's incentives to self-enforce resource-use restrictions, by raising the value of the conserved resource to beneficiaries, thereby helping to overcome a lack of state enforcement (Engel et al., 2008; Engel and Palmer, 2008; Farley and Costanza, 2010). They also represent a growing trend in conservation policy as they offer a more direct method for achieving environmental outcomes above other approaches (Jack et al., 2008; Zilberman et al., 2008).

Critics challenge PES schemes' ability to reduce poverty and enhance social justice in the distribution of income and wealth, as well as whether they can achieve its objectives of nature conservation and environmental protection (Kosoy and Corbera, 2010; Muradian et al., 2010; Van Hecken and Bastiaensen, 2010). PES does primarily focus on cost-effectiveness and efficiency, by offering economic incentives to foster more efficient and sustainable use of ecosystem services. These schemes were not originally designed to reduce poverty (ForestTrends, 2008; McDermott et al., 2013). There are, however, opportunities for designing PES which can enable low-income people to earn money by restoring and conserving ecosystems. In certain contexts, PES can present new incentives for sustainable management, in the form of regular payments for ecosystem services. These regular payments can provide both a reliable source of supplemental income and additional employment in the community (ForestTrends, 2008). Water PES schemes are particularly likely to have pro-poor impacts, more so than most other environmental management interventions. This is because they can be designed to minimise trade-offs between poverty reduction and watershed services goals, they involve transfers of wealth, and because they can empower the poor by recognizing them as valued service providers (Asquith et al., 2008; Bruijnzeel and Noordwijk, 2008).

Despite the potential benefits of PES schemes and successful cases contributing to poverty alleviation, PES is not a panacea. PES schemes pose many challenges and are not feasible everywhere (ForestTrends, 2008). Furthermore, PES schemes can take many forms and resemble a suite of different incentive-based mechanisms, some schemes fulfilling PES criteria more often than others (Sommerville et al., 2009). This study considers a straight-forward form of PES scheme, following Wunder, 2005) definition, as land set-aside for water conservation. Land set-aside in this study refers to landholders halting any land uses for a contracted period and receiving a payment for the benefits obtained from improved drinking water quality. The focus of this study is on assessing how equity can be advanced through PES schemes, as a way of enhancing this policy's goals but also to promote greater equity in ecosystem service use.

2.3.1 Designing PES Schemes for Improved Equity

The likelihood of achieving equity in PES schemes will mainly depend on the scheme design and the local context where it is implemented. Variations in the design of PES schemes include which services are provided and their characteristics, who the providers or sellers are, who receives the benefits, who are the implementers and intermediaries, the participation and contracting eligibility, the form of the incentive or payment, and how the payments are funded (Babcock et al., 1997; Kroeger and Casey, 2007; Ferraro, 2008; Sommerville et al., 2009). Ecosystem services and their distinct characteristics were considered in section 2.1.1, so only the knowledge on PES schemes will be discussed here.

The wide variety of buyers and providers in PES schemes and their possible relationships are important to consider in the design of any intervention (Sommerville et al., 2009). The potential providers of an ecosystem service are those actors, often private landholders, who are in a position to safeguard the delivery of the ecosystem service through ownership of the rights over the ecosystem service and the land (Sommerville et al., 2009). Ecosystem services are generally difficult to privatise or control; so suitable property rights need to be ensured and cooperation strategies negotiated between formal and informal providers (Arrow et al., 2000; Engel et al., 2008). Governments can also be landholders, and local communities can have joint property or management rights, raising issues of intra-community distribution (Rojahn and Engel, 2005). Whoever the providers may be, PES seeks to take advantage of their knowledge of the cost of ecosystem service provision and to seek out the low-cost providers where appropriate. As long as participation is voluntary, ecosystem service providers are unlikely to accept a payment lower than their cost of providing the ecosystem service, while conditionality ensures that they actually comply with their contracts (Engel et al., 2008). Landholders have better information than conservation agents and service users about the opportunity costs of supplying ecosystem services. Landholders can thus secure higher payments by claiming their costs are higher than they are; but society benefits more if the payments just compensate the landholders' opportunity costs of contract compliance and nothing more (Ferraro, 2008; Sommerville et al., 2009). Thus, estimating accurate opportunity costs for all landholders providing a service is vital for scheme feasibility and design, but it is also a challenging objective.

Who the buyers of an ecosystem service are is also important, particularly if they are the actual users of the service or a third party (typically the government, an NGO, or an international agency) acts on behalf of the users. Pagiola and Platais, 2007) argue that user-financed PES schemes are particularly likely to be efficient above other types, as the actors with the most information about the value of the service are directly involved, have a clear incentive to ensure that the scheme functions well, can observe directly whether the service is being delivered, and have the ability to re-negotiate (or terminate) contracts if needed. When benefits accrue to a small number of actors, incentives to free-ride and transaction costs are also relatively low. However, sometimes the conditions for user-financed schemes do not hold, and third party involvement may be the only way that PES can be implemented. In third party-financed PES schemes the buyers are not the direct user of the service, they have no first-hand information on its value, and generally cannot observe directly whether it is being provided. They also do not have a direct incentive to ensure that the scheme is working efficiently and are often likely to be subject to a variety of political pressures (Pagiola and Platais, 2007; Wunder et al., 2008; Corbera et al., 2009). However, these schemes may be more cost-effective because of economies of scale in transaction costs and they can overcome free-riding problems by charging compulsory user fees. The key distinction between user-financed and third party-financed schemes, then, is not just who is paying the bills, but who has the authority to make decisions about paying the bills. However, these are just two classifications of PES schemes, there are other possible classifications ranging between these two (Pagiola and Platais, 2007).

It is important to try to ensure that existing inequities in providers and beneficiaries are dealt with in any scheme. Considerations must be taken for those beneficiaries who can’t pay, such as excluding them from paying or granting concessions (Brink et al., 2009; Paavola, 2009). Also, poor potential service providers need to be made more competitive versus the better-off providers. This could be achieved by reducing transaction costs, simple contracts, have donors subsidised start-up costs, among others (Grieg-Gran et al., 2005). PES schemes are likely to make a true improvement in poverty outcomes only if they pay landholders an amount substantially higher than they would otherwise have earned with the land. PES schemes have the advantage of offering payments that are relatively certain compared to more variable and uncertain income sources, such as from agriculture. Providers are also likely to prefer a PES scheme over traditional regulation because it offers compensation for service improvements and participation is voluntary (Jack et al., 2008).

PES schemes do not only involve beneficiaries and providers, but also the wide variety of institutional contexts where they operate (Sommerville et al., 2009). The institutional structure or rules of a PES scheme include property rights or entitlements, monitoring (i.e. additionality assurance), enforcement, exclusion, governance, decision making, and contracting arrangements (Paavola, 2007; Corbera et al., 2009; Clements et al., 2010). This structure guides the practice and ultimate effectiveness of any intervention (Engel and Palmer, 2008; Corbera et al., 2009). It also greatly influences actor relationships, funding sustainability, and the nature of PES outcomes (Corbera et al., 2009). The PES literature has begun to explore many institutional structure choices based on early PES experiences (Laffont and Martimort, 2009). Wunder, 2007) suggests that effective implementation of PES schemes may be considerably more difficult where institutions are weak. However, schemes driven by non-state actors may be able to partially compensate for weak state institutions. Informal institutions can provide security to landowners in receiving compensation, where this security is not given by state legal institutions (Jack et al., 2008).

Within the past two decades a number of government-financed PES schemes have been established in developing countries with similarly well-defined institutional frameworks (Engel et al., 2008). Examples include Mexico's payments for hydrological environmental services program (Muñoz-Piña et al., 2008) and Costa Rica’s program initially aimed at reducing deforestation rates (Pagiola, 2008). In addition, there are a growing number of user-financed programs, such as payments for watershed services between downstream users and upstream forest owners in Ecuador (Wunder and Albán, 2008) and Bolivia (Asquith et al., 2008), and contracts brokered between organisations and private landowners, communities or governments (Milne and Niesten, 2009; Clements et al., 2010).

The number of PES studies and schemes implemented has steadily increased over the last decade, but in-depth research on the institutional processes mediating service provision through incentive schemes has only started to emerge (Corbera et al., 2009).

Incentives can be classified as positive or negative based on whether a decision maker perceives a gain or loss from their baseline. This study only focuses on PES schemes as a source of positive incentives for conservation. A PES scheme should aim to provide a net gain for participants through the use of positive incentives to bridge the gap between needs of users and landholders (Wunder, 2007; Garbach et al., 2012) and provide critical ecosystem services. In the most straightforward PES approach, individuals have legal control over the service provision and incentives are transferred to influence the decision to produce the service (Sommerville et al., 2009). PES incentives can be in cash or in kind (Wunder, 2005; Asquith et al., 2008; Engel et al., 2008), but there has been an overemphasis on monetary payments within the general PES discourse and practice (Jack et al., 2008). This is probably due to monetary payments being considered a more direct way of ensuring conditionality, as they are amenable to adjustment (Fisher, 2012). The roles and interactions of a range of potential positive and negative incentives throughout a scheme’s lifespan need to be considered (Wunder, 2005; Kosoy et al., 2007; Sommerville et al., 2009; Garbach et al., 2012).

PES scheme payments present a wide range of payment types, but are overall based on conditionality and additionality. Conditionality refers to giving payment if and only if the provider secures the provision of the ecosystem service; and additionality means that the payment stimulates new conservation that would not otherwise take place (Morrison and Aubrey, 2010; Muradian et al., 2013). The payment can be for conditionality measures as defined actions or as a general state of the system (Musters et al., 2001; CREC and CJC-Consulting, 2002; Engel et al., 2008; Sommerville et al., 2009). The size of the payment is conditional on performance relative to others or individualised specific criteria. The payment time horizon can be annual or at the end of an agreement (Marland et al., 2001; Wunder, 2005; Peskett et al., 2008; Sommerville et al., 2009). The openness of spatial and participation incentives can be inclusive or targeted (Wätzold and Drechsler, 2005; Ferraro, 2008; Wünscher et al., 2008; Barton et al., 2009; Sommerville et al., 2009). The scope and design of incentive payments, including how contracting is done, is crucial to the levels of equity achieved and maintained in any scheme. Sometimes it is not the level or amount of payment that defines fairness but the actual distribution of payments (Gross-Camp et al., 2012). Thus, the distribution of costs and benefits associated with any PES scheme need to be identified and understood to inform scheme contracting.

The viability of any PES program requires that the maximum amount that users of ecosystem services would be willing to pay for improvements in a service exceed the minimum amount that service providers would be willing to accept. Most PES programs base payments on the (opportunity) cost of the providers' adoption of particular land uses or management activities (cost-based approach). When additional management activities, such as reforestation are involved, the PES payment equals the sum of opportunity cost, transaction cost, and conservation cost. Benefit-based PES programs do exist, but they are exceptions. The focus on cost-based approaches has been due to markets for ecosystem services often not being competitive, or equity concerns that may require uniform rates. Very importantly, there is a lack of information on benefit estimates due to time and resource constraints, and they are often harder to estimate. A major problem with the cost-based approach is underpayment, whereby the payment is not high enough to attract potential providers to the most important areas of ecosystem service conservation. A future direction for PES is to establish schemes considering both benefits and costs supported by ecosystem service valuation (Liu et al., 2010).

2.4 Valuing Ecosystem Services

Most of the literature analysing costs and benefits of conservation and ecosystem service use have done so with methods such as literature reviews, case studies, cost-benefit analysis, among others. For instance, Bräuer, 2003) and Zheng et al., 2009) evaluate conservation using cost-benefit analyses. Both Balmford et al., 2003) and Grieg-Gran et al., 2005) reviewed case studies to compare global costs and benefits of conservation, and to explore poverty issues, respectively. Xue and Tisdell, 2001) used opportunity costs and alternative cost methods to determine the monetary value of services in a Chinese reserve. However, there are gaps in studies applying valuation methods to understand costs and benefits of ecosystem services based on human preferences and values.

Ecosystem service valuation methods are increasingly promoted as a means for documenting the values humans place on ecosystems and the services these provide (de Groot et al., 2002; Chee, 2004; Groffman et al., 2004; Eamus et al., 2005; Kremen, 2005; MEA, 2005; Farber et al., 2006). This is an important trend as these values are often difficult to describe in economic terms and are rarely well-explained in conservation and development decisions (Wallace, 2007). Several studies have employed valuation methods to assess the costs and benefits of ecosystem services, but rarely both and seldom their distribution (e.g. Xue and Tisdell, 2001; Bruner et al., 2004). Valuation of ecosystem services highlights the important link between human and ecological systems (Liu et al., 2010); and it has become an essential analytical tool in protected areas (Chan et al., 2006). The estimated value of an ecosystem service can provide a basis for establishing PES schemes, substantiating a conservation claim (especially against an imminent threat), improving environmental knowledge and concerns, and hopefully inspire the local government and stakeholders to be more concerned about limited resources (Chen et al., 2009). In this study valuation is employed as a way of accounting for the role and economic value of ecosystem services, as well as the true benefits they generate for human wellbeing.

Some argue that valuation of ecosystems is either impossible or unwise, that we cannot place a value on such intangibles as environmental aesthetics or long-term ecological benefits. But in fact, we do so every day, e.g. when we set standards for infrastructure or life insurance. Valuation is useful as money demonstrates to the public the social importance of conservation; it promotes a de-emotionalisation in decision-making; it provides knowledge of the real costs; it provides information about the potential damage to be internalised; and green accounting needs an economic valuation of ecosystem services (Bräuer, 2003; Liu et al., 2010). Nowadays, with unprecedented and intensifying pressures to deplete ecosystem services, the traditional arguments in support of ecosystem conservation alone are not sufficient. They do not capture the complete dependence of human wellbeing on nature. The socioeconomic focus of valuation is a vast improvement over business as usual (Brown et al., 2007; Badola et al., 2010). Although ecosystem valuation is certainly difficult and fraught with uncertainties, we are forced to make choices and these are enhanced when informed by valuation techniques (Costanza et al., 1997).

Individuals and societies allocate their limited resources so as to obtain the maximum welfare possible. To make decisions, they need to assess the relative value of services in order to choose those that provide the highest value per unit of costs incurred in attaining them (Figueroa and Aronson, 2006). Value can be defined as the contribution of an action or object to a user's goals or utility (Costanza, 2000). Thus, value is the result of people's expressed tastes and preferences, and the limited means with which services can be obtained. The value of ecosystem services is based on the intrinsic value of a service, measured by its contribution to maintaining the health and integrity of an ecosystem or species, irrespective of human satisfaction, and its instrumental value, that reflects the difference that something makes to the satisfaction of human preferences (Edwards and Abivardi, 1998; van Wilgen et al., 1998; de Groot et al., 2002; Farber et al., 2002; Straton, 2006).

Valuation methods can be divided into two main categories, indirect or revealed preference and direct or stated preference. Revealed preference methods explore the use of existing market and behavioural data to estimate the ex-post willingness to pay for various commodities. This is done using methods such as travel cost, hedonic price, averting behaviour, production function, or surrogate markets. For instance, averting behaviour focuses on expenditures that people make to reduce exposure to disamenities (Boyle, 2003b). Stated preference methods are based on the simulation of the market or hypothetical data to estimate the ex-ante willingness to pay for various commodities by means of questionnaires; such as the contingent valuation and choice modelling methods (Eade and Moran, 1996; Whitehead et al., 2008). For instance, contingent valuation techniques elicit willingness to pay (WTP) to maintain or improve a service or willingness to accept (WTA) its loss. WTP is the factor limiting how much of this value can be translated into a monetary flow (Fearnside, 1999; Nunes and van den Bergh, 2001; Nijkamp et al., 2008).

As the extensive literature on ecosystem services valuation has shown, each of these methods has its strengths and weaknesses. The major strength of the revealed preference approaches is that they are based on actual choices, better reflecting the values of the population and allowing more valid estimates of willingness to pay. Their major weakness though is their reliance on historical data. Stated preference approaches have the strength of flexibility to construct realistic policy scenarios but its major weakness is their hypothetical nature. The strengths of the revealed preferences approaches are the weaknesses of the stated preference approaches and vice-versa; so a more comprehensive comparison of both methods offers a better value of the ecosystem service being studied (Costanza et al., 1997; Hanley, 1997; de Groot et al., 2002). PES designers have often turned to stated preference methods, and particularly to contingent valuation surveys (CV), to estimate the benefits provided by ecosystem services. CV can play several possible roles in PES design and equity advancement: to assess whether PES would be welfare-improving; provide guidance on the price to be charged to service users; and provide reassurance to policymakers that implementation of PES is politically feasible, by indicating that users would indeed be willing to pay (Whittington and Pagiola, 2012). Other valuation methods, such as revealed preference and market approaches, provide similar advantages. In this study the benefits provided by ecosystem services and the value ascribed by users to these services are used interchangeably.

There is a serious gap in the knowledge of ecosystem service valuation which suggests that much original research needs to be done to value ecosystem services (Naidoo and Ricketts, 2006). Most studies looking at the value of improving drinking water quality have focused on one approach or the other, only a few (Alberini et al., 1996; Laughland et al., 1996; Pattanayak et al., 2005; Rosado et al., 2006; Urama and Hodge, 2006; Haq et al., 2007; Vasquez et al., 2009) have in some way or another compared averting behaviour (revealed preference) and contingent valuation (stated preference). And only Dasgupta, 2004) was found to include averting behaviour and illness damage costs for a more complete measure of WTP.

The costs of conserving ecosystem services can include transaction costs, opportunity costs, costs of implementing conservation actions, and monitoring costs (Grieg-Gran et al., 2005; Coad et al., 2008; Fisher et al., 2008; Pagiola and Bosquet, 2009). Opportunity costs are widely accepted as the main cost of conservation (Sinden, 2004; Naidoo and Adamowicz, 2006). Opportunity costs are a useful tool employed for a variety of reasons, such as calculating conservation costs in protected areas or natural resource management, determining their distribution among landholders, assessing trade-offs in land uses, to test methodological issues, and more recently to assess the feasibility and design of PES or REDD+ projects (Pagiola and Bosquet, 2009). Estimating opportunity costs is a crucial starting point to determine the economic viability of PES schemes to effectively change land use practices (Plumb et al., 2012). A large challenge also exists to understand the distribution of opportunity costs among and within different ecosystem service provider groups as they have been found to be quite heterogeneous (Tallis and Polasky, 2009; Adams et al., 2010; Badola et al., 2010). Understanding how opportunity costs are distributed will inform who would gain and who would lose from a scheme, which is important both from an equity perspective and from a practical one (Pagiola and Bosquet, 2009).

Three main approaches have been used in the literature to estimate opportunity costs for PES schemes and other conservation initiatives. These approaches include the more recent screening contracts and procurement PES auctions, as well as more commonly used methods based on land attributes or returns, such as costly to fake signals, actual net returns from land uses, as well as land prices. First, screening contracts consist of offering a contract for each of the different types of landholders believed to exist and letting them self-select a contract. However, this method is limited by requiring detailed knowledge about the distribution of landowner types and sophisticated calculations by conservation practitioners. So far, no applications of this approach exist in practice (Wünscher et al., 2011). Second, procurement PES auctions consist of a buyer of ecosystem services inviting bids from the suppliers for a specified contract and then buying the contracts with the lowest bids (Ferraro, 2008; Tóth et al., 2010). Auctions, if designed appropriately, get landowners to reveal the distribution of landowner types through their bids. For example, Jack et al., 2009) applied a procurement auction to determine how payment contracts can be configured during the design-phase of a conservation program for soil erosion control in Indonesia. Also, Khalumba et al., 2014) combined procurement auctions for reforestation contracts with payments based on contractor performance in Western Kenya. Both studies found that this approach helps reveal private landholders’ opportunity costs. However, these auctions have disadvantages, such as being quite complex to design and requiring a large pool of bidders to be valid.

Third, information can be gathered on observable landholder and land attributes that are correlated with opportunity costs and use these attributes to determine opportunity costs and establish PES contracts. Naidoo and Adamowicz, 2006) estimated opportunity costs based on observed spatial patterns in conversion of natural habitat to agricultural land and observed net benefits from agricultural plots in a Reserve of Paraguay. Notably, collecting information on these attributes can be costly and the accuracy of this information will only be as good as the strength of the correlations between the attributes and landholder types. OCs can also be estimated using generic or average data often from secondary sources, most frequently government data. Many studies have applied this approach, most recently for REDD+ projects (Börner and Wunder, 2008; Börner et al., 2010; Hunt, 2010; Fisher et al., 2011b; Fisher et al., 2011c). This approach is useful for studies at regional or national scale, but does not capture local variation (Grieg-Gran, 2006) and can yield quite varied results depending on the data sources employed.

Furthermore, land use net returns can be estimated at the local or micro level, also referred to as the flow approach. Local level opportunity costs have helped develop payment levels for many existing PES programs (Plumb et al., 2012). Among the more recent studies we find: Borrego and Skutsch, 2014) that quantified the net returns to land uses that degrade dry tropical forests in Jalisco, Mexico. Illukpitiya and Yanagida, 2010) estimated farm returns to explore the trade-off between agriculture and extraction of forest products and to determine the efficiency improvement necessary to compensate the current income generated by non-timber forest products in the Badulla district of Sri Lanka. Adams et al., 2010) estimated opportunity costs of agriculture and ranching focusing on single stakeholder groups at Mbaracayu Forest Biosphere Reserve, Paraguay. This widely used flow approach provides detailed local information and variability. However, its drawbacks are that it is not suitable for extrapolating to larger areas, it bears the risk of strategic bias, can be quite costly, and a lot of data is at a coarse scale and can lack important information (Cattaneo, 2002; Grieg-Gran, 2006; Börner et al., 2007; Fisher et al., 2011b; Wünscher et al., 2011).

Finally, land market prices can be converted into values that can serve as proxies for opportunity costs, also referred to as the rents approach. For example, Chomitz et al., 2005) estimated the opportunity costs of conservation in a biodiversity hotspot of Brazil using hedonic price model to impute land values. Ando et al., 1998) used county-level data on agricultural land values from the USA government to study the effect of heterogeneous land prices on the efficient selection of reserve sites. Ma and Swinton, 2011) demonstrate how hedonic analysis of agricultural land prices can be used to estimate the private values of land-based ecosystem services with data from Michigan, USA. The use of land values to determine opportunity costs is commonly used, reveals landholders true value for land and is quite straightforward. However, this approach is not recommended when no land market exists or it is undeveloped, where land can be obtained for free, or when it may reflect returns from potential land use not the actual one (Cattaneo, 2002; Ferraro, 2004; Grieg-Gran, 2006; Börner et al., 2007).

More comprehensive studies utilise two or more of the above described approaches to obtain more accurate and robust opportunity cost estimates (Sinden, 2004; Kosoy et al., 2007; Wünscher et al., 2011). The authors recommend further research into opportunity cost estimations, particularly the flow approach techniques that are applied to deliver farm net returns. Particularly because cost-effective and precise estimation of site-specific opportunity costs is a major challenge (Wünscher et al., 2011). This study follows the more comprehensive studies described above by employing both a flow and a rent approach. The flow approach uses local level net returns from agriculture in order to obtain detailed insight into the heterogeneity of landowners and variability of opportunity costs. The rent approach employs stated land values that potentially reflect more stable longer term values.

2.5 Conclusion

This chapter first explains the long-standing debate and need for achieving both development and conservation goals simultaneously, particularly in protected areas. It also highlights how one of the main concerns arising from this challenge is dealing with inequity. It then explores how the ecosystem services approach provides a useful view of the link between ecosystems and anthropogenic activities, the benefits that ecosystems provide to humans and the extent of ecosystem services beyond protected area boundaries. Ecosystem services are then defined, as well as the key characteristics that affect ecosystem service use. This research aims to contribute to this debate by considering the challenge of improving ecosystem service provision for local inhabitants within a protected area setting.

Subsequently, a critical review on how inequity has tried to be addressed and the impending challenges that persist is presented. The need for further study is highlighted as ignoring issues of equity will likely produce suboptimal outcomes and risk failure in prioritization efforts and permanence of actions. It is generally agreed that equity is a measure of the fairness of distribution and it is very important that this distribution be understood, as costs and benefits are not evenly spread over all people, places and time. Many studies have investigated costs and benefits of conservation efforts, but they have only assessed costs or benefits (rarely both), and have not studied their distribution. Thus, this study focuses on the distribution of both the costs and benefits of ecosystem service use to inform equity outcomes of a potential PES scheme, beyond arguments on poverty reduction alone.

This chapter also describes Payment for Ecosystem Services schemes, a market-based instrument, as a highly popular means of providing ecosystem services. Then, the potential of PES schemes to account for equity in their design, as well as being used to advance equity in ecosystem service use above other methods is discussed. This study contributes to the understanding of how PES schemes can be designed to advance equity based on several of its features, such as governance and property rights. Finally, economic valuation of ecosystem services is presented as a mean to assess the costs and benefits distribution of ecosystem service use. The use of valuation methods is favoured as it accounts for the true benefits ecosystem services generate for human well-being, and it provides the price to be paid for ecosystem services in a PES scheme, as well as its potential distribution. This study provides methodological contributions by comparing stated and revealed approaches to estimating willingness to pay (WTP) for ecosystems service provision. Particularly, a more complete revealed WTP is estimated by considering both averting behaviour and illness damage costs to deal with contaminated water, which provides a novel context to interpreting WTP. Another important methodological contribution of this thesis is the comparison of two different opportunity cost methods, the flow and the rent approach.

This comparison further strengthens the results obtained but also highlights the challenges involved in the estimation of these costs. In brief, this review identifies that the study of advancing equity, through studying the costs and benefits distribution of ecosystem service use through potential PES schemes, is an important research area, especially for water provision at the local scale in developing countries. This study aims to contribute to this.

Specifically, the review highlights that many studies have investigated the costs or benefits of conservation. Few of them, however, have examined the distribution of both costs and benefits, the factors affecting this distribution, and with an ecosystem services approach. Objective 1 of this thesis seeks to contribute to this gap. This chapter also shows that many policies have been implemented to try to solve issues of inequity that often arise in conservation efforts. Although the market-based instruments of Payment for Ecosystem Services schemes were not primarily intended to improve equity, there have been claims that they have the potential to do so. Also, these schemes are an increasingly popular and widely applied policy, so consideration is needed on how to best design them to improve equity. Objective 2 of this thesis strives to contribute to the challenge of how to advance equity through PES scheme design and application. Finally, this review shows that economic valuation methods are useful means of assessing the value of ecosystem services. However, further understanding is needed on how different valuation methods are estimated and how they can be utilised in determining costs and benefits of ecosystem services. The 3rd objective of this thesis aims to add knowledge in this area.

Chapter 3: Methodology

This chapter describes the overall research design and the specific methods used to collect data to achieve the objectives of this thesis. It highlights why the ecosystem service of water provision and the Honduran study site were selected. Furthermore, it provides a description of the sampling approach, as well as the providers and beneficiaries of the ecosystem service. The chapter also describes how the qualitative and quantitative data were collected and analysed. Throughout, the strengths and limitations of the various methods are highlighted and the main research limitations are presented.

3.1 Ecosystem Service Selection: Water Provision

Contaminated drinking water is a major health problem in developing countries and diarrhoea is the most common illness associated with it (Alberini et al., 1996; Dwight et al., 2005). Diarrhoea is particularly a problem for the poor and vulnerable as it is a leading cause of morbidity and mortality in developing countries (LeChevallier and Au, 2004; Guh et al., 2008; Jalan et al., 2009; Halder et al., 2013). Each year there are approximately 4 billion cases of diarrhoea worldwide (LeChevallier and Au, 2004) and an estimated 88% of diarrhoeal deaths worldwide are attributable to unsafe water, inadequate sanitation and poor hygiene (Black et al., 2003). It is recognised that diarrhoeal illness is multi-cause and is affected by a variety of biological, environmental and social factors (Figueroa, 1990). Thus, the provision of clean drinking water in the developing world is an especially pressing matter as many people do not have enough of it.

Water provision refers to the filtering, retention and storage of water in streams, lakes and aquifers. The retention and storage capacity depends on topography and sub-surface characteristics of the involved ecosystem. The filtering-function is mainly performed by the vegetation cover and soil biota (de Groot et al., 2002). Water provision has been defined as a rival service that can be exclusive or non-exclusive depending on land tenure. It also has specific consumptive, directional benefits, i.e. the service is produced at one location and the beneficiaries are at another, and benefits accrue at local to regional levels. Specifically, water provision is the ecosystem service and the actual benefit to society is improved drinking water quality.

One reason for selecting water quality as the ecosystem service to study is because it has been found that aiming to increase water retention and storage through the expansion of forest cover is highly debated and evidence for the link is poor. Tackling water quality problems is more likely to be effective since there is less technical uncertainty and less divergence between public expectations and scientific evidence on the relationship between land use and water quality. Many national and local projects are based on a direct relationship between forest cover and water availability, such as the Mexican federal government program that pays forest owners for watershed protection and aquifer recharge (Muñoz-Piña et al., 2008). However, it has been found that the prospects for enhanced rainfall and augmented base flows as a consequence of forestation in the humid tropics are generally poor, and more dependent on site-specific factors (Scott et al., 2005). Thus, the empirical scientific evidence on the relationship between forest cover and water quantity is still debated (Hamilton and King, 1983; Bruijnzeel, 2004; Ayward, 2005; Kosoy et al., 2007). Importantly, the positive link between forest cover and water quality is much better established than that between forest cover and quantity (Bruijnzeel, 2004). Watersheds with a high proportion of land covered by intact forests and wetlands are particularly effective at moderating runoff and purifying water supplies. The vegetation and soils of forests and wetlands have a remarkable capacity to filter out contaminants and trap sediment that would otherwise enter rivers, lakes, and streams (Postel and Thompson, 2005). Thus, this study only focuses on the regulatory service of water quality provision.

The focus of this study is to assess the value of an improvement in drinking water quality to a clean or potable level from a contaminated status quo. Thus, the terms improved, clean and potable water are used interchangeably in this study, unless otherwise stated. The ecosystem service of water quality provision was selected based on its usefulness to address the issue of equity in rural protected areas; since it offers the clearest and most valued locally perceived benefits (de Groot et al., 2002; Van Hecken et al., 2012). Also, it is a service present and prioritised in most protected areas and it has vital importance for long-term quality of life. Importantly, access to safe drinking-water is essential to health, a basic human right and a component of effective policy for health protection (WHO, 2011). In 2011, an estimated 768 million people did not use an improved drinking water source, 83% of which lived in rural areas (WHO and UNICEF, 2014).

3.2 Case Study: Honduras and the Güisayote Biological Reserve

Latin America and the Caribbean possess about a third of the world's water resources, and yet In 2000, 77 million people lacked access to safe water, 66% of which were rural inhabitants (CONAGUA, 2006). Additionally, this region has the most inequitable income distribution in the world, hampering the resolution of water problems (Canales Davila, 2011). In the 1990s and 2000s the tendency was towards dealing with the challenges of increasing water scarcity, pollution and climate change, with initiatives such as new water laws (Canales Davila, 2011). However, there has been a widespread inability to establish formal institutions that are able to deal with water allocation issues, extreme events and water pollution under conditions of scarcity and conflict.

In contrast, Latin America has stood out in recent years for its pioneering and growing ecosystem services schemes (Pagiola et al., 2005) that have been recognised as a potential new form of watershed management in Latin America and further afield. National mechanisms have been implemented in Costa Rica and Mexico, and independent schemes focusing on biodiversity, water and carbon-related services throughout the continent (Herrador and Dimas, 2000; Sanchez-Azofeifa et al., 2007; Asquith et al., 2008; Kosoy et al., 2008; Pagiola, 2008; Barton et al., 2009; Daniels et al., 2010; Van Hecken and Bastiaensen, 2010). A number of payment schemes at the watershed level have already been implemented, allowing for preliminary lessons to be learned (Landell-Mills and Porras, 2002; Rosa et al., 2003; Mayrand and Paquin, 2004; Warner et al., 2004). Nevertheless, there remains much to learn before recommendations can confidently be made on how such programs should be best designed in developing countries (Pagiola et al., 2008).

Honduras is a small country (112,492 km^2) in Central America, with a population of over 8 million of which more than half is rural and two thirds live below the poverty line (FAO, 2010; GWP-Centroamerica, 2011; INE, 2014). The country has abundant water sources but uses less than 10% of its hydrological potential (GWP-Centroamerica, 2011). Thus, water availability is not an issue, but accessibility and quality are. In general, water quality is affected by population growth, the prevalence of untreated sewage, deforestation and the use of chemicals in agriculture. The government has recognised the importance the water services have in creating conditions for economic growth and the alleviation of poverty (Canales Davila, 2011). An effort has been made to decentralise natural resource management by greater involvement of NGOs, local governments and communities. However, despite these efforts and adequate legislation, such as the relatively recent 2009 Honduran General Water Law, adequate water management and conservation are still lacking (GWP-Centroamerica, 2011).

Honduras has a long tradition of centralised command-and-control style conservation, focused on the creation of protected areas. Currently, 95 protected areas cover approximately 27% of the country (CIPF, 2009; Figure 3.1). However, the limited political will and capacity of government agencies to effectively enforce legislation means many protected areas are just paper parks, with limited or non-existent protection. At the local and national levels Honduras is highly dependent on its natural resources, mainly forests for timber, firewood and other non-timber forest products (Jansen et al., 2006; Gareau, 2007; Larson et al., 2007). However, unsustainable practices and weak environmental governance threaten its protected areas and the livelihoods of their inhabitants (Rivera et al., 2000; Cherrett, 2001; Ericksen et al., 2002; Southworth et al., 2004). According to the Google Earth layer on deforestation, created by David Tryse, which draws its data from the World Resources Institute and Greenpeace, Honduras had the highest deforestation in the world between 1990 - 2005. In response, the country has seen the development of several initiatives, including some PES schemes. These remain geographically dispersed and have had differing effects on local livelihoods (e.g. Martinez de Anguita et al., 2006; Kosoy et al., 2007; Ballestero Madrigal and Rodríguez Alpizar, 2008). The Honduran government, like many developing countries, is unable to ensure suitable conservation efforts and guarantee clean drinking water for its inhabitants. Thus, Honduras is an ideal setting for this study representing Latin American developing countries.

The Güisayote Biological Reserve (referred to as the Reserve from now on; Figure 3.1) was selected as a representative case study for Honduras and Latin America. The Reserve is a protected area with several environmental problems and threats, a management category that is not respected, high levels of deforestation (30 - 68% forest coverage for the micro-watersheds included in this study; Mendoza, 2002) and forest degradation (AESMO, 2010; Magaña Portillo et al., 2010). The Reserve offered an ideal research setting to assess in-depth, local level equity issues and was selected as representative of rural areas in developing countries due to its socioeconomic heterogeneity, population pattern and the size of the watersheds. This in turn determines the variety in water use behavioural patterns of domestic consumers and thus contributes to assessing the WTP of these users. Furthermore, as protected areas are in their majority managed by NGOs on behalf of the government, it was important to secure their support and permission to carry out the research. AESMO, in charge of the Reserve, proved to be approachable due to current PES scheme explorations and provided the researcher with access to the area.

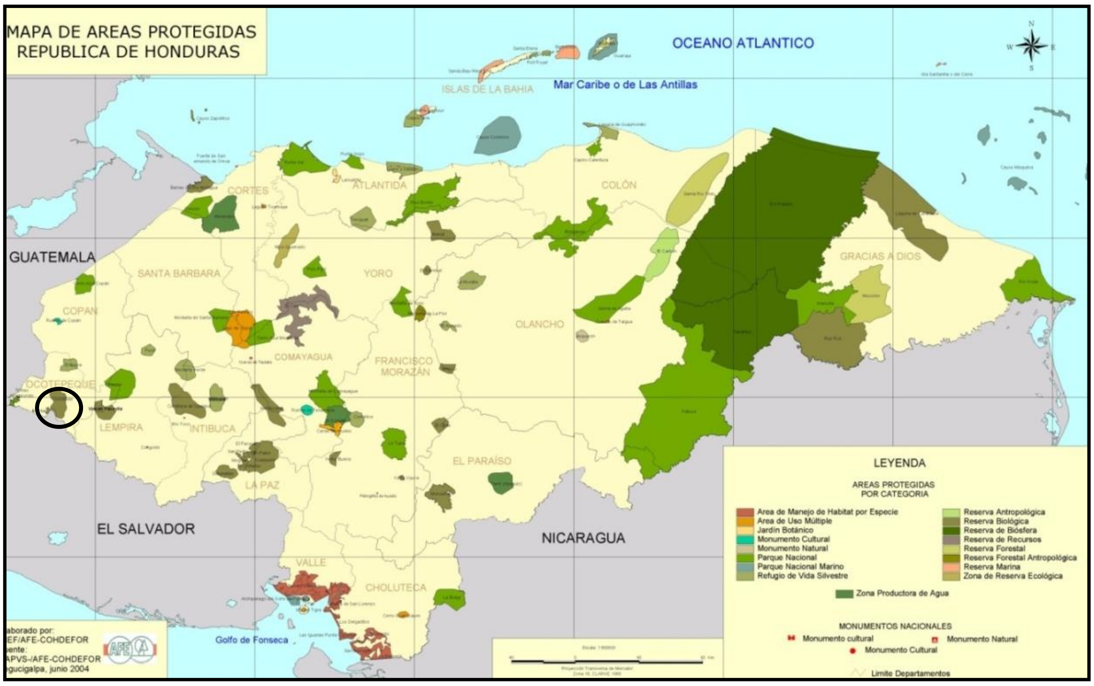

Figure 3.1 Map of the Honduran protected area system, showing each management category in a different colour and the location of the Güisayote Biological Reserve circled in black (source: AFE-COHDEFOR 2004).

The Reserve is located between UTM 1586980 - 1603550 latitude north, and 277850 - 281800 longitude east, in the west of Honduras close to the borders with El Salvador and Guatemala. It is 14,479.38 ha in size and crosses the municipalities of La Labor, Sinuapa, Fraternidad, San Marcos, Mercedes and San Francisco del Valle in the department of Ocotepeque (Figure 3.2). The Reserve is located between 1,140 and 2,310 m above sea level, with a strict conservation core zone of 4,563.87 ha and a managed buffer zone of 9,915.51 ha. Annual precipitation is high, between 1,150 and 1,300 mm, with a rainy season from May to October and a dry season from November to April. The average mean temperature ranges from 18 to 22 °C. The highest parts of the Reserve have rain throughout the year due to permanent rainforest cloud cover, evidenced by a relative humidity of 82 to 93% (AESMO, 2010).

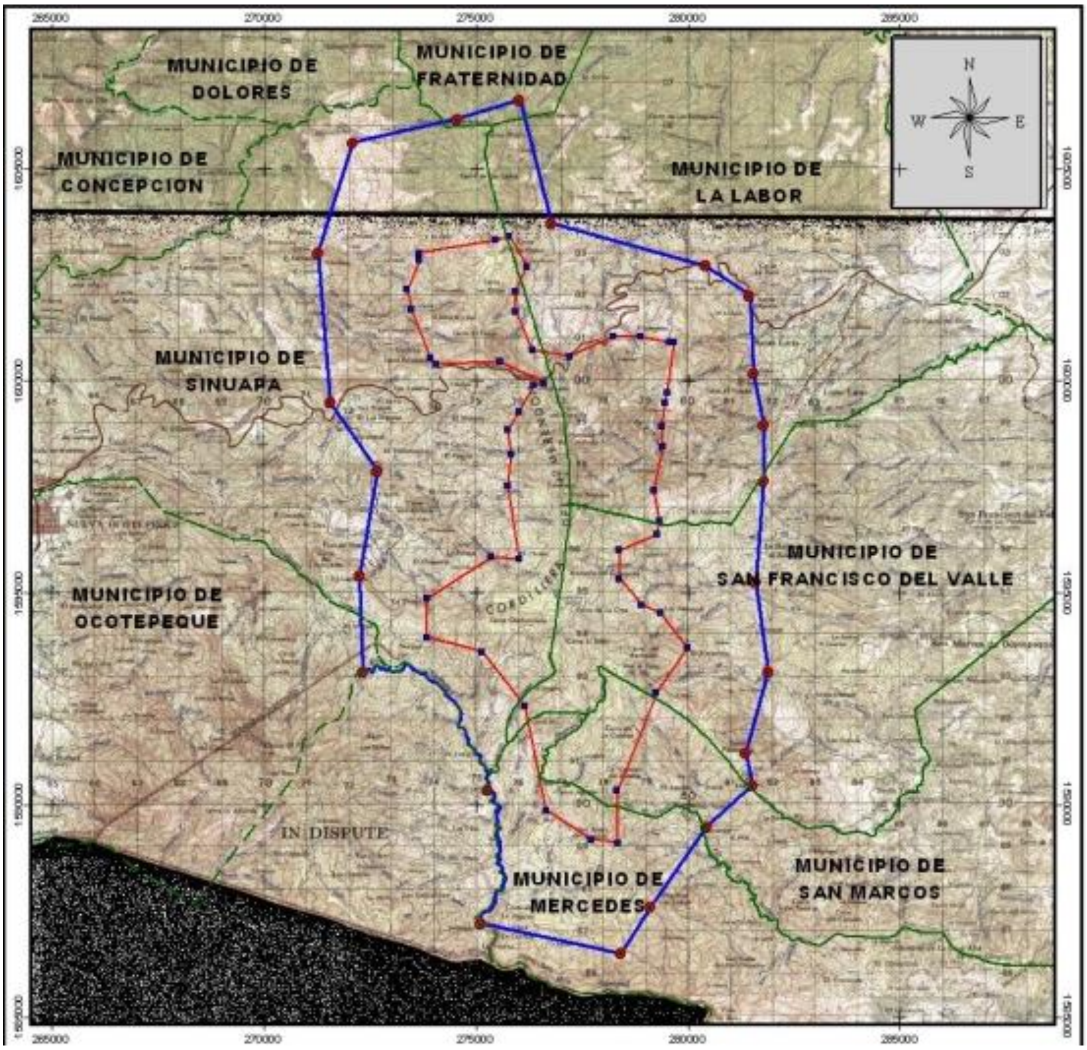

Figure 3.2. Map of the Güisayote Biological Reserve, showing the core zone in red, the buffer zone in blue and the municipality borders in green (source: AESMO 2006).

A biological reserve is a strict management category for "*an untouchable area that contains ecosystems, aspects or flora and fauna of scientific value. Its main function is to protect, conserve and maintain unaltered phenomena or natural processes, for studies and scientific research*" (La Gaceta Presidential Agreement No. 921-97, 25th of September 1999). The Reserve encompasses seven ecosystems: broadleaf forest, mixed forest predominant in broadleaf, intervened broadleaf forest, mixed forest predominant in conifers, low forest with bushes, pastures, and agriculture systems (see pictures in Appendix 1). However, the Reserve was created in 1987 through a government bid to explicitly protect thirty seven rainforests providing key hydrological services in the country. The Reserve itself contributes indirectly to two nationally important watersheds, the Ulúa (most important economically) and Lempa Rivers (AESMO, 2010).

Most of the Reserve is privately owned, which has hampered its management as a strict Biological Reserve. However, since 2003, the Reserve has been co-managed by the Asociación Ecological San Marcos de Ocotepeque (AESMO), with the support of the municipalities and the national forestry institute. More recently, AESMO has bought forested land in the core zone with own funding and that from the municipality of La Labor, the community of Llano Largo, the Ocotepeque area project of World Vision, and the Small Grants for the Purchase of Nature of UICN and the Dutch Lottery. To date, a total of 268 ha have been purchased and are under conservation by La Labor municipality. AESMO has also started an initiative to change the Reserve's management category to a National Park, to allow laxer management (AESMO, 2010).

This study specifically covers a watershed in the Reserve formed by the Idolo and El Potrero Rivers, and the El Chupadero stream (Figure 3.3), encompassing approximately 4,793.4 ha of rugged topography with very steep slopes. This watershed was selected as it is subject to the most problems in water provision compared to other areas of the Reserve and for covering the two protected area zones. The watershed has a history of non-existent protection and is threatened by varied and complex problems. Problems of water quality and quantity have been reported due to over grazing, land use change (agriculture and cattle ranching), use of agrochemicals, forest fires and inadequate extraction of timber and firewood (MSMO 2002). The greatest use of water is for domestic activities, followed by cattle ranching, agriculture and very rarely for industry.

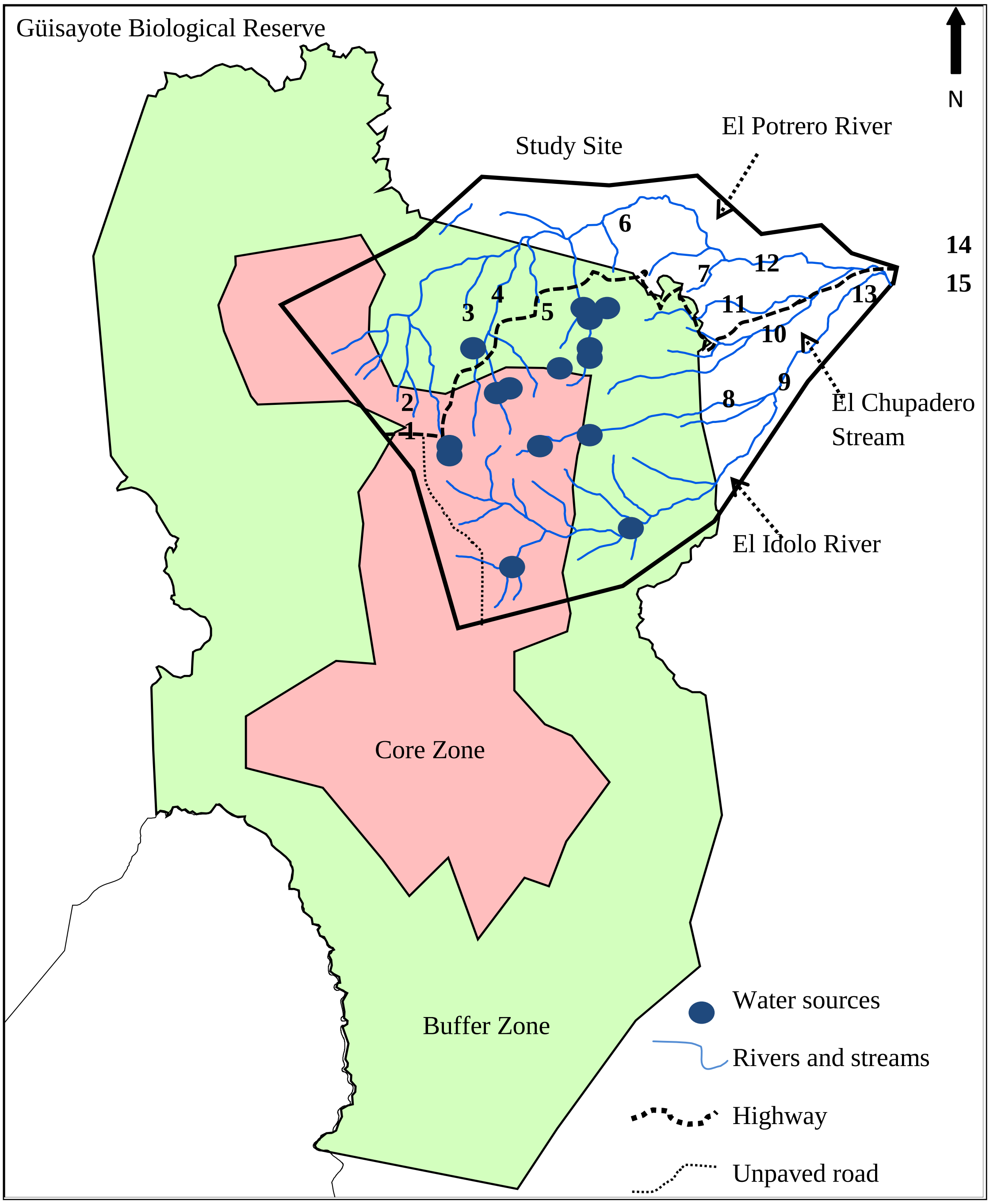

Figure 3.3. Map of the Reserve showing study site with core and buffer zones, rivers and streams in watershed, beneficiary communities and water sources; beneficiary communities: 1 = El Portillo, 2 = La Granadilla, 3 = Rio Chiquito, 4 = Las Flores, 5 = La Ruda, 6 = Pashapa, 7 = El Anicillo, 8 = El Ingenio, 9 = Llano Largo, 10 = Santa Lucia, 11 = Santa Efigenia, 12 = Montepeque, 13 = La Labor, 14 = Santa Cruz, and 15 = Los Amates.

The user population benefitting from the three watersheds is estimated at 7,725 inhabitants (PNUD, 2010b) in fifteen communities with low affluence and mostly depending on farming for their livelihoods. These communities have a total of 1545 households, between 11 and 393 households each, with only the largest considered an urban town (Table 3.1). Two communities are located within the core zone and three in the buffer zone, at a short distance from water sources, and the rest are located outside the Reserve. Furthermore, land ownership of water sources is generally insecure and varied, one is owned by the community, three by the municipality and the rest verbally donated. The annual water bill ranges between Lps. 120 and 500 (US$ 6.35 - 26.46) and is unrelated to the water system or supply. The reported proportion of households per community paying their water bill on time ranges from 30 – 100%. Each community has a water system independently managed by a locally elected water board, as in all cases the water systems were built with little or no government support. These community systems cannot guarantee water quality as water treatment is rudimentary, i.e. irregular or non-existent chlorine application. Each water system has a dam and/or collection box at the spring source, except El Portillo which uses a bucket system (see pictures in Appendix 2), and piping that takes water to a storage tank and then to households. Water sources are located between 15 and 180 minutes from the respective beneficiary community.

Upstream private landholders cover a large part of the water provision area through dispersed plots dedicated to both subsistence and commercial land uses. Some land is forested and the rest is used for maize and beans for staple subsistence, extensive cattle ranching throughout for subsistence and local commerce (of milk and cheese, seldom for meat), vegetables at higher altitudes (e.g. potato, cabbage, carrot) and coffee at lower heights for national and international commerce (Appendix 3). Generally these different land uses involve the application of fertilizers and pesticides, but have low technological inputs due to poverty and the irregular terrain. For most land uses, only a couple of communities have organised into informal farmer groups. Also, select vegetable farmers get support from NGO-based agricultural projects examining sustainable practices, increasing productivity, and marketing. Coffee is the main source of employment in the study site (PNUD, 2010b), so coffee growers generally receive a lot of support and are organised into local or national associations and cooperatives. In addition to its local importance, coffee is the main export of Honduras, making it the second largest Latin American producer and the sixth in the world (CentralAmericaData.com, 2011).

Table 3.1. Main characteristics of the fifteen beneficiary communities; note: DA = Donated by an individual from another community, DC = donated by an individual of the same community, M = municipality owned, C = community owned. *La Labor is divided into La Mesa and Centro neighbourhoods

Community	**Location in Reserve**	**No. of houses**	**Annual water bill (Lps.)**	**% pay on time**	**Time to source (min.)**	**Water source ownership**	**Water has been contaminated**	**Water board has savings**
La Ruda	Buffer zone	11	--	N/A	30	DA	Yes	No
El Anicillo	Outside	18	240	100	60	M	Yes	No
El Portillo	Core zone	19	--	N/A	25	DA	No	Yes
Los Amates	Outside	28	240	90	150	DC	Yes	Yes
Las Flores	Buffer zone	32	120	80	15	DA	No	No
Rio Chiquito	Buffer zone	33	372	50	20	DA	Yes	Yes
La Granadilla	Core zone	35	180	100	30	DA	Yes	No
Pashapa	Outside	68	150	60	80	DA	Yes	Yes
Santa Efigenia	Outside	68	240	100	80	DA	Yes	Yes
El Ingenio	Outside	68	120	100	90	DA	No	Yes
Montepeque	Outside	71	300	90	95	DC	Yes	Yes
Santa Cruz	Outside	119	360	40	180	DA	Yes	Yes
Llano Largo	Outside	260	500	85	90	C	Yes	Yes
Santa Lucia	Outside	322	180	75	120	M	Yes	Yes
La Labor	Outside	393	120	30/50*	120	M	Yes	Yes

3.3 Research Design

The research design developed to address the thesis objectives was based on an integrated range of methods including participatory methods to assess the local context and test research instruments; two quantitative valuations of water provision benefits to users; and two quantitative estimates of water provision costs to providers. Data collection comprised three distinct phases:

i. *Understanding the local context and testing research instruments.*

   The first phase consisted of three general exploratory methods: focus groups, mapping and interviews. Focus groups provided knowledge about the local context, views on water-related issues and tested the design of survey instruments; participatory community mapping helped determine the population and sample size, and facilitated fieldwork logistics; and interviews with water boards provided background on water supply and governance.

ii. *Valuing the WTP of beneficiaries for water provision.*

   The second phase was subdivided into two comparable stages: (i) a contingent valuation survey was employed to obtain the stated WTP of beneficiaries for improved drinking water quality through a PES scheme scenario; (ii) averting expenditure and damage costs were estimated to obtain a revealed WTP for improved drinking water quality. For both stages, the factors explaining the WTP distribution among beneficiaries were examined.

iii. *Defining the cost to providers of water provision.*

   The third phase originally consisted of three corresponding stages. An experimental procurement PES auction was implemented, but excluded from this study due to very low participation rates of an already small sample. Thus, the study includes two stages based on a survey that ascertained the opportunity cost of taking land out of production to ensure water provision: (i) the net benefits of each land use were calculated for all farmers based on the revenue and costs in a one year period, for a flow approach estimate; and (ii) landholders and farmers potential land rental and sale values, and the actual purchase price were recorded, for a rents approach estimate.

Safeguarding drinking water quality is a complex issue and the use of different methodological approaches contributed to a better understanding of the different aspects involved in the problem. Qualitative methods such as focus group discussions contributed to the understanding of local views and attitudes on water-related issues. Quantitative approaches such as the contingent valuation and the opportunity cost surveys allowed the measurement of the costs and benefits involved in drinking water quality improvement. The following section defines each of the data collection methods employed in this study, but detailed descriptions are deferred to the respective empirical chapters (4, 5, and 6) to aid readability.

3.4 Data Collection

Data collection commenced with a brief scoping trip between the 28th of March and the 7th of April, 2010 to carry out informal interviews with key informants in Tegucigalpa, the capital of Honduras. The trip also included a visit to the field site to check its suitability and to meet with AESMO staff. Fieldwork took place between 21st February and 29th October, 2011. Fieldwork commenced with three exploratory methods: focus groups, participatory community mapping and water board interviews. These initial methods provided knowledge about the local context and views on water-related issues, informed survey design and complemented subsequent methods. Two hired interviewers took part in all these methods in order to understand the local context and train for survey application.

3.4.1 Exploratory Methods

3.4.1.1 Focus Groups

A focus group is a small group of stakeholders that brainstorm and discuss their interests, influences and other subjects. It is a rapid, cost-effective and adaptable method (Reed et al., 2009). Two focus groups were facilitated by the researcher, following Kitzinger, 1995), with representatives of the water boards of each community. Water board representatives were invited by a personally delivered letter (Appendix 4). Both focus groups were implemented the same day, lasting approximately three hours each, with participants divided geographically to obtain upper and lower watershed views and to keep group sizes manageable and homogenous. The focus groups served to obtain the greatest amount of information in a short time period covering views and social dynamics of the local water context, and to test the contingent valuation survey questions were comprehensible to respondents and appropriate to the study site.

The morning focus group consisted of twenty participants representing ten communities, including one community not included in the final sample. The afternoon focus group had nine participants representing eight communities, including two communities not included in the final sample (Appendix 5). A series of open ended questions were used to guide discussions (Appendix 6) and were enhanced with PowerPoint slides. Also, the representatives of each community were given a study site map to locate their water source, landowners adjacent to the source, and contamination threats (Appendix 7). These visual aids were used in order to avoid discriminating against people who can't read or write. Sessions were relaxed, in a local cultural venue, with refreshments and lunch provided, and sitting in a semi-circle in order to view the PowerPoint slides (Figure 3.4). At the start, the researcher explained the aim of the focus group using slides and encouraged people to talk. The researcher maintained a back seat, only intervening when discussions were going off topic or to ensure all questions were covered within the available time. The focus groups were recorded, with participants' prior consent, and then transcribed in order for the researcher to concentrate on the discussions.

Figure 3.4. Photograph of afternoon focus group discussion led by researcher at local venue "Casa de la Cultura" in La Labor on the 15th of April 2011.

3.4.1.2 Participatory Community Mapping

Due to the lack of a land registry for the study site, participatory community mapping was carried out (Corbett, 2003). The first phase was carried out at the end of a municipal meeting (Figure 3.5a). It consisted on each community's auxiliary mayor (i.e. the community elected representative for municipal meetings) and any other community members, locating individual houses (with names), roads/tracks and main infrastructures on a draft map (Figure 3.5b). The initial maps were enlarged and redrawn from past project documents stored at the municipality office. The second phase involved water board committees and key informants revising the initial maps. All efforts were made to include relevant users of the service and exclude non-relevant users, to ensure representativeness and reduce non-response.

Figure 3.5. Photographs of a) Auxiliary mayor and community members elaborating their community’s map; and b) the completed map for Llano Largo community with household names attached on upper right-hand corner.

3.4.1.3 Water Board Interviews and Water Source GIS Mapping

Each water board committee, generally represented by the president (Figure 3.6), answered a structured interview, that is, the wording of questions and their sequence is the same from one interview to another (Fielding, 1994). The interview consisted of qualitative and quantitative questions, covering the water board committee structure, operationalization, accounting, financial security, ecological integrity of source, links and networks, and infrastructure (Appendix 8). Water board interviews were complemented by a visit to the community water source in order to corroborate answers, which also served to map the usual route taken to and location of the water source using a hand-held Geographic Positioning System (GPS) unit (Garmin Map62s). The aims of these interviews were to develop an understanding of local water governance and water conservation problems, and obtain spatial data to support findings.

Figure 3.6. Photographs of researcher interviewing two community water board presidents, (i) of Pashapa at water source (President is standing on water box; left) and (ii) of La Granadilla at the community (right).

3.4.2 Valuation of the WTP for Water Provision

Markets cannot efficiently allocate public goods or resources with pervasive externalities, or for which property rights are not clearly defined. Measurement of the costs and benefits involved is central to improving allocation and it is typically done through tools such as valuation methods. All valuation methods rely on people's innate ability to prefer, to place one object above or below another in a given context (Brown, 2003). Valuation is based on obtaining people's willingness to pay (WTP) to avoid a negative change or obtain a positive one, or willingness to accept (WTA), to forgo a positive change or accept a negative one. Typically, WTP is associated with a desirable change and WTA is associated with a negative change (Flores, 2003).

A variety of methods exist to determine the value of each ecosystem service (e.g. de Groot et al., 2002; Farber et al., 2002; Costanza, 2003; Chee, 2004; Olschewski and Benitez, 2005). In developing countries water quality valuation studies have used preference methods, such as contingent valuation and choice experiments, or revealed preference methods, such as averting behaviour, production functions, opportunity costs, travel cost methods, and hedonic pricing (Briscoe et al., 1990; North and Griffin, 1993; Nunes and van den Bergh, 2001; CBM-CCAD, 2002; Kaliba et al., 2003; Hopkins et al., 2004; Ahmad et al., 2005; Bauda et al., 2007; Martinez Tuna and Kosoy Daroqui, 2007; Barkmann et al., 2008; Ojeda et al., 2008).

This study applies the contingent valuation method to estimate a stated WTP and the averting behaviour plus the illness damage costs to estimate a revealed WTP. The revealed preference methods of averting behaviour and illness damage costs are considered the main methods when assessing the cost of illness due to poor drinking water quality (Boyle, 2003b). The stated preference methods of contingent valuation and choice experiment are the most commonly used nowadays due to their superiority above other methods in this category. Choice experiments are popular due to allowing for the estimation of numerous goods and/or different combinations of attributes for a single good (Brown, 2003). Contingent valuation on the other hand is useful when the estimation of any single kind of public good or service is desired (Haab and McConnell, 2003). Contingent valuation was selected for this study as there were limited options for the hypothetical scenario design for the good being valued, so a more complex method like choice experiment was not applicable or necessary.

The major strength of the revealed preference approaches is that they are based on actual choices, better reflecting the values of the population and allowing more valid estimates of willingness to pay. Their major weakness though is their possible reliance on historical data. The stated preference approach has the strength of flexibility to construct realistic policy scenarios but its major weakness is its hypothetical nature. The strengths of the revealed preferences approaches are the weaknesses of the stated preference approaches and vice-versa (Costanza et al., 1997; Hanley, 1997; de Groot et al., 2002). Thus, a more comprehensive comparison of both methods will offer a better value of the ecosystem service being studied and inform the validity of using a revealed approach to inform service valuation.

3.4.2.1 Sampling for Valuation Methods

The sample of water users to be surveyed for both valuation methods was randomly selected following Yamane, 1967) sample size formula at a 95% confidence level (Appendix 9). A 30% non-response rate was included in the estimated sample size (Macmillan et al., 2001) and households were selected using computer-generated random numbers. The unit of measurement was the household through the person self-identified as household head. The household head was most often male; in line with the male dominant culture of Honduras. Data elicitation was an in-person survey, covering both stated and revealed preference methods (Appendix 10), as other survey modes, i.e. telephone, mail and email, are inappropriate for rural populations that have inadequate communication infrastructure and high levels of illiteracy. In-person interviews also were selected to provide visual information to respondents and to ensure the interviewer was available to answer any questions that arose.

3.4.2.2 Determining a Stated WTP: Contingent Valuation

Stated preference methods for valuing the environment rely on answers to carefully worded survey questions and are often the most effective way to understand people's preferences. These surveys can describe new goods, limit the choice set and posit hypothetical policy scenarios. There are three main stated preference methods: attribute-based (choice experiments), paired comparison and contingent valuation. The first two methods ask respondents about numerous goods, allowing for the estimation of a preference ranking. On the other hand, contingent valuation is commonly used to value a single good, such as that assessed in this study, through a monetary measure (Brown, 2003).

The extensively used stated preference method of contingent valuation (CV), asks questions that help reveal the monetary trade-off each person would make concerning a change in the quantity or quality of a good or service by providing respondents with information about a hypothetical scheme that would bring about the change (Arrow and Solow, 1993; Boyle, 2003a; Haab and McConnell, 2003; Carson, 2012). The CV method offers many advantages, such as allowing for a more direct valuation of the characteristics of a service, contributing insights into the feasibility of potential projects and policies, and the ability to estimate non-use values which are not captured in other methods (Bateman et al., 2002).

3.4.2.3 Determining a Revealed WTP: Averting Behaviour plus Damage Costs

a) Averting Behaviour

Revealed preference methods draw statistical inferences on values from actual choices people make within markets, i.e. purchase decisions. Unlike stated preference methods, revealed preference methods rely on data that record people's actual choices (Boyle, 2003b). The four most commonly used of these methods are travel cost, hedonic models, averting behaviour and damage costs. Averting or defensive behaviour and damage cost methods are typically applied to value health effects.

The averting behaviour method is the most popular revealed preference approach to valuing safe drinking water as it more accurately estimates WTP values over other methods (Laughland et al., 1993; Whitehead and Van Houtven, 1997; Um et al., 2002). The method focuses on expenditures that people make to reduce exposure to disamenities or to offset adverse effects of exposure. Averting behaviour arises from a household production framework whereby people combine market goods that they purchase and their own time to produce a desired outcome: improved health or wellbeing from reductions in exposure to a disamenity. The purchased inputs and time comprise the implicit price of improved health. This method simply assumes that a rational person will take averting behaviours as long as the value of the damage avoided exceeds the cost of the defensive action. Averting behaviour is considered an adequate estimate or at least a lower bound of a measure of economic value like WTP of improving water quality because people may not be able to fully avert or there may be inconvenience in defensive actions that is not captured in the monetary cost (Boyle, 2003b; Dickie, 2003).

b) Damage Costs

Unlike averting behaviour, the damage cost method, also referred to as cost-of-illness or coping costs, implicitly assumes that there is no behavioural response to environmental changes or that behavioural responses are not effective. The damage cost method measures attempts to measure the full cost of illness caused by environmental contamination, such as the cost of waterborne illness due to drinking contaminated water (Boyle, 2003b). The method is straightforward because it uses market data on wages, hours worked, prices and quantities that are revealed through changes in behaviour in labour and health care markets (Kenkel, 1994; Whitehead and Van Houtven, 1997). Damage costs include both direct and indirect costs. Direct costs are expenditures to treat illness and restore health; indirect costs reflect the opportunity costs of reduced productivity or output foregone because of environmental contamination (Dickie, 2003). The method has the advantages of being relatively simple to employ, involving little subjective judgement or interpretation on the part of the researcher and being easy to understand by non-economists (Harrington et al., 1989; Whitehead and Van Houtven, 1997). This method is not generally assumed to estimate a measure of economic value like WTP, and is almost surely less than WTP, but it is a well-defined way of determining a lower bound estimate of benefits (Dickie, 2003).

3.4.3 Defining the Cost of Water Provision

As any human or domestic animal use of upstream land is likely to generate faecal contamination of water (Arby, 2008; Jewitt, 2011), besides contamination from agriculture, the PES scheme in this thesis was designed to remove land from production entirely and opportunity cost estimation is based on this premise. Opportunity costs were calculated to determine what would be the cost of conserving the study site watershed in order to improve drinking water quality.

These costs were chosen as usually they represent the largest portion of conservation costs, they provide insights into the drivers and causes of deforestation, they can help identify the likely impacts of conservation programs across social groups in a specific area, and they help identify fair compensation for those who change their land use practices (WBI, 2011). The concept of opportunity cost is based on scarcity and exclusiveness, because one course of action prevents another one from occurring (Pirard, 2008). Opportunity cost analysis generates a money-based representation (e.g. US$/ha) of the trade-off between conservation and generating profit from land use.

Opportunity costs can be estimated using various approaches, based on primary or secondary data, ranging from economic optimization or general equilibrium models (Cattaneo, 2002; Börner et al., 2007) to land prices being used as surrogates for the discounted stream of future deforestation returns (Richards et al., 1993; Antle and Valdivia, 2006; Naidoo and Adamowicz, 2006; Börner and Wunder, 2008). Most commonly, these costs are based on actual land-use changes, on historic trends or on the highest-value alternative land use (Pagiola and Bosquet, 2009). More specifically, opportunity costs can consist of direct, on-site costs (profit difference between conserving an area and converting it to another more valuable, land use), socio-cultural costs (livelihoods restricted or changed; psychological, spiritual or emotional impacts) and indirect, off-site costs (changes in economic sectors, tax revenue differences and agriculture and forest product price increases from economy feedbacks; Pirard, 2008; WBI, 2011). Due to the study's local focus on cost and benefit distribution, this study uses two bottom-up approaches based on local, on-the-ground, empirical data. The flow approach estimates direct, on-site opportunity costs and the rent approach includes direct costs likely to take account of socio-cultural costs also. Both approaches were covered within one opportunity cost survey (Appendix 11).

There are some limitations associated with opportunity cost estimations. First, estimations can inaccurate, as seemingly similar land use changes may have very different opportunity costs and many factors determine opportunity costs, both biophysical and socio-economic. Second, they might be considered to be the sole costs of conservation, excluding potential substantial costs. If transaction and implementation costs are also taken into account, different conclusions regarding viable schemes and policies could be reached (WBI, 2011; Rendón Thompson et al., 2013). Third, they do not always account for all types of opportunity costs; if possible, socio-cultural and indirect off-site costs should be considered besides direct, on-site costs (WBI, 2011). Therefore, opportunity costs should never be applied uncritically.

3.4.3.1 The Flow Approach to the Opportunity Cost

The flow approach consisted of estimating the micro-level net returns of each land use by subtracting from the sum of incoming monetary flows (e.g. from sales of agricultural products) the sum of outgoing monetary flows (e.g. through purchase of farm inputs such as fertilizer and petrol). This approach is likely to deliver slight overestimates of opportunity costs for several reasons: (i) the cost of land conversion is not considered, (ii) family labour is deducted at 50% of the local worker wage assuming there are few readily available alternative sources of income and (iii) data only cover a single year period (Wünscher, 2008; Wünscher et al., 2011). However, as mentioned in the previous section, this approach might also deliver underestimates of opportunity costs as it omits socio-cultural costs and indirect, off-site costs.

The opportunity cost survey included questions on farmer socioeconomic data and the costs and revenue for each land use to derive profits for a single year (2010 – 11). Only this period was covered because information on historical land conversion, factors influencing conversion patterns and land market prices were unavailable. Throughout the survey, no reference was made to the legality of forest resource use before or during the questioning, to avoid influencing responses; though some respondents may be aware of the legal implications of extracting forest resources in a reserve.

3.4.3.2 The Rent Approach to the Opportunity Cost

In the rent approach, land returns are approximated using annual land rents (Wünscher et al., 2011). In this study site land is infrequently rented, and sales rarely recorded. Three alternative methods to elicit rental values, namely stated sale and rental values, and actual purchase price were therefore used.

3.5 Valuation Data Analysis: Theoretical Background

3.5.1 Stated Preference Approach

The valuation of public goods and resources, such as drinking water quality, is based on welfare economics. Markets cannot efficiently allocate public goods or resources with pervasive externalities, or for which property rights are not clearly defined (Haab and McConnell, 2003). An example of this market failure is agricultural activities for food production, where farmers do not take account of the negative effects of their farming practices on water quality, such as contamination from agrochemicals, erosion from certain land practices and deforestation for land use expansion.

An improvement in resource allocation requires the measurement of benefits and costs, and the former need to exceed the latter. Economists have devised and refined methods for measuring benefits and costs; and thus whether and to what extent resources are being allocated efficiently. Two basic approaches are used for benefit estimation: indirect or behavioural methods (i.e. revealed preferences) and direct or stated preference methods. The need for statistical inference and econometrics arises because individual actions, whether observed behaviours or responses to hypothetical questions, almost never reveal precisely the economic value that needs measurement. First one needs to infer a preference function such as a utility function, or behavioural relation such as a demand function, and then benefit measures such as willingness to pay are calculated (Rodriguez et al., 2009).

The process of benefit estimation begins with the measurement of the net change in income that is equivalent to or compensates for changes in the quantity or quality of public goods; and then these are expanded to the relevant population. To start, let u (x, q) be the individual preference function, where x $= x_1 \ldots x_m$ is the vector of private goods and q $= q_1 \ldots q_n$ is the vector of public goods. Individuals choose their x but their q is exogenous. The individual maximises utility subject to income y and p represents price. The indirect utility function V (p, q, y), is given by (equation 3.1)

$$V\,(p, q, y) = \max_{x} \{u\,(\mathrm{x}, \mathrm{q}) | \mathrm{p} \cdot \mathrm{x} \leq y\}$$

The minimum expenditure function m (p, q, u) is dual to the indirect utility function (equation 3.2)

$$m\,(\mathrm{p}, \mathrm{q}, u) = \min_{x} \{\mathrm{p} \cdot \mathrm{x} \,|\, u\,(\mathrm{x}, \mathrm{q}) \geq u\}$$

The indirect utility function and the expenditure function provide the theoretical structure for welfare estimation. For stated preferences approaches, the changes in these functions are needed. For revealed preference approaches, a conceptual path from observations on behaviour to these constructs is needed. There are two equally valid ways of describing money welfare measures: compensating and equivalent variation, and WTP and WTA. They measure the same phenomenon, the increment in income that makes an individual indifferent to a change in some public good.

WTP is the maximum amount of income an individual will pay in exchange for an improvement in circumstances, or to avoid a decline in circumstances. WTA is the minimum amount an individual will accept for a decline in circumstances or to forego an improvement in circumstances. Compensating variation is the amount of income paid or received that leaves the individual at the initial level of wellbeing, and equivalent variation is the amount of income paid or received that leaves the individual at the final level of wellbeing. WTP and WTA relate to the right to a utility level; so for this study where individuals are required to pay to achieve a higher wellbeing, the right to that level of wellbeing lies elsewhere. Equivalent and compensating variation rely on the initial versus final wellbeing for their distinction. Recent practice adopts WTP and WTA terms chiefly because contingent valuation surveys use the terms, so we follow this focus here (Haab and McConnell, 2003; Smith, 2006).

WTP is preferred over WTA for several reasons, including the fact that WTA always exceeds WTP in empirical settings but not in behavioural methods, the general belief that WTA is not an incentive-compatible measure, and the recommendations of the NOAA that researchers should measure WTP. Thus, this study utilises the WTP approach to valuation. For an individual, WTP is the amount of income that compensates for an increase in the public good (equation 3.3):

$$V\left(\mathrm{p}, \mathrm{q}^{*}, y - WTP\right) = V\ (\mathrm{p}, \mathrm{q}, y)$$

The WTP can also be defined with the expenditure function (equation 3.4):

$$WTP = m\ (\mathrm{p}, \mathrm{q}, u) - m\ \left(\mathrm{p}, \mathrm{q}^{*}, u\right)\ when\ u = V\ (\mathrm{p}, \mathrm{q}, y)$$

The dichotomous choice approach to asking the question that leads directly to WTP has become the presumptive method of elicitation for CV practitioners. This is mainly due to this question format being incentive-compatible in theory. Since the contingent valuation responses are binary variables, yes or no, a statistical model appropriate for a discrete dependent variable is necessary. The aim is to estimate a probability distribution for the true WTP in a CV setting, using information on upper and lower bounds. The CV responses are analysed using statistical models, but the models need to make sense from the point of view of economic theory. This places significant restrictions on the statistical models that can be used (Hanemann et al.; Haab and McConnell, 2003).

Parametric models provide the most information from an economic point of view, but they can be fragile if misspecified. Non-parametric models are more robust and offer greater flexibility in the shape of the response function, but they provide less economic information (Hanemann et al., 1999). Thus, a parametric model is used to estimate the preference function that allows the calculation of WTP given the estimated parameters. The basic model for analysing dichotomous CV responses, including parameter estimation, is the random utility model (Hanemann, 1984; Hanley, 1997). This model assumes that while the individual knows their own preferences, these are not observable by the researcher. In the CV case there are two choices, so that the indirect utility for respondent j can be written:

$$u_{ij} = u_i(y_j, z_j, \varepsilon_{ij})$$

Where $i = 1$ is the state that prevails when the CV scenario is implemented, that is, the final state, and $i = 0$ for the status quo. The factors that determine utility are y_j (for income), z_j (for household characteristics and attributes of the given scenario) and ε_{ij} (a component of random preferences known to the individual respondent but not observed by the researcher; Hanemann, 1984). Due to these unobserved random preferences researchers can only make probability statements about yes and no. The probability of a yes response is the probability that the respondent thinks that he or she is better off in the proposed scenario, even with the required payment, so that $u_1 > u_0$. For respondent j, where t_j is the bid amount offered to the jth respondent, the general probability estimation is:

$$\Pr(yes_j) = \Pr[v_1(y_j - t_j, z_j) + \varepsilon_{1j} > v_0(y_j, z_j) + \varepsilon_{0j}]$$

This probability statement is too general for parametric estimation, so modelling decisions are needed. In order to understand the decision to answer positively, the utility difference between the yes and no responses needs to be examined. That is, the probability of a certain response is examined as a function of the differences in the utilities at the base and final states. Given that the random term can be rewritten as $\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$, the probability of a positive response is:

$$\Pr(yes_j) = 1 - F_\varepsilon\left[-\left(v_1(y_j - t_j, z_j) - v_0\left(y_j, z_j\right)\right)\right]$$

where $F_\varepsilon(a)$ is the probability that the random variable ε is less than a known as the cumulative distribution function (CDF). The above equation is the point of departure for all the random utilities with different functions. In the linear utility function specification the deterministic part of a respondent's preferences is linear both in covariates and income:

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

where α_i denotes an *m*-dimensional vector of parameters and β_i is the marginal utility of income. The deterministic utility for the initial and final states are:

$$v_{0j}(y_j) = \alpha_0 z_j + \beta_0 y_j$$
$$v_{1j}(y_j) = \alpha_1 z_j + \beta_1 (y_j - t_j)$$

and assuming that the marginal utility of income is constant in the quality change (*i.e.* $\beta_0 = \beta_1$), the change in deterministic utility for respondent *j* can be written as:

$$v_{1j} - v_{0j} = (\alpha_1 - \alpha_0)z_j + \beta_1 (y_j - t_j) - \beta_0 y_j = \alpha z_j - \beta t_j$$

and the probability of a yes response becomes:

$$\Pr(yes_j) = \Pr(\alpha z_j - \beta t_j + \varepsilon_j > 0)$$

Once the response model to the CV responses is built, a measure of welfare (i.e. people's WTP for the change to be valued) is estimated. The expression for the expectation of WTP with respect to preference uncertainty, following Hoyos, 2010) is:

$$E_{\varepsilon}\left(WTP_j \,|\alpha, \beta, z_j\right) = \alpha z_j/\beta$$

Logistic and probit models are both parametric models that play a key role in the analysis of discrete CV data. The aim is to estimate a probability distribution for the true WTP in the CV setting using information on upper and lower bounds (Hanemann et al., 1999). Both models focus on proportions of cases in two categories of the dependent variable and they are akin to multiple regression in that the dependent variable is predicted from a set of variables that are continuous or coded to be dichotomous. They produce an estimate of the probability that the dependent variables equal to 1 given a set of independent variables. The difference between the two models lies in the transformation applied to the proportions forming the dependent variable that, in turn, reflects assumptions about the underlying distribution of the dependent variable. In probit analysis each observed proportion is replaced by the value of the standard normal curve (z value) below which the observed proportion is found, that is, it assumes a normally distributed dependent variable. The assumption of a normal distribution makes probit analysis a bit more restrictive than logistic regression. However, the shapes and the results of the probit and logit distributions are quite similar (Tabachnick and Fidell, 2013). Thus, the commonly used probit model is used to analyse the CV data.

3.5.2 Revealed Preferences Approach

When behavioural methods are used, it is necessary to follow the influence of the public good on behaviour, and behaviour on welfare. For this, some structure needs to be imposed on the preference function, and the price or quality change (i.e. welfare measure) requires some restrictions. The principal restriction for quality is weak complementarity, an assumption about an individual's preference function that permits the value of changes in public goods to be traced to private behaviour. For more details on the theoretical basis of weak complementarity see Haab and McConnell, 2003). Weak complementarity implies that the value of, or WTP for, changes in the public good equals the change in the value of access to the private good. The weak complementarity result is (equation 3.5)

$$WTP = \int_{p}^{p*} x_1^u\,(p', q^*, u)dp' - \int_{p}^{p*} x_1^u\,(p', q, u)dp' = m\,(p, q, u) - m\,(p, q^*, u)$$

where x is the vector of private goods, q is the vector of public goods, p is the price paid for the private goods, u is the utility, and $m\,(\text{p}, \text{q}, u)$ is the minimum expenditure function**.** Thus, weak complementarity allows the change in the WTP for access to the private good to equal the WTP for changes in the public good (Haab and McConnell, 2003).

The incidence of illness is a function of the potential for contamination and the household's averting behaviour. Contamination is exogenous and averting behaviour is endogenous to the household. The household perceives being adversely affected by illness and deems the averting behaviour necessary. The incidence of illness is modelled as a function of the averting behaviour through a bivariate probit model. This model assumes observed independent variables and unobserved risk factors, e.g. daily fluctuations in the drinking water quality. Such a model captures the effect of behaviour on health and is therefore useful for analysing real-world situations, since it treats health and behaviour as interlinked variables (Alberini et al., 1996; Dasgupta, 2004). A univariate probit regression would yield inconsistent estimates because the hidden risk factor has introduced a correlation between averting behaviour and the error term in the damage cost equation; implying that the probability of becoming ill is not independent of engaging in averting behaviour (see Briscoe et al., 1990). Furthermore, the researcher used individuals' perceived level of contamination in the averting behaviour model (a discrete yes or no response), instead of the objective contamination measure (contamination magnitude; see Um et al., 2002).

The value for water provision obtained from the stated WTP and the revealed WTP were compared to the opportunity costs obtained from upstream landowners in order to assess the feasibility of a PES scheme. This section presents the theoretical background for the two main valuation models used in chapters 4 and 5, but detailed descriptions of the statistical models and other statistics used are deferred to the respective empirical chapters (4, 5, and 6) to aid readability.

3.6 Ethical Considerations and Study Limitations

This study has important ethical considerations as it includes working with data of human participants. In order to safeguard respondents, based on a University approved ethical review, participation was entirely voluntary, withdrawal at any time was allowed, consent was obtained for all elicitation methods, a project information sheet was provided to participants, and all data collected remained confidential, i.e. coded. Additionally, permission to do research in the Güisayote Biological Reserve was obtained from the organisation AESMO, who co-manages the Reserve on behalf of the government.

The usefulness of cost and benefit distribution analyses for research and policy applications depends in part on the accuracy of the estimates. This study had some limitations, minor ones will be discussed in each relevant chapter, such as survey design, valuation of time, and valuation of illness assumptions, among others. Here the overarching or central limitations are discussed. The study site presented four exogenous factors, outside the researcher’s influence, that in all probability affected the results of this study. First, long distances and infrequent transport in the rural, mountainous setting meant that there were substantial delays and restrictions during fieldwork. Second, many study site inhabitants seemed to be very wary of and guarded against the researcher and interviewers. Their wariness was evidenced in their unwillingness to provide accurate income and land values, in non-response rates to surveys, and some reluctance to sign the consent form despite their willingness to participate, among others. For example, some inhabitants in the El Ingenio community refused to answer the CV survey claiming that the interviewers worked for the government, who was trying to take control over the community water system. Third, some study site inhabitants were interest-seeking, observed when inexistent houses were included on community maps based on the belief that a new water project might be funded (despite clear explanations of research goals). Finally, the distinct characteristic of many beneficiaries also being providers of the ecosystem service is a complex situation that probably influenced respondents' answers. This dual role needs to be kept in mind when considering the recommendations made in this thesis.

Methodologically, two main weaknesses can be mentioned for this study. Originally, the CV question format was double-bounded (i.e. with two WTP questions) but due to the survey lacking anticipated warning of the elicitation format (which is believed to be best practice), only the first WTP question was used. This issue does not affect the contingent valuation results and analysis as the answers to the first WTP question were not allowed to be altered after a response was recorded. Additionally, the costs of water provision were initially planned to be estimated using three methods. The methods to be used for triangulation purposes were a procurement payment for ecosystem services (PES) auction, the flow approach and rent approach. A procurement PES auction estimates landowners' willingness to accept (WTA) a conservation program by creating a competitive temporary market and has been highly recommended in recent literature (Ferraro 2008; Jack et al. 2008). However, an auction of this type requires a large pool of bidders. Due to an extremely low participation level in the auction carried out at the study site, stemming from a small sample size, this data was excluded from any further analysis. Thus, the flow and rent-based opportunity cost approaches were used as the best alternatives, considering the local context and data available.

Chapter 4: Stated WTP and Benefits Distribution for a Water PES Scheme

This chapter describes the application of a contingent valuation method to estimate the willingness to pay of beneficiaries for a payment for ecosystem services scheme to improve drinking water quality. It also examines the factors affecting the benefit distribution of ecosystem service provision. Furthermore, it contributes to the discussion on contracting opportunities for local beneficiaries, considering their WTP and the local context.

This chapter looks at the stated WTP or benefits of improving drinking water quality as a direct way of assessing peoples' preferences. It also contributes information on the demand-side of a potential PES scheme in order to determine possible contracting opportunities and challenges. In chapter 7, these stated preferences will be compared to revealed preferences (see chapter 5), as well as contrasted to the opportunity costs of water conservation (see chapter 6) to assess the feasibility and challenges of contracting in a PES scheme.

4.1 Introduction

Poor drinking water quality is a major issue in developing countries due to incomplete information, inadequate monitoring and control, and pervasive contamination from point and non-point sources and diverse land uses (Soares et al., 2002; Jouravlev, 2004; Trevett et al., 2004; Smith and Porter, 2010; Smith et al., 2012; UNICEF and WHO, 2012). Improving water quality in developing countries involves a multifaceted array of challenges and the complexity of most water pollution makes it difficult to design cost-effective policies for pollution control (Olmstead, 2010). Therefore, an incentive-based approach such as land set-aside Payment for Ecosystem Services (PES) schemes could ensure water users have clean drinking water through a landscape approach to water conservation. The basic idea of these schemes is that the beneficiaries of the service, which has been ascribed a value, compensate the providers through voluntary and conditional transactions (Wunder, 2005). Land set-aside specifically, entails landholders foregoing the use of their land for a period of time which allows for the conservation of entire watersheds. This type of PES scheme could be particularly effective not only at improving water quality, but also for other ecosystem services such as flow regulation and habitat preservation (Postel and Thompson, 2005). However, these policy instruments must be carefully designed otherwise they could easily reduce, rather than improve, social welfare (Olmstead, 2010).

Valuation of ecosystem services allows for the estimation and accounting of their economic value, which means they are valued in equal terms as other land uses and can reveal social costs or benefits that might otherwise remain hidden (Troy and Wilson, 2006). Also, valuation reveals the magnitude of threats to ecosystem services and how these threats make them potentially subject to trade in market-based initiatives (Edwards and Abivardi, 1998; van Wilgen et al., 1998; Balmford and Whitten, 2003; Grieg-Gran et al., 2005; Badola et al., 2010). In order to value a change in an ecosystem service through a prospective policy such as a PES scheme, valuation is often done through stated preference methods based on survey questions to understand people's preferences. Contingent valuation is the most commonly used of these methods, where respondents take part in hypothetical scenarios and thereby reveal their WTP for ecosystem services provided through a specific policy (Mitchell and Carson, 1989; Raje et al., 2002; Haab and McConnell, 2003; Shultz and Soliz, 2007).

In the past, CV has been mainly applied in developed economies (e.g. Piper and Martin, 1997; Hite et al., 2002; Holmes et al., 2004); but more recently it is being increasingly applied in developing countries, especially in Latin America (e.g. Johnson and Baltodano, 2004; Martinez de Anguita et al., 2006; Soto Montes de Oca and Bateman, 2006). However, many of these studies are focused on urban areas with large populations (Raje et al., 2002; Shultz and Soliz, 2007; Vasquez et al., 2009; Nallathiga and Paravasthu, 2010). Studies show that the value of improved water for the rural poor in developing countries varies from place to place and in certain contexts it could potentially be large enough to justify a PES scheme (Briscoe et al., 1990). Thus, there is still a need for research in rural and also protected areas where many conflicts arise and the feasibility of PES schemes is uncertain and context specific.

More recently, the CV method has been used to understand the demand-side aspects of locally-financed PES. For instance in Latin America, Johnson and Baltodano, 2004) assessed local rural WTP for micro-watershed protection in San Dionisio, Nicaragua and obtained a low WTP (maximum US$ 1). Van Hecken et al., 2012) investigated users' WTP for improved tap water quality in Matiguás, Nicaragua through a PES scheme and compared it to an alternative scenario involving infrastructure investments. This paper mainly focused on the institutional context and found a lower WTP (median US$ 5) for the scheme than for infrastructure. Ortega-Pacheco et al., 2009) assessed rural households' WTP for a watershed PES scheme in two Costa Rican communities. Their analysis evidenced that all income quintile groups show demand for a PES scheme with a mean WTP of US$5. Rodriguez et al., 2009) determined the WTP for a payment for watershed conservation in rural Cotachi, Ecuador, finding a low WTP (maximum US$ 2) and discussing its policy implications. Thus, studies carried out so far report quite diverging WTP results for differing CV survey designs, as well as the factors affecting these estimates. Therefore the demand-side of local PES schemes needs further consideration in research.

A substantial amount of studies have looked at the impacts of local PES schemes on the poor (e.g. Grieg-Gran et al., 2005; Pagiola et al., 2005), many focused on the supply-side of the schemes. However, this is a narrow view not comprising broader distributional issues. A persisting challenge in ecosystem-based management is to understand the distribution of costs and benefits among and within different groups in society (Tallis and Polasky, 2009). This is particularly true in developing countries, where a large proportion of the population still remains directly dependent on natural resources for their livelihoods (Badola et al., 2010). Research is developing on distributional aspects of PES schemes from the beneficiaries' point of view. For instance, Gross-Camp et al., 2012) explore the effectiveness, legitimacy and equality of an experimental PES intervention for biodiversity conservation services around the Nyungwe National Park in Rwanda. McDermott et al., 2013) presents a systematic framework for the analysis of equity that can be used to examine how local equity is affected as the global value of ecosystem services changes, with a focus on REDD+ PES schemes. Still, there is a need for research on the benefit distribution of ecosystem services at the local scale and how it influences contracting opportunities for PES schemes.

The aim of this chapter is to assess the benefits of improving drinking water quality. Thus, a contingent valuation survey is applied to water users to obtain the stated WTP for improved water quality through a potential PES scheme. Also, the distribution of benefits among beneficiaries is discussed, as well as the factors affecting this distribution. Finally, this chapter evaluates contracting opportunities and challenges for local beneficiaries considering their WTP and the local context.

4.2 Study Site and Methods

4.2.1 Study Site

This study was conducted in a 4,793 ha watershed covering parts of the Güisayote Biological Reserve in the westernmost region of Honduras. The watershed was selected based on its unsafe drinking water. All community water sources have been found to be contaminated with agrochemicals, bacteria, and/or faecal coliforms at least once in the year preceding the implementation of the contingent valuation survey, as observed in water tests presented by the regional health officer. The Reserve was created for its key hydrological services and is managed by the NGO Asociación Ecológica San Marcos de Ocotepeque (AESMO). Although having Reserve status means that human activities are strictly prohibited in the core zone and restricted in the buffer zone. Landowners in both zones rarely follow these restrictions, carrying out productive land uses throughout. Also, *de facto*, illicit use is made of public and private forest land for firewood, timber and, cattle grazing, among other activities (AESMO, 2010).

Private landholders cover a large part of the watershed through dispersed plots, all with secure tenure. Although some forested land exists, the rest is used for extensive cattle ranching throughout for subsistence and local commerce (milk and cheese, seldom for meat), coffee at lower heights mostly for international commerce, vegetables (e.g. potato, cabbage, carrot) at higher and colder altitudes for national and international commerce, and some maize and beans for staple subsistence. Coffee stands out as a long-term cultivar that provides the main source of employment at the study site (PNUD, 2010a).

The study site provides drinking water to fifteen communities with an estimated population of 7,725 inhabitants (ESNACIFOR and USAID, 2002). Beneficiary communities are mostly rural ranging in size from 11 to 393 houses, and only the largest is considered urban. They are located mostly outside the Reserve (10), with a few of them (5) within the core or buffer zones. The two most distant communities are in a completely different municipality. Each beneficiary community has an autonomous water system managed by a locally elected water board. Land ownership of water sources is varied, but generally insecure. Only three sources are legally owned, the rest are verbally donated by different private landholders.

The water systems consist of a dam or capture box at a spring, which can be located up to 180 minutes walking distance from the community, from where metal or plastic piping takes the water to a storage tank. Subsequently, water goes through pipes to the community, where it is distributed by individual household tap connections. Pipes are located both above and below ground depending on the terrain. The age of the water system infrastructure varies between communities and ranges between one and 46 years. In one case (the El Portillo community) there is only a rudimentary bucket system to collect water from the source, while the Santa Cruz community has two wells that are rarely used.

Communities pay a water bill either monthly or annually to their water board, amounting to an annual total between US$ 6.35 – 26.46 per household, irrespective of water system or water provision. Two communities, La Ruda and El Portillo, have no water fee system in place. Water boards reported payment delays in their communities, between 0 - 70% of households do not pay the water fee on time. Also, the water boards reported a small percentage of non-participation (14%) when labour for maintenance activities of the water system was requested.

This section provides limited study site and methods information relevant to the focus of this chapter. For more details on the study site, sampling and methods, see chapter 3.

4.2.2 Contingent Valuation Survey Design

The extensively used stated preference method of contingent valuation (CV), asks questions that help reveal the monetary trade-off each respondent would make concerning a change in the quality of a service based on information provided about a hypothetical scheme that would bring about the change (Boyle, 2003a; Haab and McConnell, 2003; Carson, 2012). The CV survey in this study was based on the extensive literature available on CV survey design (e.g. Boyle, 2003a; Haab and McConnell, 2003), and on the information obtained from two focus groups and 102 pre-tests in situ (see chapter 3). The pre-testing also served to train three interviewers, helped ensure that survey questions were understandable to respondents and that they were eliciting the information they were designed to elicit (Brown, 2003).

The sample was selected at random from the fifteen confirmed beneficiary communities. The CV survey included five different bids: 5, 15, 30, 50, and 80 Honduran Lempiras (US$ 0.27, 0.79, 1.59, 2.65, and 4.23 respectively). These five bids were applied at random to the sample, but in equal proportions. The selection of bid amounts was based on the focus groups and the pre-testing, both which revealed information of the central tendency and dispersion of the value to be estimated (Arrow and Solow, 1993; Champ, 2003). The payment vehicle proposed was an increase of the existing monthly community water fee as the only realistic option available in the study area, e.g. taxes are irregularly paid. The final survey consisted of the following main sections of information and questions:

i. perceptions of the protected area and environmental awareness;
ii. water use and water contamination awareness;
iii. water treatment methods (i.e. averting behaviour and expenditure; discussed in chapter 5);
iv. waterborne illness and treatment costs (i.e. damage costs; discussed in chapter 5);
v. description of the study area and problem;
vi. hypothetical PES scheme scenario, cheap talk and WTP question;
vii. understanding and motivation questions;
viii. socio-economic and demographic characteristics (e.g. income, education);
ix. interviewers' evaluation of how the interview went; and
x. maps and photographs throughout.

The following sections describe the main parts of the CV survey: the PES scheme scenario, the cheap talk, and the WTP question.

4.2.3 CV Scenario: Land Set-Aside PES Scheme

The hypothetical PES scheme proposed in the CV survey entails a legal agreement between watershed landholders, the water boards and AESMO. It would provide landholders with one-off payments to purchase land or periodic incentives for setting aside their land to ensure improved drinking water quality. However, as one-off payments for the purchase of land entail the permanent transference of property rights and not a PES scheme, only the periodic incentives to landholders are discussed here. The scheme would represent a voluntary partial transfer of property rights, without change in land ownership, tailored to the landholding characteristics and the landholder's opportunity costs. It is proposed that the municipality and AESMO would cover all transaction and monitoring costs of the scheme, to reduce participants' costs. Water boards would collect the additional payment from users through the water bill and would monitor the area. AESMO would provide a more structured monitoring of the area through park guards and would pay landholders quarterly. As the scheme takes off and compliance is ensured, payment could become annual to reduce transaction costs.

By means of a PES scheme the current water market dynamics would change. The buyers would still be the community households, but the sellers would not only be the water boards, but also the landholders, with AESMO acting as intermediary. The explicit involvement of AESMO and the municipality would add weight to the scheme, support the work of the water boards and enhance compliance. This would mean more secure conservation in the area and thus improved water quality. Also, a PES scheme will be vital for strengthening the existing conservation mechanisms - at the study site these include protected area status, land purchase for conservation and sustainable practices - which are currently carried out with limited success. This type of scheme, land set-aside, could ensure access and use of other dispersed and complex ecosystem services by beneficiaries, such as recreation, carbon and biodiversity.

4.2.4 Cheap Talk and WTP Question

Inadequate provision of information to the interviewees was avoided by providing clear, neutral and specific information aimed at reducing the use of subjective perceptions by respondents (Bateman et al., 2002). The hypothetical nature of a CV survey lends itself to some participants stating that they would pay for the service, when in reality they would not, or pay less, if placed in an actual purchase situation. In order to mitigate this potential hypothetical bias, cheap talk is one of the most frequently used methods. This instrument informs participants of the tendency to overestimate their WTP and asks them to complete the valuation task as if the payment was real (Cummings and Taylor, 1999; Mahieu et al., 2012). The cheap talk utilised has been loosely translated from Spanish, it includes bold text that the interviewer was asked to make emphasis on, and reads:

"As the majority of people that use the water in this area ***will have to cover the cost*** *of the payment for ecosystem services, we are using this survey to ask you if you would accept to pay if you had the opportunity. We have found that some people would be in favour of it and others against it.*

Sometimes people say they are in favour of the scheme in order to please the interviewer or for some other reason, but they can't really afford it. Some people are against the payment because they need the money for other things that are more important to them, like clothes or food. And some people say that the money they would have to pay is more than they can pay. ***Before answering, please think carefully about your financial capacity.*** *No answer is right or wrong and I don't have a preference for any answer. I remind you that you can obtain drinking water from other sources, such as bottled water.*

This payment for ecosystem services scheme proposal is not real at this moment. No one is paying money at the end of this survey. However, I ask you to answer the following questions as if the result would involve a real monetary payment from you. ***Please, only agree to pay according to what you can afford to pay****. This payment will ensure that your home and the rest of the communities receive* ***clean drinking water quality all the time.*** *For the payment to be implemented it is necessary that 80% of water users agree to pay".*

Value elicitation was done through a referendum vote format, which has incentive compatibility, i.e. truthful and accurate responses, as is recommended by the literature (e.g. Arrow and Solow, 1993). The CV survey had a double bounded question format but due to the second question's ineffectiveness at eliciting an upper of lower bound, only the first question, which is unaffected by the response to the second question, was utilised in the analysis. Furthermore, the WTP question asks about a PES scheme to improve drinking water quality, not specifying the exact improvement level. However, during pre-testing and the actual surveying it was clear that respondents understood that the improvement of water quality was to a potable level. Also, it is clearly stated in the cheap talk, "*clean drinking water all the time*", which means water at a potable level. The question stated the bid amount in a monthly and a yearly format to account for communities that paid their water bill monthly and those that paid annually. Thus, the dichotomous or discrete choice WTP question was (loosely translated from Spanish):

> *"If the implementation of this scheme to improve drinking water quality would cost your home, from now onwards, # Lempiras [of increase in your water bill] every month, which equals # Lempiras per year, would you agree to pay?"*

While dichotomous choice type questions are the most common response format, they still have weaknesses despite their potential incentive compatibility. First, answers to dichotomous choice questions only indicate whether a respondent's value lies below or above the bid threshold. Other weaknesses include anchoring of bids, yea saying and voting like good citizens. Still, a dichotomous choice format is the best that can be done as trade-offs are always to be made (Brown, 2003). Overall, these weaknesses were controlled for in the study by preceding the WTP question by a detailed and neutral scenario description, a cheap talk design highlighting the reasons respondents could have for answering yes or no, and a decision rule explaining minimum beneficiary participation required for a PES scheme.

The incentive compatibility of the WTP question was further enhanced by a decision rule, included in the cheap talk, in which at least 80% of respondents were required to answer yes to the WTP question in order for the PES scheme to be implemented. The decision rule is based on a majority proportion to highlight that if most respondents are WTP, then the PES scheme could be implemented. This rule is the mechanism used to determine if enough people would vote in favour of the scheme and as a measure to reduce hypothetical bias by emphasising that the scheme could be implemented (Vossler and McKee, 2006; Schläpfer and Bräuer, 2007; Moore et al., 2013).

A test of validity asks whether a CV study accurately measures the value it is designed to measure (Brown, 2003). The literature describes three approaches to assess the validity of a measure: criterion, construct and content validity. Criterion validity compares CV estimates to a measurement that is external to the CV study or to a behaviourally-based measure that directly represents the construct under investigation. This is considered the surest way to assess the validity of a stated preference measure. Content validity asks whether the elements in the design of the CV survey and data analyses are consistent with economic theory, established practice, and the valuation objective. Convergent or construct validity investigates the consistency of CV estimates with estimates provided by another nonmarket valuation method (Brown, 2003).

In order to ensure content validity, the survey instrument was robustly designed following the literature on the CV method and established practice. First, the survey included all the sections recommended by established practice. Second, focus groups and ample pre-testing were carried out to ensure the survey was meaningful to respondents, that the payment vehicle was reasonable and to set the bid values realistically. Third, population size of water beneficiaries was carefully determined and sampling was done at random considering all beneficiary households. Fourth, the description of the service and its institutional setting were designed considering the respondents' level of education and understanding. Fifth, the statistical model is appropriate for the CV survey design. The criterion and convergent validity are covered in chapter 7 by comparing the stated and the revealed WTP estimates.

4.2.5 Data Analysis: CV Probit Model and WTP Measure

Individuals have preferences over goods and want to maximise their utility from the quantity and quality of each of the goods and services preferred, given their budget constraint. The expenditure function considers the dual problem of minimising expenditure and at the same time obtaining a given maximised level of utility. The indirect utility function and the expenditure function provide the theoretical structure for welfare estimation. Contingent valuation is a useful way of estimating the change in the expenditure function or the change in the indirect utility function by asking WTP or WTA for that change (Brown, 2003).

A probit model of the CV responses was estimated using Nlogit - Limdep 4.0 software to calculate WTP for the PES scheme scenario described and to assess the effect of independent variables on the WTP. In a dichotomous question there are two choices or alternatives, yes or no to implementing the scenario, so that the indirect utility for respondent j can be written

$$u_{ij} = u_i(y_j, z_j, \varepsilon_{ij})$$

Where $i = 1$ is the state that prevails when the CV scenario is implemented, that is, the final state, and $i = 0$ for the status quo. The factors that determine utility are y_j for income, z_j for household characteristics and attributes of the given scenario, and ε_{ij} , a component of (random) preferences known to the individual respondent but not observed by the researcher, in what has been known as random utility models (RUM) (Hanemann, 1984). Due to these unobserved random preferences, researchers can only make probability statements about yes and no. The probability of a yes response is the probability that the respondent thinks that he is better off in the proposed scenario, even with the required payment, so that $u_1 > u_0$. For respondent j, where t_j is the bid amount offered to the jth respondent, the general probability estimation for the probit model is

$$\Pr(yes_j) = \Pr[v_1(y_j - t_j, z_j) + \varepsilon_{1j} > v_0(y_j, z_j) + \varepsilon_{0j}]$$

In order to understand the decision to answer positively, the utility difference between the yes and no responses need to be examined. That is, the probability of a certain response is examined as a function of the differences in the utilities at the base and final states. Given that the random term can be rewritten as $\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$, the probability of a positive response is

$$\Pr(yes_j) = 1 - F_\varepsilon\left[-\left(v_1(y_j - t_j, z_j) - v_0\left(y_j, z_j\right)\right)\right]$$

where $F_{\varepsilon}\ (a)$ is the probability that the random variable ε is less than a known as the cumulative distribution function (CDF). In the linear utility function specification the deterministic part of a respondent's preferences is linear both in covariates and income

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

where α_i denotes an *m*-dimensional vector of parameters and β_i is the marginal utility of income. The deterministic utility for the initial and final state is

$$v_{0j}(y_j) = \alpha_0 z_j + \beta_0 y_j$$
$$v_{1j}(y_j) = \alpha_1 z_j + \beta_1\,(y_j - t_j)$$

and assuming that the marginal utility of income is constant in the quality change (*i.e.*$\beta_0 = \beta_1$), the change in deterministic utility for respondent *j* can be written as

$$v_{1j} - v_{0j} = (\alpha_1 - \alpha_0)z_j + \beta_1\left(y_j - t_j\right) - \beta_0 y_j = \alpha z_j - \beta t_j$$

and the probability of a yes response becomes

$$\Pr\left(yes_j\right) = \Pr(\alpha z_j - \beta t_j + \varepsilon_j > 0)$$

Once the response model to the CV responses is built, a measure of welfare (*i.e.* people's WTP for the change to be valued) was estimated. Compensating surplus (CS) or WTP for an environmental improvement is the maximum sum of money an individual would be willing to pay rather than do without the improvement. The equivalent surplus (ES) or willingness-to-accept (WTA) for an improvement is the minimum sum of money the individual would require to voluntarily forgo the improvement (Brown, 2003). WTP and WTA relate to the right to a utility level (Haab and McConnell, 2003). In this study WTP is used as, although national legislation favours beneficiaries' rights to clean water, the de facto rights are ascribed to landowners as is the case in many developing countries. WTP is the amount of income that compensates for (or is equivalent to) an increase in the public good. Using the expenditure function to measure the monetary value for a change in the nonmarket good, the compensating surplus is used as welfare measure

$$CS\ (WTP) = e(p, q, u) - e(p, q^*, u)$$

Where p is price of market goods, the non-market good is q and the improvement in non-market good is q^*. Respondent characteristics are included into the WTP function using a welfare measure in order to understand how WTP responds to individual characteristics (Brown, 2003; Carson and Hanemann, 2005). Incorporating respondents' characteristics provides information on the validity and reliability of the CV method and allows the extrapolation of sample responses to the whole population (Haab and McConnell, 2003).

The cumulative distribution function of WTP, G_C, and the corresponding probability density function, g_C , depend on the form of the survey question. In the case of a closed-ended question format like the one employed for this study, where individuals are asked whether they would pay a certain amount of money, *A*, the probability that their WTP is equal to or greater than this amount is

$$\Pr(WTP\ \geq A) = 1 - \ G_C\ (A)$$

Given that the fitted response model was derived from an underlying WTP distribution, *GC* , the underlying WTP distribution can be recovered from the fitted response model. However, calculating WTP with linear random utility models requires two sources of uncertainty (parameters and preferences) to be taken into account as well as the variability induced by the covariates included in the model. In dealing with these sources of uncertainty, it is usually assumed that the parameters are given. The expression for the expectation of WTP with respect to preference uncertainty, following Hoyos, 2010) is

$$E_\varepsilon\left(WTP_j \left|\alpha, \beta, z_j\right.\right) = \alpha z_j/\beta$$

The individual and household characteristics selected for the probit model are specified in Table 4.1. Correlation analysis was done to examine any close association between independent variables, which might lead to multi-collinearity. Significant correlations with a coefficient above 0.4 were examined to determine variables to be excluded. The following variables were correlated: years living in area and age, family size and presence of at least one child, female and stable job of head of household, and female and partner of head works. Age was selected as it is expected to provide more insight into WTP estimates than years living in area, child was selected as there is a greater tendency to provide clean drinking water to children than adults, female was selected as the job variables reflect education and income that are already included in the model.

Table 4.1. Independent variables included in the probit model for the WTP for clean drinking water obtained from the contingent valuation survey. Note: Opinion scales 1 = excellent, 2 = good, 3 = average and 4 = bad; groups include social (e.g. church, school parents), community (e.g. water board, community council), municipal (e.g. transparency committee) and producers' associations (e.g. coffee growers).

Variable	**Expected sign**	**Explanation**
Bid	+	As bid amount increases, willingness to pay decreases
Community size in houses	+	Larger communities have higher levels of income and education
Age in years	-	Older people are likely to be less supportive of improved water quality
Education above primary school	+	Education increases the probability of desiring improved water quality
At least one child under 15 years	+	Children's health is a family concern and clean drinking water is provided to them

Continues…

Variable	Expected sign	Explanation
Water quality perception	+	Thinking water is contaminated is one of the main reasons for demanding clean water
Group member	+	Being in groups facilitates social and environmental awareness
Number of cars	+	Richer individuals are more likely to support a scheme and stimulate desire for improvements
Annual water bill	-	Those paying a high water bill are likely to be less willing to accept an increase
Perception of importance of PES scheme for study site	+	Generate a positive probability of willingness to pay for a scheme
Opinion on NGO's work (dummies)	-	Less satisfaction with NGO is likely to mean less support for a scheme involving the NGO
Opinion on water board's work (dummies)	-	Less satisfaction with the water board is likely to mean less support for a scheme involving the water board
Household income	+	Richer individuals are more likely to support a scheme and stimulate desire for improvements

4.3 Results

4.3.1 Socioeconomic Characteristics and Environmental Awareness of Respondents

Household heads are generally middle-aged males with mostly stable work (e.g. farming, own business), but with little education and low affluence, i.e. low income and few cars (Table 4.2). A predominance of male household heads is in line with the cultural setting where men are in charge of the home. Also, households are on average large, most of them with at least one child and located in small to medium-sized rural communities. Only a few respondents participate in local and municipal groups. Also, a small proportion of households reported free-riding on their neighbours' water source for drinking water.

Table 4.2. Socioeconomic characteristics of respondents ([a]see Appendix 12 for description of what constitutes stable and temporal work).

Characteristics	Mean/ Proportion	SE	SD	Range
Female	0.33			
Age	46.10	0.80	15.10	17 - 85
Education above primary school	0.15			
Household head has stable work[a]	0.63			
Presence of at least one child	0.74			
Household size	4.54	0.11	1.99	1 - 13
House ownership	0.90			
Group member	0.20			
Cars	0.40	0.04	0.82	0 - 8
Annual water bill (Lps.)	247	7.78	146	0 - 500
Annual household income (Lps.)	61,211.24	4348.54	81,585.8	700 - 1,037,600
Community size	231.15	7.24	135.89	11 - 393
Households free-riding	0.05			

Table 4.3 provides information on respondents' environmental awareness in regard to the Reserve and water contamination. Most respondents know about the existence of the Reserve, of the water benefits it provides and don't perceive damages from it. However, less than half knew if their community was within or outside the Reserve boundaries. Knowledge of the latter would have clear

implications for their environmental behaviour in the area. Most respondents knew that their water sources originated in the Reserve and many respondents believed their water source was contaminated. Consequently, the majority of respondents believed that a PES scheme was important for the area.

Table 4.3. Environmental awareness of respondents in regards to the Reserve, their water and the PES scheme proposed; note that 13% of respondents do not know if their water is contaminated and this proportion is excluded from the table).

Characteristics	Proportion
Knows Reserve exists	0.97
Knows community's location in regards to Reserve	0.46
Community gets benefits from Reserve	0.95
Community gets water benefits from Reserve	0.92
Community perceives damages from Reserve	0.01
All water sources of this area come from Reserve	0.93
Thinks water source is contaminated	0.72
Thinks PES scheme is important for study site	0.88

Respondents think the work carried out by AESMO is overall good or excellent; but a significant proportion (almost 30%) doesn't know of AESMO's existence or the work it carries out in the area. On the other hand, the opinion respondents' have of their community water board is predominantly good. These results evidence general degree of satisfaction with the two local organizations working on water and environmental management, but there is scope for improving the work of both organizations and disseminating AESMO's.

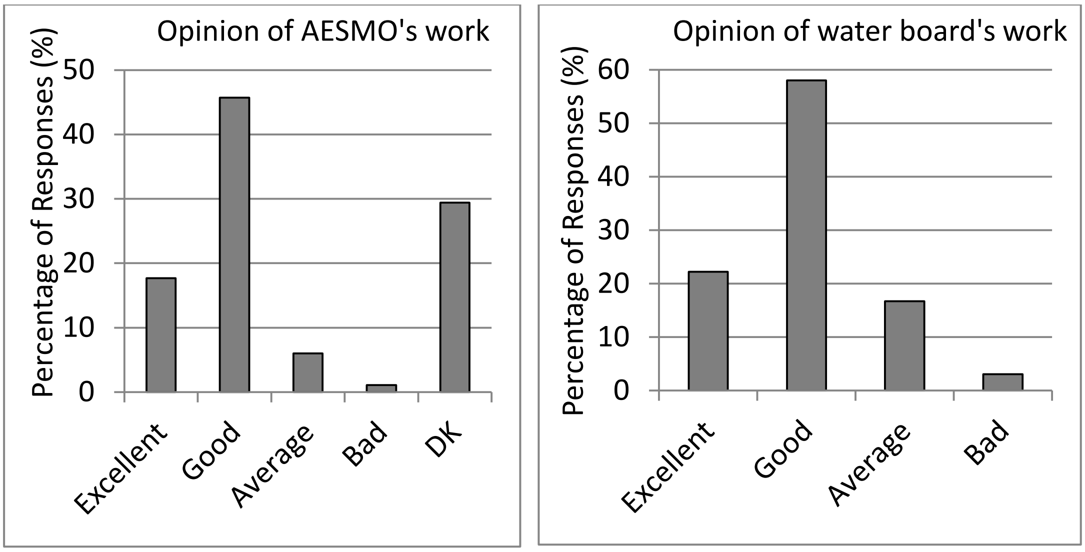

Figure 4.1. a) Opinion of AESMO's work (2 missing observations) and b) opinion of water board's work (4 missing observations; DK= does not know AESMO)

Overall, the sample of water beneficiaries has socioeconomic characteristics typical of Latin American rural areas. There is evidence of some environmental awareness, such as the knowledge of water contamination and the belief that a PES scheme is important for the area. Also, there is a general degree of satisfaction with the two main organizations involved with water and environmental management. However, there is still scope for improving participation in local groups, the work of the two organizations and environmental education. The likely influence of these factors on the value beneficiaries ascribe to improvements in drinking water quality is discussed below.

4.3.2 WTP for a PES scheme to improve drinking water quality

The WTP for a PES scheme to improve drinking water quality was estimated for each household with the coefficients obtained in the probit model using a welfare measure. The mean WTP amounts to Lps. 14.56 (US$ 0.77; S.D. = 26.47) per month. This WTP was estimated for all households in the sample, not only for those that responded positively to the referendum question, in order to avoid over estimation of this value. A total of 352 contingent valuation surveys were completed and there was a 28% non-response, 8% refused to participate and 20% were unavailable due to frequent travel, illness, or disability. The response frequencies for each of the five bids employed to elicit WTP in the CV are shown in Figure 4.2. As expected, the frequencies show a decreasing probability of answering yes to the willingness to pay question by respondents as the bid increases; but there is an unexplained increase for the highest bid. Although sampling was done at random, a large percentage of Lps. 80 bids were applied to the municipal capital of La Labor. This urban community is likely to have a higher proportion of affluent and environmentally-aware residents than the smaller, rural communities.

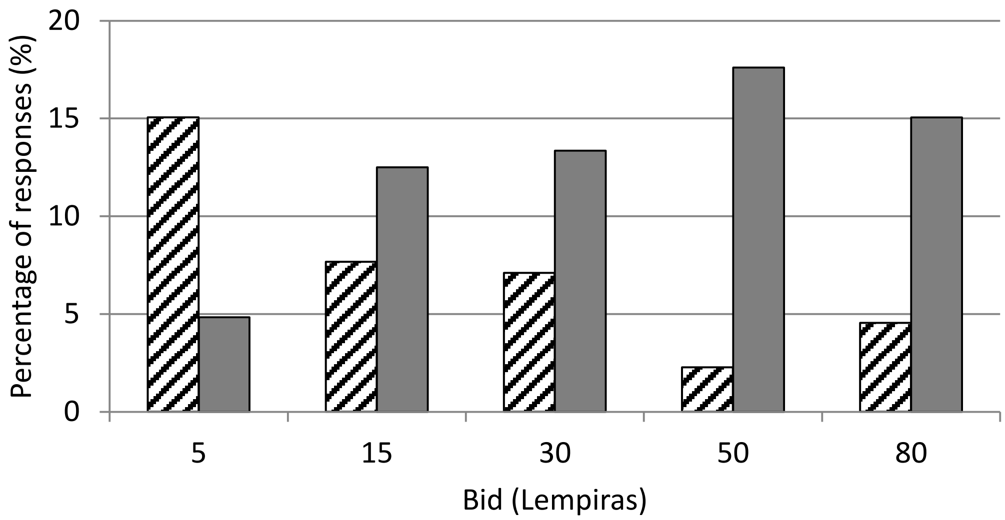

Figure 4.2. Percentage of WTP responses per bid value in the Contingent Valuation survey; striped columns= % yes responses and grey columns= % no responses.

It is common that many respondents will be unwilling to pay for an environmental improvement. However, it is important to understand the reasons for refusing to pay in order to understand the validity of the CV survey responses and respondents' preferences. Over half of respondents (63%) were not WTP at all for a PES scheme to improve drinking water quality. The reasons reported for non-WTP were inability to pay (73%), followed by the need for the community to decide together (16%), and a smaller number of diverse reasons. Only 1% of respondents felt that the PES scheme was not necessary. These figures provide validity to the survey design as the majority of respondents answered based on ability and willingness to pay and a negligible number protested against the proposed scheme. This also provides validity to the WTP question as it shows that respondents did indeed answer the question that was asked.

Furthermore, interviewer bias was tested by running a probit model with interviewer as a variable, distinguishing between the two interviewers. As can be seen in Appendix 13 there is some significance due to interviewer at 5% level. This means that respondents were more likely to say yes to the WTP question if they were being interviewed by the younger, local interviewer; in contrast to the older, foreign (from the capital city) interviewer. This is likely to be due to feeling more comfortable or trustful of the local interviewer. Thus, despite the researcher's intentions to the contrary, it is unlikely that bias was completely eliminated from the results, so consideration needs to be taken for some ambiguity in the WTP question and interviewer bias.

4.3.3 WTP Determinants

The probit model of respondents' WTP for a proposed PES scheme to supply improved drinking water is summarized in Table 4.4. The model correctly predicts yes and no responses 74% of the time. As expected the bid value is negative with decreasing yes responses as the bid value increases. As numbers of cars increases, so does the willingness to pay for a PES scheme. Considering the scheme important for the area, having education beyond primary school and local group membership are the most influential variables, probably linked to greater environmental awareness, beyond water conservation, and perceived social welfare. Also, those living in smaller communities and younger respondents had a higher willingness to pay for the scheme but with a small effect. The CV model could contain other key variables mentioned in the literature that were not included in the final model. Some were dropped from the regression because they were quite homogeneous (e.g. 90% own their house), they were correlated to other variables in the model (e.g. years living in area was highly correlated with age, as well as type of work with other income proxies), or were not statistically significant (e.g. has land near a water source).

Table 4.4. Probit model of WTP for improving drinking water quality and main explanatory variables (n = 352); note: *** 0.01 significance, ** 0.05 level significance, and * 0.10 significance level

Variable	Coefficient	SE	P value	Mean of X
Constant	- 0.06	0.50	0.90	
Bid	- 0.02***	0.00	0.00	35.78
Age	- 0.01*	0.01	0.09	46.05
Education	0.51*	0.23	0.02	0.15
Child	0.05	0.19	0.79	0.74
Community size	- 0.00*	0.00	0.08	231.15
Contamination	- 0.26	0.17	0.12	0.63
Group member	0.46**	0.19	0.02	0.20
Number of cars	0.22*	0.09	0.01	0.41
Water bill	- 0.00	0.00	0.22	247.12
Importance of PES	1.16***	0.28	0.00	0.88
NGO1	- 0.18	0.22	0.40	0.24
NGO2	- 0.00	0.21	0.99	0.26
NGO3	0.09	0.22	0.68	0.24
Water board1	0.19	0.22	0.40	0.25
Water board2	0.11	0.22	0.61	0.27
Water board3	0.15	0.23	0.50	0.25
Chi^2 test	89.36			
Prob[ChiSqd > value]	0.00			
McFadden Pseudo R^2	0.19			
Correct Predictions	74.15%			

Generally income is the key variable explaining WTP models, but in this study it was not significant and had a small effect on the model (see Appendix 14 for probit model including the income variable). A possible explanation as to why household income does not appear to influence WTP is that respondents may be unable or unwilling to accurately report their family income level, a common problem in CV surveys. Most importantly, income is low in the area due to many households relying on subsistence activities (i.e. growing and gathering for consumption). For the above reasons, it is common practice in livelihood studies in developing country settings to use other household measures for wealth. In this model the variable of number of cars is used as a proxy for wealth.

4.4 Discussion

This section assesses the WTP of water users for improved drinking water quality through a hypothetical PES scheme. The WTP estimate is a measure of the benefits that would accrue to water users if the scheme were implemented. This section also discusses how these benefits are distributed among users and what local factors determine their distribution. Results show that overall there is a low WTP for the scheme which is within the range found in similar studies. However, the estimated mean WTP is high for the area as it is almost equal to the current average water bill and would have little effect on household income. The distribution of benefits of improving drinking water quality is mainly determined by socioeconomic characteristics, spatial location, and environmental awareness. Key PES scheme contracting opportunities and challenges are discussed considering the WTP values and the local context.

4.4.1 Stated WTP for Improving Drinking Water Quality

The monthly average WTP estimated using the CV method is US$ 0.77 per household. That the benefit of improving local water quality is relatively modest is consistent with estimates from areas close to the study site. Cruz and Rivera, 2002) obtained a WTP of US$ 0.71 – 1.35[1] for the protection of the Calán River watershed, and Ballestero Madrigal and Rodríguez Alpizar, 2008) obtained US$ 0.23 – 2.25 for drinking water for the city of Copan Ruins, both located in Honduras. These findings

[1] All study figures in this paragraph were converted from US dollars of the publication year (unless data collection year stated) to 2011 US dollars using the CPI Inflation Calculator of the Bureau of Labor Statistics of the United States Department of Labor http://www.bls.gov/data/inflation_calculator.htm on 5th of November 2013, to make them more comparable to the figures in this study.

provide insight into the likely WTP range for water provision in Honduras and the potential for user-financed water conservation schemes. However, the estimate is below other reported WTP estimates for water conservation, ranging between US$ 1.20 and 19.10 (e.g. Pattanayak et al., 2005; Shultz and Soliz, 2007; Rodriguez et al., 2009; Vasquez et al., 2009; Van Hecken et al., 2012). This is likely due to these studies being carried out in highly populated or urban areas, unlike this study focusing on relatively small, rural communities with low income levels.

The WTP is almost equal to the average monthly water bill at the study site (86%; range 35 – 145%). Studies carried out in similar rural developing country settings have wide ranging results, between 5 – 200% of the average water bill (Whittington et al., 1990; Kaliba et al., 2003; Ahmad et al., 2005; Ortega-Pacheco et al., 2009). Still, the estimated WTP is in line with the water bill proportion of two similar Latin American studies proposing watershed management programs. Van Hecken et al., 2012) found a WTP amounting to 86% of the water bill in Matiguás, Nicaragua. Similarly, Shultz and Soliz, 2007) found a WTP of 65% of current water charges in the Comarapa watershed, Bolivia. This high proportion evidences an ability and willingness to pay above current charges for clean water quality and could be an indication of undercharging. Rodriguez et al., 2009) mention that the tendency to undercharge for water provision, below operation and maintenance costs, causes the quality of drinking water to decline. However, most water boards reported having savings (see Table 3.1 in chapter 3), which means the problem of poor drinking water quality is not due to a lack of financial resources owing to undercharging but water boards' lack of knowledge or ability to ensure water quality. It is more likely that water boards do not charge higher water bills in consideration of the low income households in their communities.

The estimated WTP represents less than 0.3% of the average household income, an insignificant share of the modest earnings of most households. Notably, this proportion is identical to that obtained by Ahmad et al., 2005) when estimating the value of arsenic-free drinking water in rural Bangladesh and that obtained by Moreno-Sanchez et al., 2012) for an ongoing PES scheme in the Andes of Colombia.

However, it is necessary to assess the share of income the WTP would represent for the poorest households, as these would be most affected by a water bill increase. Still, the WTP estimate amounts to only 1.3% of the average income for households in the lowest income quintile and it is believed that an affordability threshold of 2.5% of income is a reasonable upper limit for water bills (OECD, 2003). Currently, the three highest water bills (of three communities) already exceed this threshold for households in the lowest income quintile, amounting to approximately 6% of households[2]. Furthermore, if the water bill were increased by the estimated WTP, it would still only affect households in the lowest income quintile but for six more communities as well. For instance, the poorest households living in the community with the highest water bill (i.e. Llano Largo) already pay 3.8% of their income towards water and an increase would take them to 5%. Thus, it is estimated that a total of 11% of households[2] would definitely not be able to cope with a water bill increase. These findings evidence that water bills could be increased but consideration would need to be taken of those households in the lowest income quintile. This study highlights how household income and water bills can serve as measures of affordability for clean drinking water, to identify households at risk and to inform affordable water bill increments.

Affordability issues have often been found to be least visible in low income countries (Briscoe et al., 1990; Fankhauser and Tepic, 2007). Affordability refers to the ability of particular consumer groups to pay for a minimum level of a certain service. Minor affordability issues at the study site have been made evident by assessing the proportion of water bills and income that WTP estimates represent. Overall, there is a substantial willingness and ability to pay for clean drinking water through a PES scheme. This is without accounting for additional expenditure on other sources, particularly bottled water (discussed in chapter 5). Aggregating the mean WTP across the entire population of the study site amounts to a potential revenue of US$ 14,276 above current water bills. Still, willingness to pay depends

[2] Based on the proportion of households per quintile per water bill in the sample and extrapolated to the entire study site.

on a series of factors, not only ability to pay, that are discussed in the following section.

4.4.2 Stated Benefits Distribution and Implications for PES Contracting

Results highlight several issues that may arise when assessing the benefits distribution of a water service. First, identifying the beneficiaries of a water service is not always easy, contrasting the general belief that an upstream-downstream externalities framework is straightforward (Van Hecken et al., 2012). This is mostly due to beneficiaries' spatial distribution, e.g. some users reside quite close to their water source while others are many kilometres away. Second, beneficiaries often value and make use of the ecosystem service in different ways, e.g. some houses rely solely on piped water for drinking, others use alternative sources, and some a combination of both. Third, many people are unlikely to respond accurately, if at all, to questions regarding economic matters, particularly income.

Overall, a user-based PES scheme would entail a voluntary increase in water fees in order to ensure water conservation. It has been shown that an increase to current water fees is feasible based on beneficiaries WTP, but how this water fee increase will be distributed among beneficiaries through a water conservation scheme is a fundamental issue. The benefits of improving drinking water quality, reflected in the WTP values, vary widely across water users at the study site. Overall, benefits are distributed as a function of respondents' socioeconomic characteristics, spatial location, and environmental awareness. Some factors that have commonly been found to be significant in the literature (e.g. Choe et al., 1996; Kaliba et al., 2003; Pattanayak et al., 2005; Vasquez et al., 2009; Van Hecken et al., 2012), such as gender, presence of children, and water bill were not significant in this study.

The most significant variable explaining WTP is the perception that the proposed PES scheme is important for the study site. This variable highlights respondents' environmental awareness and knowledge about upstream environmental problems, as other studies have mentioned (e.g. Ahmad et al., 2005). Beneficiaries' environmental awareness allows them to understand the PES scheme proposed and believe that it can solve upstream water problems. Their environmental awareness is likely to be linked to beneficiaries' attachment and concern for the area. Along with being able to afford to pay, environmental awareness is a key factor influencing willingness to pay, without which the ability to pay is worthless. However, the variable of thinking their water is contaminated is not significant, which is normally one of the main environmental awareness factors determining WTP reported in the literature (e.g. Kaliba et al., 2003; Vasquez et al., 2009; Beaumais et al., 2010). This contradictory finding indicates that respondents have incomplete health risk awareness related to water (as discussed in chapter 5) or some other unobserved reason. Respondents who are willing to pay irrespective of thinking their water is contaminated or not are likely to perceive co-benefits from a possible PES scheme, including water system improvements, increased water flows, forest cover, fresh air, habitat conservation, as well as non-use values (Kosoy et al., 2008; Wunder and Albán, 2008; Gross-Camp et al., 2012). This study highlights that although there might not be sufficient awareness of water contamination issues, awareness of other problems and services provided by the watershed might enhance support for a PES scheme. However, if a PES scheme were implemented care would need to be taken to clarify and manage expected outcomes.

Respondents with more education showed a higher WTP, as commonly reported in the literature (e.g. Haq et al., 2007; Shultz and Soliz, 2007). Education is linked to income and environmental awareness, as it provides access to information obtained during schooling and other sources. It also offers a greater ability to understand and make use of information obtained. Although more educated respondents are more willing to pay, they are the minority at the study site. The generally low levels of schooling at the study site will be a limiting factor for contracting in a PES scheme. Improvements in access to long-term education are necessary, but in the short-term beneficiaries' environmental awareness could be enhanced through environmental education and disseminating the work carried out by the water boards and the NGO. Younger respondents were also more WTP, which could be due to an increased access to education, social media and other resources in the last decades.

Water users that are socially active in local or municipal groups showed a higher WTP. This is linked to having environmental awareness and ability to access project activities (Krause and Loft, 2013), environmental training and information. Group members are often also decision-makers and leaders in rural communities, so these individuals have a greater influence in project decision making. The fact that some respondents were not WTP unless the community decided together is indicative of the influence that community leaders have in their communities. This uneven participation and decision-making by certain beneficiaries, unless corrected, will likely be carried on into a PES scheme where they would influence the governance of benefits distribution (Sommerville et al., 2010a). A PES scheme could help balance out this inequity in decision-making by having the NGO act as intermediary. A scheme could also provide for more participation in protected area management, which so far is done largely by the NGO. It is expected that a PES scheme could also strengthen local water management by encouraging participation in payment and maintenance activities and reducing free-riding of beneficiaries. However, discrimination is needed between free-riders due to poverty and those due to other reasons, so as to not disadvantage the poor.

Those individuals with a higher economic status had a higher WTP for improving drinking water quality, as is usually reported in the valuation literature. More affluent households are likely to have higher health standards, greater local influence, and better access to resources, such as information and alternative water sources. High income does not guarantee environmental awareness, but the ability to access information, through media and education, can contribute to awareness. Although wealthier households are willing to pay and willing to pay more, they are the minority at the study site and most likely located in the larger communities. Poor households are disadvantaged because they can’t afford to pay for water quality improvements even if they were willing to. Thus, while there is an overall demand for improved drinking water quality through increased water bills, a PES scheme needs to account for the poor or it will exacerbate inequity in water provision. These findings confirm the need for equitable benefit distribution mechanisms, such as differentiated tariffs or subsidies, as suggested in the water management literature (Ahmad et al., 2005; Meij et al., 2005; Wichelns, 2013; Justes et al., 2014). Furthermore, the proposed PES scheme would need to account for the low income levels at the study site by having the NGO cover the start-up and monitoring costs to reduce the cost of beneficiary contracting for improved water quality.

Community size was also significant at explaining WTP, with smaller rural communities showing a higher WTP than larger communities. This result contradicts other studies where urban households have a higher WTP for environmental benefits, attributed to higher income or education levels (Uzochukwu et al., 2010; Mombo et al., 2014). Haq et al., 2007) found that urban households are more WTP for improved water services due to their dependence on government sources. However, at the study site all water systems are communally managed and smaller communities are disadvantaged by insecure water source ownership compared to larger communities that have municipally or communally owned sources. Larger communities do attract more funding from the government and donors, creating an uneven allocation of resources. Additionally, larger communities have access to drinking water substitutes, such as bottled water. Whereas small communities, usually farther from shops in remote areas, are directly dependent on drinking water coming from spring sources at the study site. This disparity between communities evidences a current lack of distributive equity (Konow, 2001; Corbera et al., 2007a; Proctor et al., 2008), which could be overcome with a PES scheme that considers smaller communities. A scheme could ensure all water sources are secure and monitored periodically by the water boards and the NGO, which would benefit all communities but particularly smaller ones. This study highlights a different community size relationship to WTP, than normally mentioned in the literature.

Access and spatial proximity to water sources have also been mentioned as key determinants of the distribution of ecosystem service benefits (Naidoo and Ricketts, 2006; Tallis and Polasky, 2009; Moreno-Sanchez et al., 2012). Beneficiary communities located farthest from their source are likely to be at a disadvantage due to spatial disconnection, having problems enforcing rights of access, monitoring and protecting their water sources. This situation applies particularly to two communities at the study site that are outside the watershed and in a different municipality from their water source. They already experience water management and benefit distribution complications through dissimilar political agendas and priorities. A PES scheme could benefit these communities by ensuring water sources are secure and protected through the involvement of the NGO, especially monitoring water sources in a challenging setting with steep terrain, vast watersheds and remote uninhabited areas.

In summary, there are certain factors that may hinder the implementation of a PES scheme for improved drinking water quality at the study site, but there are many factors that would contribute to contracting in such a scheme. Overall, the whole study area could benefit from a uniform level of clean drinking water and secure water sources, as water provision and conservation would be carried out with a watershed landscape approach, compared to the current uneven situation. A scheme would also change social dynamics by strengthening the work of the water boards, increasing benefits to disadvantaged households and communities, and providing the support of the NGO.

4.5 Conclusions

The WTP for clean drinking water through a PES scheme at the Güisayote Biological Reserve was estimated with the contingent valuation method. The monthly average WTP came to US$ 0.77 per household, which is within the range reported by the literature. This estimate represents less than 0.3% of the average household income and 86% of the monthly water bill. However, some households in the lowest income quintile are already paying above the affordability threshold for water and if it were increased, approximately 11% of households will not be able to cope. Overall, there is affordability and willingness to pay above current charges, indicating that substantial increases could be made to water bills.

The benefits reflected in the WTP are distributed as a function of respondents' socioeconomic characteristics, spatial location, and environmental awareness. It is believed a PES scheme could benefit local water users, both individual households and entire communities, but especially small communities and poor households. Challenges for contracting in such a scheme include unawareness of water contamination, low income and education levels, the availability of water substitutes, inequity in decision making, and beneficiary communities in different municipalities. Alternatively, opportunities for contracting in a scheme include the demand for a PES scheme, perceiving co-benefits from a scheme beyond water quality, the participation of the NGO in several aspects of the water provision scheme, satisfaction with the local environmental organizations, and the need for secure water sources.

Findings show that some factors explaining benefit distribution correspond with those reported so far in the literature, but some novel factors were also found. Thus, the wide range of factors that has been reported elsewhere to explain WTP for water provision and results of this study indicate that case by case analysis is needed when trying to understand benefit distribution due to highly context-specific determinants. Finally, this chapter contributes key information to discussions in chapter 7 on the use of different WTP or benefit measures, the feasibility of a PES scheme by contrasting with the costs of provision, and contracting in PES schemes in a wider context.

Chapter 5: Revealed WTP and Benefits Distribution for Drinking Water Quality

This chapter describes the application of two revealed preference approaches, averting behaviour and illness damage costs, to estimate the willingness to pay for clean drinking water. The WTP estimate serves as a measure of the benefits of improving drinking water quality for users by reducing expenditure on averting actions and illness damage costs; hence this chapter examines the factors determining the distribution of these benefits. In addition, it contributes to the discussion on contracting in a PES scheme for local beneficiaries, considering their revealed WTP through actual market expenditure and the local context.

The focus of this chapter is analysing the revealed WTP or the benefits of reducing averting and illness expenditure, as a direct way of assessing peoples' preferences. It contributes information on the key factors affecting benefit distribution and how these would influence possible contracting opportunities and challenges of a PES scheme. In chapter 7, these revealed preferences will be compared to stated preferences (see chapter 4) as another way of estimating WTP of beneficiaries, as well as contrasted to the opportunity costs of water conservation (see chapter 6) to assess the feasibility and challenges of contracting in a PES scheme.

5.1 Introduction

Contaminated drinking water is a major issue in developing countries (UNICEF and WHO, 2012) mainly due to clean drinking water often being a nonmarket ecosystem service. Although the literature contains an increasing number of estimates of nonmarket water services, the benefits of water quality improvements in developing country settings deserve much more study (Olmstead, 2010). Securing drinking water quality is a challenge in developing countries (Trevett et al., 2004), but household water treatment can lead to dramatic improvements in quality and a reduction of diarrhoeal disease (LeChevallier and Au, 2004). Household water treatments are often seen as a short-term solution (Jalan et al., 2009), but in developing countries they are often the only way of ensuring clean drinking water and are therefore an established practice.

The demand for potable water can be understood by studying households’ use of market commodities related to water quality, as well as households’ resources and preferences (Alberini et al., 1996; Pattanayak et al., 2005). The economic value of potable water can be estimated using revealed preference approaches which are based on actual choices in the market. Choices based on the perceived costs and benefits better reflect the values of the population and provide valid WTP estimates (Whitehead and Van Houtven, 1997; Whitehead et al., 2008) that can be used to assess the benefits that a water conservation initiative, such as a PES scheme, could provide. The presence of water contamination and associated illness gives rise to two categories of behaviour-related market costs: averting behaviour and damage costs, both revealed preference approaches. Averting behaviour estimates the household expenditure associated with the actions taken to reduce exposure to contaminated drinking water, e.g. treating water and buying bottled water; and damage costs consist of direct, out-of-pocket expenses arising from illness, e.g. medical costs, as well as indirectly incurred opportunity costs, e.g. lost earnings (Harrington and Portney, 1987; Harrington et al., 1989; Whitehead and Van Houtven, 1997; Byford et al., 2000; Um et al., 2002; Dickie, 2003; Haq et al., 2007).

The averting expenditure that would be needed to exactly offset the effects of contaminated drinking water is a theoretical correct measure of WTP for clean water (Harrington and Portney, 1987; Whitehead and Van Houtven, 1997; Hanley et al., 1999; Pattanayak et al., 2005). However, in practice this measure is difficult to estimate because certain conditions are required; such as no sunk costs, no direct utility from the averting behaviour, no joint production, efficient averting behaviours and secure property rights to raw water sources (Bartik, 1988; Pattanayak et al., 2005; Whitehead et al., 2008). Thus, in the literature the measure of averting expenditure is not referred to as a perfect substitute for clean water, but as approximating a lower bound of WTP (Courant and Porter, 1981; Bartik, 1988; McConnell and Rosado, 2000; Wu and Huang, 2001). Some studies go as far as stating that WTP and averting expenditure are not related, and that inferences from averting behaviour are limited (Laughland et al., 1996).

Conversely, there have been a few studies that have found averting expenditure to be a true, or upper bound, WTP (Abdalla et al., 1992). For instance, Roy et al., 2004) estimated the averting expenditure undertaken by each household to produce one litre of clean drinking water in the city of Kolkata, India. Starting from the general utility maximising behaviour of an individual they arrived at the conclusion that averting behaviour gives a true estimate of WTP. Similarly, Haq et al., 2007) estimated the WTP for improved water service levels and for water quality improvement with contingent valuation and averting behaviour (including the opportunity cost of illness) in the mostly rural district of Abbottabad, Pakistan. They assert that averting expenditure provides a true estimate of WTP for good quality drinking water.

Furthermore, Urama and Hodge, 2006) compare irrigators' stated WTP for a river basin restoration scheme designed to mitigate soil and water pollution problems in their farms with their actual expenditures to mitigate the same pollution problems in south-eastern Nigeria. They found that the averting expenditure was higher than the stated WTP due to farmers' having higher discount rates and greater risk aversion. More generally, Shogren and Crocker, 1991) theoretically showed that the lower bound property of averting expenditure was not assured when the results of the averting behaviour were uncertain. There is limited empirical literature on averting expenditure which is insufficient for making conclusive statements regarding their theoretical properties (Pattanayak et al., 2005). Thus, there is still a need for research into averting expenditure providing valid WTP estimates for water quality improvements.

When averting behaviour is not carried out or is not done effectively, consumption of contaminated water can lead to illness. The second revealed preference method is illness damage costs, also referred to as cost-of-illness or coping costs. It is assumed that damage costs are also likely to be a lower bound WTP because they do not capture the pain and suffering during illness or the value of reduced mortality risk (Harrington and Portney, 1987; Kenkel, 1994; Whitehead and Van Houtven, 1997; Alberini and Krupnick, 2000; Dasgupta, 2004; Aziz and Aziz, 2012). However, available evidence suggests that the relationship between WTP and damage costs is not constant, but instead varies by illness and approach (Dickie, 2003). For instance, Guh et al., 2008) compared damage costs with stated preference estimates of WTP associated with shigellosis in a rural area of China. They found that damage cost estimates approximate an upper bound estimate of WTP and they ascribe this to low preventive expenditures and pain and suffering for shigellosis cases. These findings suggest that for some diseases, damage costs may approximate more comprehensive measures of economic benefits. Therefore the estimation of damage costs as contributing a valid WTP measure requires further attention.

Furthermore, several authors report that the true benefits associated with the improvement of water quality equal averting expenditure, plus damage costs and the net direct disutility of illness (Harrington and Portney, 1987; Pattanayak et al., 2005; Jalan and Somanathan, 2008). However, so far few studies have attempted to estimate such a measure. Alberini et al., 1996) applied a bivariate probit model of averting behaviour and waterborne illness to assess the effects of engineering and individual behaviour on diarrhoeal disease in Jakarta, Indonesia. They highlight the dependent relationship between averting behaviour and illness, but no WTP estimate is provided. Similarly, Dasgupta, 2004) uses a bivariate probit model following a health production function for the averting behaviour and health damages incurred by households in Delhi, India. The author discusses the variables determining averting behaviour and illness. Alternatively, Harrington et al., 1989) estimated total losses (equivalent to a WTP) due to averting expenditure and illness damage costs of a one-off water contamination Giardiasis episode in Pennsylvania, USA. The authors found that the lost benefits are substantial and discuss the accuracy of estimates. The estimation of a full WTP, based on averting expenditure and damage costs, as well as its validity as an estimate of the benefits of improving drinking water quality requires further attention. To the researcher’s knowledge, a full revealed WTP, obtained from averting behaviour and illness damage costs, has not been employed to inform the demand-side of a PES scheme before.

Many socioeconomic and psychological factors have been found to affect households' averting behaviour, such as income, education, water source and water quality (Roy et al., 2004; Haq et al., 2007; Nauges and Van Den Berg, 2009). Perceptions and lack of awareness of contamination and the adverse health effects of unsafe drinking water are significant barriers to the adoption of averting behaviour (Redding et al., 2000; Jalan et al., 2009). According to Nauges and Van Den Berg, 2009) the perception of risk related to water consumption by households in developing countries has hardly been studied in the applied economics literature. Thus, a study on the factors determining a revealed WTP for clean drinking water in a developing country will contribute to the understanding of household health behaviour and its implications for PES scheme contracting.

This chapter describes the estimation of the WTP or the benefits of reducing expenditure on averting actions and illness damages. This chapter contributes to the discussion of the use of summing averting expenditure and illness damage costs as a valid WTP measure to inform PES scheme design. The socioeconomic factors and perceptions determining households' health behaviour and benefit distribution are also analysed. Finally, opportunities and challenges for PES scheme contracting are discussed based on the results obtained.

5.2 Study Site and Methods

5.2.1 Study Site

This study was conducted in a 4,793 ha watershed of the Güisayote Biological Reserve in the westernmost region of Honduras. The watershed was selected based on its unsafe drinking water. All community water sources have been found contaminated with agrochemicals, bacteria, and/or faecal coliforms at least once in the last year by the local health office. This study recognises that a one-off test can't possibly reveal more complex fluctuations in drinking water quality. There is a degree of uncertainty on the exposure to contamination owing to the variability of contamination in time and space and to the number of possible contamination routes – such as poor hygiene practices (Alberini et al., 1996). However, positive water test results are evidence of unreliable water quality. In Honduras, as in most other developing countries, diarrhoea is one of the main causes of illness and death. The highest rates of diarrhoea hospital consultations were reported for two health regions, including the west of Honduras (Solorzano Giron et al., 2006) where the study site is located. On the whole the study site is representative of the uncertain drinking water quality that prevails in rural Honduras and Latin America.

The Reserve was created for its key hydrological services and is managed by the NGO Asociación Ecológica San Marcos de Ocotepeque (AESMO). Although having Reserve status means that human activities are strictly prohibited in the core zone and restricted in the buffer zone. Landowners in both zones rarely follow these restrictions, carrying out productive land uses throughout. These land uses include forest, but also extensive cattle ranching, coffee, vegetables, and some maize and beans. The study site provides drinking water to fifteen communities with an estimated population of 7,725 inhabitants (ESNACIFOR and USAID, 2002). Beneficiary communities are mostly rural ranging in size from 11 to 393 houses, and only the largest is considered urban. Land ownership of water sources is varied, but generally insecure. Each beneficiary community has an autonomous water system managed by a locally elected water board. Communities pay their water bill either monthly or annually to their water board, amounting to an annual total between Lps. 120 - 500, irrespective of water system or water provision. Two communities, La Ruda and El Portillo, have no water fee system in place.

This section provides limited study site and methods information relevant to the focus of this chapter. For more details on the study site, sampling and methods, see chapter 3.

5.2.2 Averting Behaviour and Expenditure

All data on averting behaviour and illness damage costs was obtained through the contingent valuation survey (discussed in chapter 4). Questions on averting behaviour covered water usage, water sources, perceptions of contamination, household water treatments and costs, and expenditure to treat illness. The complete survey, including contingent valuation questions, is presented in Appendix 10.

The cost of avoiding contaminated drinking water was estimated with a revealed preference approach, the averting behaviour method. This method consists of calculating the monthly expenditure on household treatment methods: a) purchasing bottled water, b) chlorinating water, c) boiling water, or a combination of these methods. Four households used either a filter or a purifier, but owing to none appearing during 102 pre-tests and incomplete data obtained, these observations were included in general descriptive statistics but excluded from expenditure estimations. All these actions taken to avoid contaminated drinking water are reasonably assumed to allow households to reach the highest level of water quality. The monthly averting expenditure per household was thus calculated as follows

$$Monthly\ Averting\ Expenditure = \sum water\ treatment\ costs$$

The following sub-sections describe how each of the water treatment methods was estimated, the cost of purchasing bottled water, of chlorinating water and of boiling water with firewood and electricity.

5.2.2.1 Cost of Purchasing Bottled Water

Bottled water was purchased in refillable plastic five US gallon containers, except for one household that purchased water in 20 litre bags. The survey elicited the amount of water purchased per month and the unit price of a container, which varied across households. The majority of respondents purchased bottled water in their community, except six respondents, so the opportunity cost of time to purchase bottled water was assumed to be zero. The reasoning is that the distance within communities is negligible. Thus, the formula for the monthly household cost of bottled water is

$$Cost\ of\ bottled\ water\ (CBt) = number\ of\ containers\ *\ unit\ price$$

5.2.2.2 Cost of Chlorinating Water

The most inexpensive water treatment method used at the study site is chlorination and its cost was estimated by the number of 210 ml bags of chlorine purchased in a month and the unit price of a bag. No time cost is included for chlorination as households purchased these small bags of chlorine jointly with other goods at a community shop and just added drops of chlorine to tap water. Thus, the formula for the monthly household cost of chlorination is

$$Cost\ of\ chlorination\ (CC) = number\ of\ bags * unit\ price$$

5.2.2.3 Cost of Boiling Water

The cost of boiling water was estimated using primary and secondary data on water consumption per household, the fuel type used, the time value for each fuel, the amount of firewood used, and the market value of firewood.

The reported daily drinking water requirement for a person varies widely in the literature and ranges from one to six litres (Gleick, 1996; Roy et al., 2004; WBCSD, 2006; WHO, 2011). Water intake depends on many factors, such as temperature and activity level. However, soft drinks like Coca-Cola have become a staple commodity in Latin America, as well as the rest of the world (Ismail et al., 1997; Leatherman and Goodman, 2005; Malik et al., 2010; Pistochini et al., 2011). A high use of soft drinks was observed at the study site, so water consumption is assumed to be low. Furthermore, a rough estimate of water consumption at the study site can be calculated based on family size and reported bottled water purchase. The median use of bottled water at the study site is 38 litres per person per month (mean = 51) only considering households with a consumption over 30 litres per person per month as a minimum water requirement. This estimate also likely accounts for water used for cooking. Thus, the amount of water boiled was determined according to the number of people in the household multiplied by a requirement of one litre of water per day, or 30 litres per month, based on 30 days in a month. The household water consumption was multiplied by the boiling frequency stated by respondents: always (100%), almost always (80%), occasionally (50%), and rarely (25%). The formula for determining the amount of water boiled monthly per household is

$$Water\ Boiled\ (WB) = number\ of\ household\ members * 30\ litres * frequency$$

Boiling drinking water includes two cost components: fuel and time. The three fuel sources used to boil drinking water at the study site were firewood (89%), electricity (9%) and liquid petroleum gas (LPG; 2%). Apart from the arrival of electricity to the area, these proportions have hardly changed in 30 years (Jones and Perez, 1982). The households using LPG as fuel were given the electricity cost of boiling drinking water due to low frequency, the difficulties of accurate measurement and similar use properties (i.e. no time value as in firewood). Following is the estimation of the cost of boiling water using electricity and firewood, the latter including a market and a time cost.

a) Cost of Boiling with Electricity

To determine the cost of boiling water with electricity as fuel source, we use Abdalla et al., 1992) and Laughland et al., 1993) estimate that 0.19 KWh of electricity is needed to boil one litre of water. However, it is acknowledged that electricity consumption will vary depending on many factors, including initial water temperature, wattage of stove, amount of water boiled, among others. The electricity tariff applied is Lps.1.95 (US$ 0.10) per kWh, based on the average of the first two tariff levels reported by the National Energy Commission of Honduras (Lopez Oliva, 2009). The use of the two tariffs assumes low energy consumption at the study site due to the high cost of electricity (compared to other fuels available), poverty and widespread firewood usage. Based on the above, boiling one litre of water is estimated to cost Lps. 0.37 (US$0.02). The time to boil water with electricity is assumed to be negligible due to the ease of use of this method. Thus, the monthly household cost of boiling water with electricity is estimated as

$$Cost\ of\ Boiling\ with\ Electricity\ (CBe) = WB *\ Lps. 0.37$$

b) Cost of Boiling with Firewood

According to the Red Cross (IFRCRCS, 2008), one kilogram of firewood is needed to boil one litre of water for a minute. Similarly, Elhadi and Ahmed, 2009) found that on average slightly over 700 g of firewood is used to boil water in Sudan. Thus, for this study an average of 850 g of firewood to boil one litre of water per minute is used. The Honduran unit of firewood measurement is the human "carga" or load, studies carried out close to the study site report a load weighing between 35 - 50 kg in Copan (Cruz et al., 2011) and 35 kg for Lempira (Ferreira Catrileo et al., 2010). At the study site a park guard mentioned an average weight of 35 kg per load (Cabrera, 2011). Thus, a value of 35 kg per load is used, indicating that a load of firewood can boil just over 41 litres of water. At the study site all landholders reported firewood collection at a rate of 10 loads per day[3], equal to 1 load per 1.25 hours, considering an 8 hour working day. Thus, the loads of firewood used per household to boil water for a month were determined as

$$Loads\ of\ Firewood\ Used\ (LF) = (WB * 0.85kg)\ \div 35\ kg$$

Boiling drinking water with firewood is the most time-consuming treatment of all, as it involves family members' time collecting firewood and tending the fire.

[3] Based on data elicited for the opportunity cost survey discussed in chapter 6.

Household production theory suggests this time cost should be part of the averting cost measure (Laughland et al., 1993). Two approaches were used to value the cost of boiling water with firewood, the time cost, based on firewood collection, and the market cost, based on firewood purchase.

The time cost includes the time invested in firewood collection and the time invested tending to the fire while the water boils. Two average wage rates were used to value time, the “jornal” or labourer wage of Lps. 120 (US$ 6.35) per day and the farmer national minimum wage of Lps. 227 (US$ 12.01) per day, both based on an 8 hour work day. So, one hour collecting firewood, reported to be done mostly by men, has a value of Lps. 15 (US$ 0.79) at a labourer’s wage and Lps. 28.38 (US$ 1.50) at a farmer’s wage. The time value of tending to the fire is estimated at a third of the collection time value. This estimate is based on the assumption that household chores are generally carried out by a female homemaker that does not work or works from home, and that tending to the fire allows for performing other simultaneous activities. Furthermore, large families (4.5 members on average) are common in the area and high levels of unemployment (60%) have been reported for the study site (ESNACIFOR and USAID, 2002). So it is assumed that at least one person remains at home, consistent with a low opportunity cost of time.

Harrington et al., 1989) empirically determined that it takes four minutes to boil 1.14 litres of water with firewood, McConnell and Rosado, 2000) also used this figure. However, according to Laughland et al., 1993) only one fourth of boiling time is spent boiling while the remaining time is used for other activities, e.g. food preparation, tending to children, watching television. The respondents at the study site reported a wide range between 4 – 60 minutes, with an average of 19 minutes, boiling water in large saucepans of varied volumes with a minimum capacity of approximately 4 litres. Based on the above information, it is assumed that it takes approximately 1 minute to boil 1 litre of water. So, one minute of female time boiling one litre of water has a value of Lps. 0.08 (US$ 0.004) at a third of a labourer’s wage and Lps. 0.16 (US$ 0.01) at a third of a farmer’s wage. Therefore, the monthly time cost per household boiling water with firewood is estimated as:

$$Time\ Cost\ of\ Boiling\ with\ Firewood\ (TCF) = \\ LF * 1.25\ hrs/load * male\ wage/hour * (WB * female\ wage/minute)$$

Studies in neighbouring areas show that the market value of firewood varies from Lps. 30 (US$ 1.60) per load in the similarly forested department of Lempira (Ferreira Catrileo et al., 2010) to Lps. 50 (US$ 2.65) and Lps. 55 (US$ 2.91) in dry forest areas of the towns of Ajuterique and Siguatepeque in Comayagua (Torres Ferrera, 2007). In this study a market value of Lps. 30 (US$ 1.60) per load is employed as recommended by a Reserve park guard (Cabrera, 2011) and following the literature based on similar forest ecosystems. Thus, the monthly market cost of boiling water with firewood per household is estimated as:

$$Market\ Cost\ of\ Boiling\ with\ Firewood\ (MCF) = LF * Lps. 30$$

Thus, as explained above, three averting expenditure estimates are presented and discussed in this chapter. The labourer estimate uses a labourers wage to value to the time involved in boiling water with firewood. The market estimate uses the market price for the firewood used to boil water. The national estimate uses the national minimum farmer's wage to value the time involved in boiling water with firewood.

5.2.3 Illness Damage Costs

The cost of drinking contaminated water was estimated with the damage cost method, consisting of the household value of treating waterborne illness (direct costs) plus the value of the missed work days due to illness (indirect costs). These costs were adjusted to per month of illness incidence using a weighting factor. The monthly damage cost per household was calculated as

$$Monthly\ Damage\ Cost = (indirect\ costs + direct\ costs) * weighting\ factor$$

The direct costs of waterborne illness include medical expenditures on laboratory tests, prescribed or self-medicated medicines, doctor or clinic fees, overnight stays in health facilities and all relevant transport. Direct damage costs are estimated as the sum of all these costs per illness case reported. The indirect costs of waterborne illness were calculated as the product of the number of work days missed and the appropriate monetary value or opportunity cost of the lost earnings. The opportunity cost of the lost earnings was based on a proportion of the average daily labourer's wage of Lps. 120 (US$ 6.35) considering the high levels of unemployment mentioned above. All patients were assumed to be hindered from performing any work or household activities for the reported missed work days. An adult patient could be in the labour force or be a homemaker, so half of a labourer's wage, Lps. 60 (US$ 3.18) was applied to adults. Children, less than 18 years old, and elderly patients, above 65 years old, were assumed to be taken care of by a homemaker, without greatly affecting household activities. Although these age groups are less likely to be in the work force, some teenagers and elders might engage in work tasks on a regular or intermittent basis. So a third of the labourer's wage, Lps. 40 (US$ 2.12), is applied to these patients.

The prevalent-based costs approach for measuring damage costs is used in this study, with the population consisting of all persons who have a condition at a given time (Rice, 1994; Whitehead and Van Houtven, 1997; Byford et al., 2000). Data covers the six-month direct and indirect costs associated with cases of diarrhoea, vomit and stomach pain. The diarrhoea peaks in Honduras occur between January – April and June – August. The first peak is generally associated to rotavirus and the second to bacteria pathogens, such as *Escherichia coli* (Solorzano Giron et al., 2006; Quiroz, 2007). The two main symptoms of rotavirus are diarrhoea (100% of cases) followed by vomit (approximately 90% of cases; Quiroz, 2007); other common symptoms include stomach pain and fever (Howard and Bartram, 2003). Damage costs data cover both diarrhoea peaks and the two seasons, dry from November to April and rainy from May to October. This study recognizes that the transmission routes of diarrhoea causing pathogens is quite complex and has to be taken into account in assessing the impact of any single intervention to control diarrhoea (Briscoe, 1984; Dasgupta, 2004).

Damage cost data was obtained for the six month period prior to the survey delivery, and as the survey was applied over a two month period, a total coverage of eight months was obtained. However, a differentiated estimate per month is needed as the incidence of waterborne illness in rural developing areas varies throughout the year depending on certain factors, mainly precipitation and temperature (Figueroa, 1990). It is also necessary to ensure damage costs are comparable to averting expenditure estimates. Thus, a weighted damage cost for each month was estimated using data from the Health Secretariat on diarrhoea and dysentery cases for the department of Ocotepeque (department where study site is located) between 2011 and 2013 (SSH, 2013). First, an average of the government cases was obtained for each month over the three year period covered by the data. The monthly averages were divided by the average obtained for the six month period covered in this study to obtain a proportion. Then each monthly proportion was multiplied times the six-month average damage costs estimated in this study to obtain a weighted monthly cost. It is important to note that the weighting factor is based on secondary data that reports illness cases for every month of the year and only considers cases reported by government facilities. Thus, it is a conservative estimate as it does not include untreated cases, cases treated at home or by private doctors or clinics. The weighting factor was obtained thus

$$Weighting\ Factor = \frac{X\ month\ case\ average}{average\ six - month\ damage\ cost}$$

A limitation of the damage costs method is that third parties, such as institutions, may bear some of the costs associated with illness. In the study area, paid sick leave or medical insurance would be quite rare, only available to those in government (3% of respondents and 2% partners) or private employment (3% of respondents and 4% partners). Thus, at the study site third party costs mostly accrue to the state when patients visited public clinics. However, third party costs are omitted from this study as the visits to private doctors and public clinics were not differentiated. Furthermore, due to the high levels of subsistence activity and the complexities of estimation no attempt was made to value discomfort or lost leisure time in this study. However, it is recognised that some value can accrue to the disutility of foregone leisure, and the pain and suffering associated with the illness (Harrington et al., 1989; Whitehead and Van Houtven, 1997; Roberts, 2007).

5.2.4 Data Analysis

5.2.4.1 Bivariate Probit Model

In this study the incidence of illness is modelled as a function of the averting behaviour through a bivariate probit model following Alberini et al., 1996). This model assumes a correlation between averting behaviour and presence of illness (and its associated damage costs; see Briscoe et al., 1990). Likewise, the significance of different variables at explaining the presence of averting behaviour and illness is analysed with this model.

A household perceives being unfavourably affected by contamination when illness occurs and deems averting behaviour necessary. The incidence of illness is a function of the level of contamination and the household's averting behaviour. Contamination is exogenous to the household but averting behaviour is endogenous. So, this model assumes observed independent variables and unobserved risk factors, e.g. daily fluctuations in drinking water quality. Such a model captures the effect of behaviour on health and is therefore useful for analysing real-world situations, since it treats health and behaviour as interlinked variables (Alberini et al., 1996; Dasgupta, 2004; Fleming and Kler, 2008).

Furthermore, this model is based on respondents' water quality perceptions, employing a discrete yes or no according if they thought their water was contaminated or not; instead of the measure of actual contamination levels which are unavailable for the study site (see Um et al., 2002). Following is the formula for the bivariate probit model used and formed by two binary choice models nested together

$$y_1^* = x_1\beta_1 + \gamma_1 R^* + \varepsilon$$

$$y_2^* = x_2\beta_2 + \gamma_2 R^* + \delta y_1^* + v$$

Presence of averting behaviour is represented by y_1^* and presence of illness by y_2^*. Presence of averting behaviour y_1^* is determined by individual and household characteristics (e.g. monthly income, water bill) and proxies for risk factors known to the researcher (e.g. type of toilet available) x_1 and unknown risk factors R^* (e.g. fluctuations in water quality). Presence of illness y_2^* depends on x_2 , R^* and whether a household carries out averting behaviours y_1^* or not. There are three parameters of interest to be estimated: $\beta, \gamma,$ and δ. While ε and v represent normally distributed error terms with mean zero, variance one and correlation ρ. These two error terms are jointly distributed, but are assumed to be independent of each other, and capture the unobserved determinants of presence of illness and presence of averting behaviour, respectively. Because the risk factor R^* is not known to the researcher, it is absorbed into the error terms. In this analysis, the independent variables of individual and household characteristics x_1 were selected based on the literature and any variables exhibiting significant Pearson correlations above 0.4 were excluded from the model to avoid multi-collinearity. The independent variables included in the bivariate model are described in Table 5.1, as well as the expected sign for the model.

Table 5.1. Independent variables included in the bivariate probit model for the presence of averting behaviour and illness. Note: the classification of stable and temporal jobs is explained in Appendix 12.

Variable	Expected sign AB	Expected sign illness	Explanation
Age in years	?	?	Expected to be significant, but no a priori reason Continues…
Education above primary school	+	-	Education likely to increase desire for improved water quality
At least one child under 15 years	+	-	Children's health is a family concern and clean drinking water is provided to them
Has toilet or latrine	+	-	Having a toilet or latrine is a sign of sanitary awareness
Stable job	+	-	A stable job is likely linked to higher income and education
Partner has stable job	+	-	A stable job is likely linked to higher income and education
Large community	+	-	Larger communities have higher levels of income and education
Group member	+	-	Being in groups facilitates social and environmental awareness
Has car	+	-	Richer individuals have greater access to averting methods
Cable television	+	-	Richer individuals with access to social media have access to averting behaviour methods to reduce illness
Household income above minimum wage	+	-	Richer individuals have access to averting methods to reduce illness

Variable	Expected sign AB	Expected sign illness	Explanation
Water bill	-	-	Those paying a high water bill might expect clean water
Drinks from piped water system	-	-	The piped system is expected to provide cleaner water than other sources
Water quality perception	+	+	Thinking water is contaminated is one of the main reasons for presence of illness and thus averting
Water interruptions	+	+	Water interruptions are linked to water contamination and illness

5.2.4.2 Averting Expenditure Estimates

The three averting expenditure estimates (labourer, national minimum wage and market) were calculated by first estimating probit models with independent variables and subsequently welfare measures using Nlogit - Limdep 4.0 software (same as for the CV probit model, see detailed information on procedure in section 4.2.5 of chapter 4). Although the significance of the independent variables is not discussed, they are employed to obtain a realistic WTP considering the effect of these variables on respondents' preferences.

The consumption of bottled water has risen in the last decade worldwide not only because it is being perceived as a source of potable water, but also as water of good taste, odour and appearance (e.g. Doria, 2006; Ward et al., 2009; Hu et al., 2011; Saylor et al., 2011). These multiple benefits of bottled water are referred to as joint production, which is an important limitation of averting behaviour. Joint production is more likely to exist in studying long-term or persistent drinking water contamination situations (Abdalla et al., 1992), as is the case at the study site. Bottled water has also become a popular market commodity, a form of cultural consumption driven by status competition or as a lifestyle choice (Wilk, 2006; York et al., 2011). This status-derived benefit contributes to jointness but it is believed that this is not as great as its utilitarian value as a source of potable water (Knox and de Chernatony, 1989). Thus, to account for the jointness of bottled water at the study site, averting expenditure on bottled water is reduced by a conservative 11%, considering that the study site is a poor rural setting. This proportion is an average of Abrahams et al., 2000) findings of bottled water jointness in Georgia, USA.

5.2.4.3 Illness Damage Cost Estimate

As described in the previous section, data were collected on the damage costs for the six months before and up to the survey application. This six month value was converted to a weighted monthly value using secondary data from the government. However, it is recognised that the symptoms surveyed might be due to other non-water related causes as evidenced by some high outlier values. In order to account for this, 3% is trimmed off at both ends of the initial estimates as a valid method of removing outliers (e.g. Ramsey and Ramsey, 2007). Estimates were calculated based on all symptoms and for diarrhoea only cases, so that a broad value and a more conservative value were obtained.

Common problems with the data from revealed preference methods, such as averting behaviour and damage costs, are recall bias and incomplete information. Recall bias arises when people are asked to recall expenditures over a long time period (Chu et al., 1992); and incomplete information can occur when people do not have full information when they make purchase decisions (Boyle, 2003b). These limitations are considered when analysing the results and by referring to them as conservative estimates. Finally, the revealed WTP was calculated by summing the averting expenditure estimate and the damage cost estimate.

5.3 Results

5.3.1 Respondents' Socioeconomic Characteristics and Environmental Awareness

As described in chapter 4 (see table 4.1 for full socioeconomic characteristics), respondents are generally middle-aged males with stable work (mostly farmers), but with little education and low affluence. Most households do have a toilet or latrine and half have a cable television connection (Table 5.1). Three-quarters of households drink water from the piped water system, the rest use their neighbour's water connection, hoses, wells or other sources. Despite the fact that 72% of respondents think their drinking water source is contaminated (13% were unsure, excluded from Table 5.2) and 40% reported water interruptions, only 20% reported illness in the six months prior to the survey and 54% carried out some kind of averting behaviour to avoid contaminated water. A small proportion of households carrying out averting behaviour still reported illness, as well as some not averting and reporting illness (14%).

Table 5.2. Socioeconomic characteristics of water beneficiaries (n = 348, unless otherwise stated).

Characteristics	**Proportion**
Stable job	0.63
Partner has stable job	0.66
Has toilet or latrine	0.89
Has cable television	0.52
Drinks from piped system	0.76
Reports water interruptions	0.40
Carries out averting behaviour	0.54
Presence of illness (n = 352)	0.20
Thinks water is contaminated (n =308)	0.72
Averts but reports illness	0.13
Does not avert and reports illness	0.06

An important decision in health behaviour is the choice of drinking water source. Most households drink water from the community piped water system, including a small proportion free-riding on their neighbour's connection. The second most used drinking water source is bottled water with less than a quarter of households; followed by other infrequent sources (Table 5.3). There is a clear relationship between income and water source. The poor are more likely to use a neighbour's pipe connection (significant X^2 (4) = 19.07, p = 0.00, Cramer's V = 0.23), i.e. free-riding on the water system, and wealthy households are more disposed to buy bottled water (significant X^2 (4) = 25.01, p = 0.00, Cramer's V = 0.27). Although using piped water is significantly related to income (X^2 (4) =12.53, p = 0.01, Cramer's V = 0.19), the relationship is low, as evidenced in the Cramer's V value and no trend is visible. Table 5.3 thus clearly shows that water sources used are distributed by income of water beneficiaries.

Table 5.3. Drinking water source by income quintile; 1= Lps. 73,416 – 1,037,600 (US$ 3,886 – 54,914), 2= Lps. 43,200 – 72,000 (US$ 2,286 – 3,811), 3= Lps. 36,000 – 40,800 (US$ 1,905 – 2,159), 4= Lps. 24,000 – 35,000 (US$ 1,270 – 1,852), 5= Lps. 700 – 22,000 (US$ 37 - 1,164). * Note: total households equals 377 due to 25 households using more than one drinking water source.

Drinking Water Source	**Number of households per income quintile**					**Total (%)**
	1	**2**	**3**	**4**	**5**	
Piped	44	62	62	47	54	269 (76)
Neighbour (piped)	0	2	2	9	3	16 (5)
Bottled	30	20	18	8	6	82 (23)
Hose	3	0	2	1	1	7 (2)
Well	1	0	0	0	1	2 (0.5)
Other	1	0	0	0	0	1 (0.3)
Total	79	84	84	65	65	377*

The choice of water source is based on accessibility but also on respondents' knowledge and understanding of water quality issues. More than half of respondents thought their water source was contaminated and the way they acquired this information was assessed. Many sources of information were mentioned for knowing if water was contaminated, some accurate and some less so (Figure 5.1a). Almost half of respondents mentioned having seen the contamination at the water source, but only a small proportion mentioned water test results and visual reasons as determinants of water contamination. The low frequency of water test reporting is probably due to water users not having access to water test results or not grasping the link between contamination evidence and health risk.

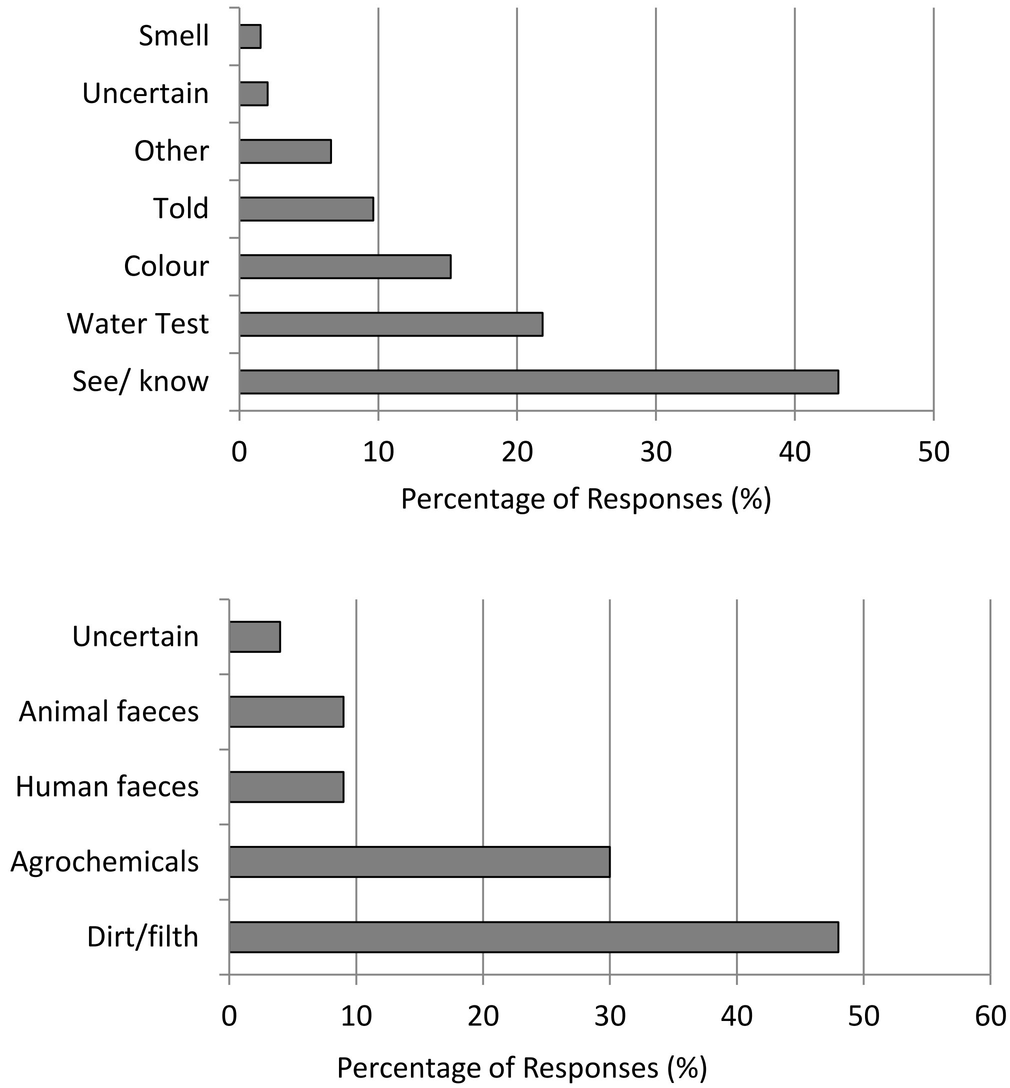

Figure 5.1. a) Respondents' ways of knowing that their water source is contaminated (n=256); and b) respondents' opinion on the type of contamination of their water source (n=275; respondents could give more than one answer).

The knowledge that respondents' have on the cause(s) of contamination is also important. When respondents stated what they thought the type of contamination was (Figure 5.1b), there is evidence of a lack of awareness of threats and inconsistency with results in Figure 5.1a. Water tests for the study site report contamination by faecal coliforms and bacteria mainly, followed by nitrates (from agrochemicals). Half of respondents mentioned dirt as the cause of contamination, followed by agrochemicals and, to a lesser extent, faeces. These findings evidence a considerable reliance on visual cues to assess water contamination, but also deficiencies in health risk awareness. Thus, there is water contamination awareness considering it is a rural setting, but it is largely based on visual cues and misinformation which likely influences their health behaviour and the value ascribed to improvements in drinking water quality.

5.3.2 Averting Behaviour and Expenditure

A total of 348 surveys were obtained with averting expenditure information. More than half of respondents carried out some kind of averting behaviour to avoid contaminated drinking water. The most frequent action was boiling, followed by buying bottled water, chlorinating and rarely a combination of two of these actions (Table 5.4). Some treatment methods yield higher utility than others, as evidenced by pathogens eliminated and taste, but respondents were probably not completely aware of utility differences and health risks. Boiled water and buying bottled water are believed to provide greater protection against pathogens, but both boiled and chlorinated water are known for bad taste. Thus, the water treatment method providing greater utility is bottled water, assuming bottling companies follow potable water standards.

Table 5.4 Pathogens eliminated and taste provided by each water treatment method, as well as the percentage of households utilising each method; [a] based on respondents overall views; [b] Four households (1%) used other treatment excluded from this study, see section 5.2.2 (Source of pathogens data: McConnell and Rosado, 2000; LeChevallier and Au, 2004)

Treatment	Pathogens eliminated	Taste[a]	Percent of Households[b]
Chlorinate	bacteria, viruses	Bad	7
Boil	protozoa, bacteria, viruses	Bad	22
Bottle	protozoa, bacteria, viruses	Good	20
Bottle and boil	--	--	2
Chlorinate and boil	--	--	1
Bottle and chlorinate	--	--	1
No treatment	None	Varied	46

Households carrying out averting behaviour have a positive WTP for clean drinking water since they undertake water treatment methods. However, each household values drinking water quality differently since their averting expenditure varies widely. Individual methods range from a monthly average of Lps. 10.16 (US$ 0.54) for chlorination up to Lps. 133.21 (US$ 7.05) for purchased bottled water (Table 5.5). Averting expenditure mainly depended on the price of the treatment method for each household, which ranged widely, and its frequency of use. Total monthly household averting expenditure averaged between Lps. 90.02 and 114.51 (US$ 4.76 – 6.06) based on three estimates. The labourer estimate is based on an agriculture labourer's wage, representing the lowest work time value at the study site. The market estimate is based on the market value of firewood and represents a mid-value averting expenditure. The national estimate is based on the farmer national minimum wage defined by the central government and represents the highest averting expenditure.

Table 5.5. Descriptive statistics of monthly averting expenditure (AE) in Honduran Lempiras per household for each individual method and in total.

Averting Behaviour	Mean	SE	SD	Range
Chlorinate (n=19)	10.16	2.60	11.34	0 – 50
Boil-Labourer (n=89)	55.06	3.19	30.07	4.02 – 167.03
Boil-Market	73.76	4.45	42	5.46 – 227.31
Boil-National	102.38	6.36	60.01	7.66 – 318.62
Bottle (n=78)	133.21	15.05	132.88	20 – 800
Total AE (n=172)				
Labourer estimate	90.02	8.04	105.38	0 – 880.30
Market estimate	99.70	8.12	106.55	0 – 909.29
National estimate	114.51	8.47	111.06	0 – 953.18

The final mean averting expenditure estimates were obtained through a welfare estimate considering the effect of independent variables. These estimates can serve as an initial WTP for a change in water quality from the current level to clean drinking water. The monthly averting expenditure per household is US$ 0.71 with a labourer estimate, US$ 0.79 with a market estimate, and US$ 0.86 with a national estimate. However, the joint production of purchased bottled water needs to be considered in the averting expenditure. In order to account for jointness, the purchase of bottled water for other reasons beyond quality (such as good taste, sight, odour, and as a luxury item), the cost of bottled water was reduced by 11% (see section 5.2.4 for more details). The amended averting expenditure estimates come to US$ 0.67 with a labourer estimate, US$ 0.74 with a market estimate, and US$ 0.79 with a national estimate. Although individual household averting expenditure amounts to less than US$ 1, the annual averting expenditure amounts to US$ 12,422, 13,720 and 14,647 respectively, for the entire study site. These estimates reflect the amount that could be raised for water conservation if water quality could be guaranteed. However, a more complete revealed WTP will be obtained by accounting for the illness damage costs, presented in the following section.

5.3.3 Illness Damage Costs

Households at the study site were evidently exposed to waterborne illness. When asked to report illness, i.e. symptoms of diarrhoea, vomit and stomach pain in the six months prior to survey application, 20% of households reported at least one case of illness and 14% reported diarrhoea cases. A total of 104 cases were reported, with costs largely formed by direct costs or medical expenses. Work days were rarely missed due to illness, so the indirect costs were low. The symptoms data reported are quite wide-ranging both for individual patients and for households and mean values are affected by a few costly cases. However, households did not report more than 3 cases for the six month period, patients were generally young adults and only two-fifths were under five years old (Table 5.6). See Appendix 15 for descriptive statistics of diarrhoea only cases.

Table 5.6. Descriptive statistics for illness cases per household and per patient for the six months prior to survey delivery; all costs in Honduran Lempiras (n = 69).

Characteristic	**Mean**	**SE**	**SD**	**Range**
Age of patient	23.84	2.65	21.99	1 – 89
No. patients under five years old	0.39	0.07	0.60	0 - 3
No. of cases per household	1.51	0.09	0.72	1 – 3
Per patient:				
Lost work days	2.94	1.26	10.50	0 – 90
Indirect costs	176.54	75.87	630.22	0 – 5,400
Direct costs	777.83	289.39	2,403.86	0 – 20,000
Per household:				
Lost work days	4.43	1.55	12.90	0 – 90
Indirect costs	266.09	93.19	774.11	0 – 5,400
Direct costs	1,143.87	367.36	3,051.51	0 – 22,300

The above data represents damage costs for the six months prior to the survey being administered. However, monthly values are needed to obtain values comparable to the averting expenditure estimates and to account for the variability of illness incidence throughout the year. To obtain a damage cost representative of each month covered in this study, data from the Honduran government was used to obtain a monthly weighting factor and a per month damage cost. Table 5.7 shows that May and June bear the most weight as they exhibit the highest number of cases due to being the start of the rainy season, resulting in greater contamination of superficial waters. The average damage cost per household is US$ 3.04 considering all three symptoms and US$0.28 only for diarrhoea cases. The households incurring expenditure to treat diarrhoea are too few (7) to analyse this data any further. However, the all symptoms estimates are trimmed by 3% at both ends mainly to reduce the effect of high outliers representing more serious and costly illnesses. A much reduced overall average of US$ 0.49 is obtained for all symptoms and is considered a valid measure of damage costs. The estimated damage cost provides an annual expenditure of US$ 9,085 for treating illness across the entire study site. The choice of symptoms, the weighting factor and the trimming of outliers are a major source of variation in the damage cost estimates.

Table 5.7. Weighting factor and weighted monthly damage cost in Honduran Lempiras (US$ in parenthesis) for all symptoms (A) and only for diarrhoea (D), with all cases and with a 3% trimmed data set (see section 5.2.3 for estimation procedure).

Month	**Weighting factor**	**Damage Cost-All**	**Damage Cost-Diarrhea only**	**Damage Cost-All 3% trim**
January	0.16	42.42	5.20	9.05
February	0.14	37.12	4.55	7.92
March	0.16	42.42	5.20	9.05
April	0.11	29.16	3.58	6.22
May	0.17	45.07	5.53	9.62
June	0.27	71.58	8.78	15.28
July	0.14	37.12	4.55	7.92
August	0.15	39.77	4.88	8.49
Average		57.44 (3.04)	5.29 (0.28)	9.19 (0.49)

5.3.4 Explaining the Presence of Averting Behaviour and Illness

A bivariate probit model was used to assess the impact of a number of variables on the likelihood that respondents carried out some form of averting behaviour and that they presented illness cases in the last six months previous and up to the survey application (Table 5.8). The full model containing all predictors is statistically significant at a 5% level, with a ρ (rho) = 0.29, indicating that data are missing randomly or the regression coefficients of the selection model and the regression coefficients of the substantive model were estimated by unrelated processes (i.e. rho closer to zero indicates little or no selection bias). Moreover, there is a positive relationship between presence of averting behaviour and illness.

Table 5.8. Maximum Likelihood Estimates of Bivariate Probit Model with averting behaviour and illness as discrete dependent variables. Note: *** 0.01 significance, ** 0.05 significance level

Variable	Coefficient	Standard Error	b/St.Er.	Mean of X
Equation for presence of averting behaviour				
Constant	-1.22***	0.49	-2.50	
Age	0.01	0.01	0.92	45.75
Education above primary level	- 0.07	0.26	- 0.26	0.15
Stable job	0.15	0.18	0.81	0.63
Stable job partner	0.11	0.10	1.04	0.65
Has kids	0.25	0.19	1.31	0.74
Has toilet or latrine	0.79***	0.26	3.01	0.89
Cable TV	0.33**	0.17	1.97	0.53
Has car	0.16	0.22	0.74	0.27
Income above minimum wage	0.14	0.21	0.65	0.26
Large community	0.40**	0.17	2.34	0.70
Group member	0.33	0.21	1.57	0.20
Drinks piped water	-1.02***	0.27	-3.73	0.76
Water bill	0.00	0.00	1.04	192.37
Source is contaminated	0.31**	0.13	2.41	0.87
Source has interruptions	- 0.18	0.16	-1.15	0.41
Equation for presence of illness				
Constant	- 0.95	0.58	-1.64	0.10
Age	0.00	0.01	0.27	45.75
Education above primary level	0.53**	0.27	1.99	0 .15
Stable job	- 0.42**	0.20	-2.04	0.63
Stable job partner	- 0.27***	0.11	-2.47	0.65
Has kids	0.13	0.25	0.51	0.74
Has toilet or latrine	0.42	0.39	1.09	0.89
Cable TV	- 0.15	0.20	- 0.75	0.53
Has car	- 0.16	0.25	- 0.63	0.27

Variable	Coefficient	Standard Error	b/St.Er.	Mean of X
Equation for presence of illness (continuation)				
Income above minimum wage	- 0.07	0.24	- 0.31	0.26
Large community	0.19	0.24	0.78	0.70
Group member	- 0.20	0.25	- 0.81	0.20
Drinks piped water	- 0.64***	0.24	-2.66	0.76
Water bill	0.00**	0.00	2.40	192.37
Source is contaminated	- 0.11	0.18	- 0.60	0.87
Source has interruptions	0.48**	0.22	2.23	0.41
Disturbance correlation				
Rho (1,2)	0.29**	0.12	2.40	

Five variables made a statistically significant contribution to explain the presence of averting behaviour: cable television, toilet, community size, drinking water source and perception of contamination. As expected, those respondents who thought their drinking water source was contaminated, those with a toilet or latrine and with cable television were more likely to carry out averting behaviour. Likewise, respondents living in a large community, drinking from a different source to the piped system were more likely to avert. Furthermore, six variables made a statistically significant contribution to explain the presence of illness: education, household head’s job, partner’s job, drinking water source, water bill, and water supply interruptions. As expected, those respondents with a stable job, which had partners with a stable job, that experienced water supply interruptions, and that drank water from the piped system were less likely to report illness. However, more educated respondents and those with a higher water bill were likelier to report illness. The water bill is not correlated to water quality or community size, so even those communities with a high water bill have problems securing water quality. The implications of these findings are discussed in the following sections.

No direct information was collected on the extent to which a household is informed about health risks associated to contaminated water. So, being member of a community group, the education level, and having cable TV were intended as proxies for health risk awareness. It has also been commonly stated that the presence of children in a household and the level of income or wealth can explain averting behaviour and illness. However, these variables were not directly significant in this study. However, several proxy variables for income are significant: toilet, cable television, and job type of respondent and partner. Furthermore, variables such as electricity connection or house ownership are not used due to their homogeneity in the sample. Gender was excluded as it was highly correlated with type of job for both the respondent and partner.

5.4 Discussion

This section assesses the revealed WTP of water users for clean drinking water through actual market expenditure. The WTP estimate is a measure of the benefits that would accrue to water users if averting actions and damage costs due to illness were reduced by improving drinking water quality, in this study through a hypothetical PES scheme. This section also discusses how these benefits are distributed among users and what health behaviour factors determine their distribution. Results show that the estimated WTP is high in comparison to the average water bill, but low in relationship to household income and values reported in the literature. The distribution of benefits of having clean drinking water was found to be mainly determined by socioeconomic characteristics, perceptions and environmental awareness. Key PES scheme contracting implications are discussed considering the revealed WTP and the local context.

5.4.1 Revealed WTP Measure

A WTP measure was determined by estimating separately, and then summing, the values obtained from two revealed preference methods: averting behaviour and damage costs. The three monthly averting expenditure estimates, considering joint production of bottled water, amounted to US$ 0.67, 0.74 and 0.79 per household, respectively. The labourer estimate represents poor landless households headed by individuals that labour for land-owning farmers. The mid-level market estimate represents slightly higher-income households that prefer to buy firewood (instead of collecting it) or might need to purchase it due to being located in communities far from accessible forest areas. The high national estimate is representative of land-owning farmers that work their own land or hire labourers to do so. The range of estimates for the study site are at the lower end of the ranges reported in the literature, between US$0.05 - 20[4] (McConnell and Rosado, 2000; Wu and Huang, 2001; Um et al., 2002; Roy et al., 2004; Pattanayak et al., 2005). This is likely due to these studies focusing on large urban populations unlike the small rural communities examined in this study.

The researcher agrees with Jalan and Somanathan, 2008) finding that averting expenditure probably provides only partial protection from contaminated water, as evidenced at the study site by the presence of waterborne illness, so it represents an incomplete measure of WTP. Some authors consider that the true benefits associated with the improvement in water quality actually equal the change in averting expenditure plus damage costs plus net direct disutility of illness, i.e. monetary value of lost leisure time, pain and suffering (Harrington et al., 1991; Pattanayak et al., 2005; Jalan and Somanathan, 2008). The damage costs of illness were estimated, but this study did not cover the disutility of illness due to resource limitations and it being considered negligible (see section 5.2.3).

The trimmed monthly damage cost due to illness comes to US$ 0.49 considering all symptoms. It is recognised that the three symptoms included in the damage cost estimate could be due to other causes such as food poisoning. However, national health statistics and recent studies in Honduras report much higher diarrhoea frequencies than those reported here. For instance, Solorzano Giron et al., 2006)

[4] All study figures were converted from US dollars of the publication year to 2011 US dollars, to compare to this study's results, using the CPI Inflation Calculator of the Bureau of Labor Statistics of the United States Department of Labor http://www.bls.gov/data/inflation_calculator.htm on 5th of November 2013.

found that more than 25% of children under five years old have at least one hospital consultation for diarrhoea annually in the area of this study. Halder et al., 2013) found that 30 - 72% of three small rural communities reported diarrhoea in the previous 30 days to the study. The potential reasons for the large discrepancy between these studies and the results presented here are manifold, so no strong assumptions can be made. However, recall bias, not being able to recall expenditures over a long time period (Chu et al., 1992), is likely to play a role in the results presented here. These studies indicate that the damage costs reported in this study are likely to be conservative estimates. This statement is further backed by the damage costs being at the lower end of the values reported in the literature. For instance, Dasgupta, 2004) found the illness damage cost in Delhi, India to be between US$ 0 - 10.38; and Guh et al., 2008) estimated the cost of treating Shigellosis in Hebei, China at US$ 7.70.

The revealed WTP obtained by summing the average averting expenditure and the trimmed damage costs amounts to US$ 1.22 per month per household. This estimate also amounts to a negligible 0.5% of the average household income at the study site. This means that current measures to ensure drinking water is clean and to treat waterborne illness are overall economically accessible to households as long as they are willing to implement them. However, if this revealed WTP is considered equal to a WTP for a potential PES scheme, then it is necessary to assess the share of income the WTP would represent for the poorest households. If the water bill were increased by the revealed WTP, it would affect households in the two lowest income quintiles. For instance, a household paying the lowest water bill and in the lowest income quintile, would be spending 3% of their income towards water. Considering an affordability threshold of 2.5% of income as a reasonable upper limit for water bills (OECD, 2003), it is estimated that a total of 20% of households[5] will not be able to cope with a water bill increase. However, this high expenditure to ensure clean water is already being paid by those households who carry out averting actions. This evidences a clear ability to pay for improved

[5] Based on the proportion of households per quintile per water bill in the sample and extrapolated to the entire study site.

drinking water quality above current fees for the three highest income quintiles, so increases could be made to their water bills but not so for the households in the two lowest income quintiles.

The revealed WTP estimate is also 1.5 times higher than the mean water bill. If jointness is accounted for correctly at the study site, this high WTP estimate indicates that substantial increases can be made to water bills if water quality can be ensured. The relationship between WTP and water bill, and income value, serve as measures of affordability for clean drinking water. A revealed WTP is often a preferable justification for water conservation policy interventions, than for instance a stated WTP, as it represents actual costs incurred by users. This study highlights how household income and water bills can serve as measures of affordability for clean drinking water, to identify actual WTP expenditure and to inform affordable water bill increments. Thus, the revealed WTP for clean drinking water comes to US$ 22,619 for the entire study site. This figure represents the amount that could be raised from water users if clean drinking water can be guaranteed with a PES scheme or other policy intervention.

The value of illness disutility, through lost leisure time, and pain and suffering, has been mentioned as a key factor to be considered in illness damage costs estimations. However, in this study disutility of illness is considered negligible, as evidenced by the few lost days of work due to illness (e.g. Guh et al., 2008). It is also clear that the revealed WTP estimate is likely to increase if more information on water contamination and household water treatment methods is provided to water users (see Jalan and Somanathan, 2008). Similarly, context specific information on the joint production of bottled water at the study site might alter the averting expenditure estimate. All considered, the values presented in this study are considered sound estimates, providing a valid measure of WTP.

5.4.2 Revealed Benefits Distribution and Implications for PES Contracting

Individuals will generally pay for measures that improve their environmental quality only if they are willing and able to pay for such improvements. The previous section determined that respondents are able and willing to pay for clean drinking water. However, as a constant benefit or value across populations based on averting actions and illness damage costs is unlikely, this section focuses on the distribution of the revealed WTP. Results show that the benefits determined from water users' WTP are distributed unequally. The distribution of benefits, and thus how the water quality service is valued, is determined mainly by environmental awareness, perceptions and socioeconomic characteristics.

There are several elements that will influence a household's health behaviour related to water quality, and thus the value ascribed to ecosystem service provision. First, households need to know that a contamination problem exists, and then it is necessary to understand the causes of contamination and the associated health risks, i.e. waterborne illness. Second, with their initial awareness, households decide whether averting action should be taken or not, based on the perceptions they hold on the utility of each kind of action (Akter et al., 2006; Jalan et al., 2009). Many socioeconomic and psychological factors have been found to affect household health behaviour, not only objective risk measures, i.e. water test results (Um et al., 2002; Pattanayak et al., 2005; Whitehead et al., 2008; Nauges and Van Den Berg, 2009; Lavee, 2010).

A substantial proportion of respondents are aware of drinking water contamination at the study site, but it is characterised by imperfect information and uncertainty. Although water tests were carried out at least annually a very small proportion of respondents mentioned them as the reason for their awareness of contamination. Water test results, an objective measure of contamination, are carried out for all water boards by the local health officer. This indicates a problem with communities receiving and/or understanding the water test results that should be provided by the water boards and the local health officer. In fact, the awareness of contamination was largely based on visual factors, implying that water users do not perceive clear water to be contaminated. A visual-based awareness in contamination has commonly been reported throughout rural areas of developing countries. However, this perception contradicts reality, as the most risky contamination at the study site is non-visible, i.e. nitrates from agrochemicals and faecal coliforms. This also points towards a potential higher WTP for water quality during the rainy season, when water is quite turbid due to runoffs. Alternatively, in the summer WTP will be much reduced and focused on scarcity of water not quality. In order to ensure PES scheme contracting in such a setting, awareness of contamination would need to be enhanced and the causes of contamination clarified, to reduce false expectations for clear water. Furthermore, there is a need to support the water boards' role of informing community members and explaining the results of water tests. Although a PES scheme per se would not aim to achieve these goals, the involvement of the NGO in a scheme could support the water boards' work. Thus, ecosystem service valuations need to take into account the potential seasonal variations in WTP and the local complexities of environmental perceptions.

Although all communities had water contamination occurrences in the year previous to the study, and two thirds of respondents thought their water was contaminated, only half carried out averting actions. Similar partial levels of averting behaviour were reported by Halder et al., 2013) in two Honduran rural communities. The literature mentions many possible variables influencing if drinking water is treated or not, such as age, education, occupation, presence of children, income, location, family size, house type, water source, type of latrine, exposure to media, water shortage, among others (Figueroa, 1990; Abdalla et al., 1992; WB, 1993; McConnell and Rosado, 2000; Um et al., 2002; Roy et al., 2004; Jalan et al., 2009; Nauges and Van Den Berg, 2009). At the study site the decision to treat drinking water was found to be dependent on some of these variables and the novel variable of community size linked to location.

As mentioned in the literature, those respondents who thought their drinking water source was contaminated were more likely to avert, a key determinant besides ability and willingness to pay for water treatment methods. Households with greater income and health risk awareness, evidenced by the presence of toilets and cable television, were also more likely to avert. The latter is one of the best sources of health risk information in the area, as it is within the home, accessible to uneducated people, and constantly available compared to harder to access newspapers and government printed material. In line with the literature, those respondents drinking water from the piped system were less likely to treat water, probably due to respondents' having strong ownership feelings towards their self-governed water system and the knowledge that the system provides better water quality than other sources. Approximately 13% of households do not avert and reported illness, thus likely trading-off their health due to a lack of income or health risk awareness. These findings back the previously mentioned recommendation of enhancing health risk awareness in order to garner support for a PES scheme. Additionally, such a scheme could be hindered by the low income levels and strong reliance on water quality from community water systems at the study site.

Furthermore, households located in larger communities, generally located downstream and farther from water sources, were more likely to treat water. This is probably due to these communities having access to the good quality substitute of bottled water, as well as health risk information, health facilities and governmental health programs, among other reasons. The more disadvantaged in large communities can also benefit from the example of more health-aware neighbours. So, despite the greater awareness that smaller communities might have due to being close to water sources and able to see the conditions upstream, they are less likely to avert. Halder et al., 2013) found that out of three rural communities in Honduras, the most rural had the highest overall rate of reported diarrhoeal incidence. These findings are probably linked to smaller communities having low income and health risk awareness, variables already discussed above. Thus, benefit distribution will vary between communities, with a PES scheme providing greater benefits to larger communities, through savings on averting expenditure. However, it is important to acknowledge that substitutes are rarely perfect (Brown et al., 2007) and an integrated watershed protection through a PES scheme would provide other ecosystem services to local inhabitants.

Households perceive varied utilities from the different water treatment methods available to them. McConnell and Rosado, 2000) found that households lack understanding about the effectiveness of the different methods in eliminating pathogens from drinking water. However, at the study site boiling water and purchasing bottled water are the preferred averting methods, both of which are efficient at eliminating pathogens. Thus, willingly or not, respondents are employing the most effective water treatment methods available. Akter et al., 2006) also found that the perceived inconveniences of treatment methods are influential in determining what methods are employed in rural Bangladesh. Some inconveniences to taking averting action include the required time, impaired taste, and limited or no access to methods in rural areas. Boiling is probably favoured due to its convenience and affordability, but it does produce bad tasting water. In contrast, bottled water has good taste but its use is limited by cost and accessibility. The choice of averting action(s) influences the benefits perceived by a household, and it is clear that higher income households buying bottled water will perceive greater benefits from a PES scheme guaranteeing clean drinking water. However, although non-averting households won't perceive economic benefits from averting expenditure savings, they would still benefit from clean drinking water and its effect on their quality of life.

Once a household chooses to avert, the averting actions may not be carried out in a completely effective manner. For instance, Jalan and Somanathan, 2008) found that averting expenditure provides only partial protection from unsafe water and that by providing information on water quality, averting expenditure increased by 6.5% in Gurgaon, New Delhi, India. At the study site a quarter of averting households experimented illness, indicating that averting actions are not carried out efficiently, either not at all times or not applying the method properly. Thus, these households are incurring in double costs as they trade-off, unsuccessfully, income for averting expenditure because their health is still affected. These households would perceive double benefits from a PES scheme, as they could save on averting expenditure and also on illness damage costs.

The general consensus in the literature is that more education equals less illness (e.g. Dasgupta, 2004; Jalan et al., 2009). However, unexpectedly at the study site more educated respondents actually reported more illness. This incongruity might be explained by the educated having higher expectations of good health and higher health risk awareness, and thus being more aware, or just being able to better recall the incidence of illness than the uneducated. Additionally, although household income is not significant, the proxy of a stable job for the household head and his/ her partner is. At the study site households headed by farmers owning land or a permanent business were less likely to report illness, as well as those drinking from the piped water system. Ahmad et al., 2005) found that households where the head is a farmer, or in business or service, are relatively more inclined to opt for piped water supply than those where the head is an agricultural labourer or a manual worker. Likewise, Dasgupta, 2004) found that households that depended on non-piped sources had a higher probability of reporting diarrhoeal illness. Consequently, individuals with temporal or unstable jobs, such as agriculture labourers, and those using non-piped sources will actually perceive more benefits from a PES scheme improving drinking water quality, as they will save on illness damage costs.

Furthermore those households experiencing water supply interruptions and with a higher water bill were more likely to report illness. Alberini et al., 1996) found that interruptions in the water supply interfered with averting behaviour and thus gave way to a higher probability of illness in Jakarta, Indonesia. This could help explain why water interruptions produce a higher incidence of illness at the study site. Often ecosystem service provision depends on appropriate technologies and infrastructure in order to meet demand for a service, e.g. water distribution network and disinfection. Often, water supply interruptions are not within the control of individual households. Thus, for a PES scheme to be effective at the study site, proper maintenance of water systems by community water boards would need to be ensured to produce clean water and a constant supply. The significance of the water bill at explaining the WTP is unexpected and difficult to explain as the four communities with the highest water bills and their respective water sources do not seem to have any similarities. Whatever the reason, this finding is likely to create conflict in contracting for a PES scheme, as these communities will benefit from improved drinking water quality, but are also unlikely to agree to a water bill increase as they already have the highest water bills. This study highlights that the design of a PES scheme based on a revealed WTP would need to be preceded by explaining to water users the benefits of the scheme based on avoided averting and illness damage expenditure.

If supply of clean water were unlimited, i.e. not contaminated or abundant substitutes available, there would be no incentive for anyone to pay for water treatment methods and subsequent illness damage costs because they could get all the clean water they want for free (Brown et al., 2007). The households perceiving clean drinking water to be scarce will increase demand for it, but an almost equal proportion that perceives it to be abundant will lower the demand for it. The perception of ecosystem service scarcity and its resulting demand will affect the effectiveness of a potential PES scheme because the degree of commodification or tradability of the ecosystem service will depend on these perceptions (Muradian et al., 2010). Thus, besides thinking that drinking water is contaminated, the households' health risk awareness, perceptions and socioeconomic factors mentioned above indicate the level of demand for improved drinking water quality. Findings for the study site indicate that clean water is perceived to be locally scarce by at least half of respondents, so there is a substantial demand for clean water. This study contributes to better understand how a revealed WTP provides different insights into PES scheme contracting than those provided by a stated WTP estimate. However, it is important to acknowledge that the revealed value of an ecosystem service is not constant, but can change over time as market demand changes.

5.5 Conclusion

The WTP for clean drinking water through avoiding or dealing with contaminated water at the Güisayote Biological Reserve was estimated with an averting behaviour and an illness damage cost method. The monthly revealed WTP came to US$ 1.22 per household which is within the range reported by the literature. This estimate represents 0.5% of the average household income and 1.5 times the monthly water bill. However, if the current water bills were increased by the revealed WTP, approximately 20% of households will not be able to afford it. Overall, there is affordability and willingness to pay above current charges, indicating that substantial increases could be made to water bills and those households incurring in averting and illness damage expenditure are already paying above their water bill.

Users' benefits reflected by the revealed WTP are distributed unevenly as a function of their health risk awareness, perceptions and socioeconomic characteristics. Potential PES scheme contracting is likely to be enhanced by current levels of health risk awareness and substantial expenditure on averting actions and illness damage costs. However, the scheme could be hindered by or will need to consider the visual-based and imperfect health risk perceptions, low income levels, strong confidence in the water quality from community water systems, uneven benefit distribution between large and small communities, improvements needed to water system infrastructure. Informing the design of a potential PES scheme through a revealed WTP provides a specific distribution of benefits and is based on actual market expenditure. The researcher is not aware of any other study using a revealed WTP to inform the demand-side of PES scheme contracting.

This chapter contributes key information to discussions in chapter 7 on the use of different WTP measures, the feasibility of a PES scheme by contrasting with the costs of water provision, and contracting in PES schemes in a wider context.

Chapter 6: Costs of Water Provision

This chapter evaluates the opportunity costs of upstream landholders as the costs of setting aside land to improve drinking water quality. Opportunity costs are estimated using two approaches, the flow and the rent approach. The flow approach assesses the net returns of landholders productive land uses and the rent approach is based on three land values stated by landholders. The distribution of opportunity costs is also assessed based on landholder and land attributes. Then PES scheme contracting opportunities and challenges for service providers are discussed, considering their opportunity costs and the local context. In chapter 7 these costs will be compared to the benefits of water conservation, both the stated (chapter 4) and revealed WTP (chapter 5) of beneficiaries, to assess the feasibility and challenges of a PES scheme.

6.1 Introduction

Securing drinking water quality is a major issue in developing countries due to a complex array of challenges from both the demand and supply side (Rangel Soares et al., 2002; Jouravlev, 2004; Trevett et al., 2004; UNICEF and WHO, 2012). The contamination affecting water sources comes from point and non-point sources. Particularly in rural areas land use polluters, who are also service providers, are often numerous, disperse and remote (Olmstead, 2010; Smith and Porter, 2010; Smith et al., 2012). Understanding the magnitude of the returns currently received by landholders is therefore a prerequisite to designing water conservation initiatives. However, there are substantial difficulties in determining precise compensation or incentives to service providers due to heterogeneous land costs, multiple stakeholders, methodological limitations and inequitable distribution of project outcomes, among others (Corbera et al., 2007a; Adams et al., 2010; Dong et al., 2011; Bryan, 2013; FFI, 2014).

The cost of conserving ecosystem services can include transaction costs, opportunity costs, costs of implementing conservation actions, and monitoring costs; and can also take account of more indirect costs such as increased competition for land, reduced employment and food security (Naidoo et al., 2006; Coad et al., 2008; Fisher et al., 2008; Pagiola and Bosquet, 2009). The allocation of land to conservation unavoidably competes with the needs of society for agriculture and extraction of natural resources (Wünscher et al., 2011). The income foregone by a landowner if the land is conserved represents the opportunity costs, which are based on scarcity and exclusiveness because one course of action prevents another one from happening (Sinden, 2004; Naidoo and Adamowicz, 2006; Pirard, 2008). Opportunity costs are widely accepted as the main cost of conservation (e.g. Sinden, 2004; Naidoo and Adamowicz, 2006). The estimation of these costs is useful for a variety of reasons, such as calculating conservation costs in protected areas or natural resource management, determining their distribution among landholders, assessing trade-offs in land uses, to test methodological issues, and more recently to assess the feasibility and design of PES or REDD+ projects (Pagiola and Bosquet, 2009).

PES schemes could make conservation more attractive to private landholders who supply an ecosystem service. Hence, estimating opportunity costs is a crucial starting point to determine the economic viability of PES schemes to effectively change land use practices (Plumb et al., 2012). A large challenge exists to understand the distribution of opportunity costs among and within different ecosystem service provider groups as they have been found to be quite heterogeneous (Tallis and Polasky, 2009; Adams et al., 2010; Badola et al., 2010). Thus, understanding how opportunity costs are distributed will inform who would gain and who would lose from a scheme, which is important both from an equity perspective and from a practical one (Pagiola and Bosquet, 2009). Opportunity cost analysis has also become an essential tool to determine the most cost-effective level of payment required for individuals to alter or halt a land use, and to determine where and if schemes should be developed (Plumb et al., 2012). However, the estimation of opportunity costs has been done through several methods and is a complex process fraught with challenges.

Three main approaches have been used in the literature to estimate opportunity costs for PES schemes and other conservation initiatives. These approaches include the more recent screening contracts and procurement PES auctions, as well as more commonly used methods based on land attributes or returns, such as costly to fake signals, actual net returns from land uses, and land prices. First, screening contracts consist of offering a contract for each of the different types of landholders believed to exist and letting them self-select a contract. However, this method is limited by requiring detailed knowledge about the distribution of landowner types and sophisticated calculations by conservation practitioners. So far, no applications of this approach exist in practice (Wünscher et al., 2011).

Second, procurement PES auctions consist of a buyer of ecosystem services inviting bids from the suppliers for a specified contract and then buying the contracts with the lowest bids (Ferraro, 2008; Tóth et al., 2010). For example, Jack et al., 2009) applied a procurement auction to determine how payment contracts can be configured during the design-phase of a conservation program for soil erosion control in Indonesia. Khalumba et al., 2014) combined procurement auctions for reforestation contracts with payments based on contractor performance in Western Kenya. Both studies found that this approach helps reveal private landholders' opportunity costs. However, these auctions have disadvantages, such as being quite complex to design and requiring a large pool of bidders to be valid.

Third, information can be gathered on observable landholder and land attributes that are correlated with opportunity costs and use these attributes to determine opportunity costs and establish PES contracts. Naidoo and Adamowicz, 2006) estimated opportunity costs based on observed spatial patterns in conversion of natural habitat to agricultural land and observed net benefits from agricultural plots in a Reserve of Paraguay. Collecting information on these attributes can be costly and the accuracy of this information will only be as good as the strength of the correlations between the attributes and landholder types. Opportunity costs can also be estimated using generic or average data often from secondary sources, most frequently government data. Many studies have applied this approach, most recently for REDD+ projects (Börner and Wunder, 2008; Börner et al., 2010; Hunt, 2010; Fisher et al., 2011b; Fisher et al., 2011c). This approach is useful for studies at regional or national scale, but does not capture local variation (Grieg-Gran, 2006) and can yield quite varied results depending on the data sources.

Land use net returns, also referred to as the flow approach, can be estimated at the local or micro level. Local opportunity costs have helped develop payment levels for many existing PES programs (Plumb et al., 2012). Among the more recent studies we find: Borrego and Skutsch, 2014) that quantified the net returns to land uses that degrade dry tropical forests in Jalisco, Mexico. Illukpitiya and Yanagida, 2010) estimated farm returns to explore the trade-off between agriculture and extraction of forest products and to determine the efficiency improvement necessary to compensate the current income generated by non-timber forest products in Sri-Lanka. Adams et al., 2010) estimated opportunity costs of agriculture and ranching focusing on single stakeholder groups at Mbaracayu Forest Biosphere Reserve, Paraguay. This widely used approach provides detailed local information and variability. However, its drawbacks are that it is not suitable for extrapolating to larger areas, it bears the risk of strategic bias, can be quite costly, and a lot of data is at a coarse scale and can lack important information (Cattaneo, 2002; Grieg-Gran, 2006; Börner et al., 2007; Fisher et al., 2011c; Wünscher et al., 2011).

Finally, land market prices, also referred to as the rents approach, can be converted into values that can serve as proxies for opportunity costs. For example, Chomitz et al., 2005) estimated the opportunity costs of conservation in a biodiversity hotspot of Brazil using hedonic price model to impute land values. Ando et al., 1998) used county-level data on agricultural land values from the USA government to study the effect of heterogeneous land prices on the efficient selection of reserve sites. Ma and Swinton, 2011) demonstrate how hedonic analysis of agricultural land prices can be used to estimate the private values of land-based ecosystem services with data from Michigan, USA. The use of land values to determine opportunity costs is commonly used, reveals landholders true value for land and is quite straightforward. However, this approach is not recommended when no land market exists or it is undeveloped, where land can be obtained for free, or when it may reflect returns from potential land use not the actual one (Cattaneo, 2002; Ferraro, 2004; Grieg-Gran, 2006; Börner et al., 2007).

Further comprehensive studies utilise two or more of the above described approaches to obtain more accurate and robust opportunity cost estimates. For example, Sinden, 2004) estimated opportunity costs for biodiversity protection in Australia using state land values and net returns; and found that the land species variables selected were very important in determining opportunity costs. Corbera et al., 2007b) estimated opportunity costs through net farm returns, valuation of providers' WTA a price for PES and the expected land rent in three Central American countries. They found that the estimation of the opportunity costs may differ considerably, depending on the method used, and the assumptions adopted. Wünscher, 2008) compared three approaches in Costa Rica: hypothetical annual land rents, modelled regressions, and farm net returns. They found that the annual land rents and the modelled regressions can be recommended for practical application in conservation programs, based on how well the estimates compare to the reference farm net returns that were found plausible. These authors recommend further research into opportunity cost estimations, particularly the flow approach techniques that are applied to deliver farm net returns.

Cost-effective and precise estimation of site-specific opportunity costs is a major challenge (Wünscher et al., 2011). This study follows the more comprehensive studies described above by employing both a flow and a rent approach. The flow approach uses local level net returns from agriculture in order to obtain detailed insight into the heterogeneity of landowners and variability of opportunity costs. The rent approach employs stated land values that potentially reflect more stable longer term values.

6.2 Study Site and Methods

6.2.1 Study Site

This study was conducted in a watershed of the Güisayote Biological Reserve in the westernmost region of Honduras. The area is characterised by moist rainforests with a high rainfall rate and an abundance of both permanent and temporal streams. The study site covers 4,793 ha including core zone and buffer zone of the Reserve, as well as lower unprotected land. The area provides drinking water to fifteen communities with an estimated population of 7,725 inhabitants (ESNACIFOR and USAID, 2002). The watershed was selected based on its poor water quality levels as all water sources, have been found contaminated with excessive nutrients (from agrochemicals), bacteria, and/or faecal coliforms at least once in the last year by the local health officer.

Reserve status means that de jure anthropogenic activities are strictly prohibited in the core zone and restricted in the buffer zone. However, landholders do not always follow these restrictions and de facto forest use shows locals making (illicit) use of public and private forest land for poles, medicine, firewood, shade and cattle grazing (AESMO, 2010). The Reserve is managed by AESMO that, among other measures, employs park guards to patrol the Reserve. In the last decade AESMO has endeavoured to purchase forested land for conservation in the core zone. Also, AESMO and other organizations have implemented some initiatives to reduce soil erosion and agrochemical use in agricultural practices, but adoption by farmers is varied and unsustainable (AESMO, 2010). Overall, command and control approaches have had some success but are far from achieving conservation goals. This is a common situation in protected and rural areas of Latin America (Bonham et al., 2008; Oestreicher et al., 2009; Pacheco Angulo et al., 2011).

The upstream watershed area has an estimated extension of 2086.7 ha, including 243.6 ha owned by the municipality of La Labor and the Llano Largo community[6]. The most extensive land cover is relatively long-standing rainforests, on average 32 years. The study area has long been settled and accessible, even before the Reserve's creation in 1987, so the presence of forest is likely an indicator that the land is unsuitable for agriculture and that there has been some conservation in the area[7].

The upstream private landholders have dispersed plots, all with secure land tenure. The main productive land uses are coffee at lower heights for national or international commerce, vegetables (e.g. potato, cabbage, carrot) at higher and colder altitudes for national commerce, extensive cattle ranching throughout for subsistence and local commerce (milk and cheese, seldom for meat), and some maize and beans for staple subsistence. The cash crops of coffee and vegetables are the most profitable land uses but are also affected by quite volatile markets (e.g. Charveriat, 2001; Mohan, 2007). Coffee growers are quite organized, generally belonging to one of several associations and cooperatives. However, for other land uses few communities are organised in informal farmer groups and one has support from NGO-based agricultural projects looking at sustainable practices, increasing productivity, and marketing.

Coffee is a long-term cultivar and provides the main source of employment at the study site (PNUD, 2010a). Coffee plots are, on average, small, involve low herbicide and pesticide use (compared to other crops), and often have other trees and vegetation. Thus, it is assumed that most, if not all, land suitable for coffee is

[6] This land includes 28 ha of Llano Largo, 2.8 ha of AESMO and 212.8 ha of La Labor municipality.

[7] A few years back a conservation movement arose in the study site as a mining company wanted to start operations with the support of the central government. The local communities, with the support of NGOs, were able to stop the mining company.

already being used as such[8]. This land use does not require irrigation (AESMO, 2010) and if managed sustainably can contribute to reduce erosion (Jansen, 1993) and provide many environmental benefits (e.g. shade coffee in Miranda-Castro and Padron, 2005). Importantly, coffee is very much influenced by international market prices and, as observed in Appendix 16, for the study year the international price reached its highest in the last ten years.

This section provides limited study site and methods information relevant to the focus of this chapter. For more details on the selection and description of the study site, and methods, see chapter 3.

6.2.2 Opportunity Costs Estimation: Two Approaches

Opportunity costs were estimated employing the flow and rent approaches. The use of two different approaches increases estimate confidence that is limited by a small sample size and the complexity involved in estimating opportunity costs. Landholders were identified by several visits to the watershed and by elaborating a land ownership map with several farmers as no registry for cultivated land exists for the area. A survey was applied to upstream landholders to collect data on both opportunity cost approaches. There are an estimated 95 landholders above the lowermost water source in the study site. A total of 62 (67%) landholders completed the survey, 23 (23.5%) could not be found despite repeated visits and 10 (9.5%) refused to participate. It is recognised that the final sample size, although representative of service providers at the study site, places a limit on potential data analyses and interpretation.

[8] Coffee is restricted to areas between 1200-1500 m (Lopez Gonzalez 2007); vegetable crops are grown in higher areas above 1500 m (personal observation and project documents for “Proyecto Fortalecimiento de las Capacidades Empresariales” funded by BID/FOMIN/ADEVAS, http://www.adevas.org/web/desarrollo.html); and cattle throughout the study area.

6.2.2.1 Flow Approach

The opportunity cost survey included questions on landholder socioeconomic characteristics, land attributes, inputs (e.g. fertilizer, pesticide, tools, seeds, vaccines) and outputs (e.g. yields of vegetables or milk) of all productive land uses covering a one year period (2010-11; see survey in Appendix 11). Likewise, respondents were asked to draw each of their plots and highlight main features, such as land use distribution, neighbours, roads, streams and rivers, and infrastructure. The survey covered from one up to three growing seasons that could be carried out in a year (2010 – 11) and only crops that had been harvested at the time of the survey. Land uses included cattle ranching, maize and beans, vegetable crops, coffee, forest use and some crops that only appeared once in the sample, e.g. sugar cane. Whenever yields were reported for self-consumption, they were ascribed the market value stated by the respondent or the average for all landholders reporting that land use. All values were obtained in Honduran Lempiras for the local land measurement of Manzana and converted to US dollars per hectare at an exchange rate of US$ 1 to Lps. 18.8951 and one Manzana equal to 0.7 hectares. Although estimating the net present value (NPV) would have been ideal to account for the dynamism of opportunity costs, the lack of agricultural data for previous years prevented this. Still, the flow approach estimations are believed to be relatively accurate and therefore serve as a reference point for the rent approach (see Wünscher et al., 2011).

6.2.2.2 Rent Approach

As the local land market is informal and no records exist for previous land transactions, respondents were asked to state three different land values. The survey included questions on the price that landholders would rent their land, would sell it and at which they actually purchased it. The would sell and actual purchase prices are assumed to reflect the highest-value use of land, which is a function of several factors, mainly climate and soil properties, and access to roads. This value is expected to be an upper bound opportunity cost of dedicating land to conservation because it assumes forfeiting all future streams of income (Chomitz et al., 2005). The would rent price is the amount of money that remains from the sale of product minus the cash operating costs, depreciation and the opportunity cost of labour and management, i.e. the amount which remains to pay the rent (Lazarus, 2000).

The three 2011 rent values were estimated based on 39 would rent values, 74 would sell values and 56 actual land purchase values. A total of 10 actual rental cases were reported but due to their limited number were excluded from this approach. Land is only occasionally rented in order to balance seasonal shortages of cattle feed supply or to complement current land use.

6.2.3 Data Analysis of Opportunity Costs

6.2.3.1 Flow Approach

The flow opportunity costs were estimated per landholder and per hectare for one year by subtracting total costs from total revenue for each land use multiplied by the area used to obtain net returns per hectare. Following Fisher et al., 2011c) the total opportunity costs were obtained as follows

$$V = [\sum_{i}^{l} A_i y_i P_i] - C_i$$

where V is the net agricultural returns of the average hectare in US$, summed across all land uses; A_i is the plot size in hectares with land use i; y_i is the yield of land use i; P_i is the price of land use i in US$ per yield unit; and C_x is the cost of inputs including labour, tools and agricultural materials.

Several assumptions were made to estimate the flow opportunity costs. First, personal and family labour is deducted at 50% of the local worker ("jornal") wage. This proportion was determined based on little readily available off-farm income alternatives, the distance to available off-farm employment which is too large to be overcome at a reasonable cost, and the qualification or physical status (e.g. due to age) of landholders do not meet the requirements for off-farm work (for further discussion on the value of family labour see Wünscher, 2008; Wünscher et al., 2011). Second, the cost of land conversion is not considered as natural forest regeneration is envisioned for the PES scheme. This reduces the costs to landholders and project implementers. Third, negative net returns from lost crops are included in the analysis to provide a realistic view of the study site and obtain insight into local heterogeneity of costs. However, it is acknowledged that agricultural returns may vary from year to year. Fourth, although very few forest plots were reported as used, all forest plot data is included in the analyses. This is because respondents are likely to be influenced by the legal land use restrictions applicable to the Reserve.

The total and per land use flow opportunity costs represent net returns at the study site for the year 2010 - 11, including negative values due to some land uses experiencing low demand or prices. Thus, the data is highly variable for the study year and probably does not capture the true long-term values. Therefore, flow opportunity costs considering only positive values were also estimated, referred to as flow+; and an estimate of the positive values excluding coffee, referred to as flow+ woc. The latter estimate served to remove the effect of coffee prices being at the highest in the last ten years and thus make the flow opportunity costs comparable to the more stable land rent values.

Due to small sample size, the determinants of opportunity costs were analysed at landholder and plot levels. The variables tested for landholder and plot opportunity costs are listed in Table 6.1 and are based on data availability and the literature. Continuous variables were tested through Spearman's rho correlations and categorical variables through Mann-Whitney U tests.

Table 6.1. Independent variables tested for association with two levels of opportunity costs, per landholder and per plot, and their expected sign.

Landholder variables	Expected sign	Plot variables	Expected sign
Age in years	+	Plot size	+
Years of education	+	Time to road	-
Family size	+	Time to water	-
Female	?	Time to house	-
Proportion of household income coming from farmer	+	Altitude	?
Only agriculture income	+	Accessibility	+
Number of plots used	+	Number of plots used	+
Land owned	+	Years owned	-
Number of land uses	+	Presence of forest	+
Presence of coffee	+	Presence of coffee	-
Presence of cattle	-	Presence of cattle	+
Presence of crops	+	Presence of crops	+

The probability of presence of each productive land use was then tested through binary logistic regressions. The independent variables tested include: elevation, time to main road, access to land throughout the year, slope and time to water. These independent variables were limited to land characteristics and were based on data availability and the literature. An attempt was made to collect information on soil fertility; however the variable was dropped from analyses due to limited responses.

A binary logistic regression allows predictions of a discrete outcome when the predictors are continuous, discrete or a mix. Logistic regression allows the evaluation of the odds (probability) of membership in one of the groups, in this case presence or absence of a land use, based on the combination of values of the predictor variables. In this regression predictors do not have to be normally distributed, linearly related to the dependent variable, or of equal variance within each group. Further information on this type of regression is widely available, for instance in Tabachnick and Fidell, 2013).

6.2.3.2 Rent Approach

Three rent values were estimated based on would rent value, would sell and actual purchase price. In this approach it is assumed that the annual would rent price of a plot of agricultural land is equal to its annual net revenue flow, whereas the would sell and actual purchase price of a plot of land are equal to the discounted flow of net revenue that the parcel is expected to generate into the future (Weersink et al., 1999; Cavailhes and Wavresky, 2003; Goodwin et al., 2003).

Would rent prices were in 2011 values so they only had to be divided by plot size to obtain per hectare rent values (referred to as R1). However, it is recognised that some hectares, i.e. productive land, are more valuable than others, i.e. forested or steep land. The actual land purchase prices (referred to as R3) were adjusted for inflation as they covered transactions carried out between 1961 and 2011. Each purchase value was multiplied by the consumer price index (CPI) of the year of purchase divided by the 2011 CPI. CPI values were obtained from the Central Bank of Honduras (Appendix 17). Thus, the formula to determine 2011 land purchase values is

$$Land\ Purchase\ value\ 2011\ (LPV2011) = Purchase\ price * (\frac{CPI\ of\ Year_x}{CPI_{2011}})$$

Subsequently, in order to convert the 2011 land purchase values and the would sell prices (referred to as R2) to land values, both were multiplied by the average general interest rate for 2011 (5.25%) as reported by the Central Bank of Honduras (BCH, 2011). Ideally a capitalization rate, a market determined rate of return that attracts individuals to invest in the use of land considering all the risks and benefits which could be realized (Gwartney, 1999), should be used. However, a capitalization rate is not available for Honduras so the interest rate was used as a viable proxy. The use of a one off interest rate for all plots will affect absolute but not relative land rental values across the study site. The formula used to convert the would sell and purchase prices to rent values follows

$$Land\ Rental\ Value = Would\ sell\ or\ LPV2011\ * interest\ rate$$

Additionally, tax reporting was highly inconsistent by respondents, half of rural landholders at the study site did not report paying any land tax and the other half reported values between US$0.27 and 11.34, with a low mean of US$ 3.64 ha^{-1} (median US$ 1.90). Due to this irregularity and variability, tax is excluded from the rent approach estimations.

6.3 Results

6.3.1 Landholder and Land Characteristics

The landholders that responded to the opportunity cost survey showed similar characteristics to the beneficiaries of the water service (described in chapters 4 and 5). This is due to the majority of respondents (84%) residing in beneficiary communities with land plots elsewhere; making them beneficiaries of the service as well as providers. The implications of this duality for contracting in PES schemes are discussed in section 6.4.2.

Respondents are mostly male (89%) with an average age of 56 years old. Schooling levels of respondents are quite low, with an average of four years and families are large, with five members on average (Table 6.2). Farmers carried out an average of 1.5 productive activities probably due to some being specialists (i.e. coffee growing and cattle ranching is taught from father to son from an early age) and others perhaps limited by land characteristics or little agronomic training. Furthermore, the household income is based on few sources, on average 2.5, and the household relies largely on the landholder for that income. Landholders have on average one plot and these plots have been owned for an average of eighteen years.

Table 6.2. Socioeconomic and farmer characteristics for opportunity cost survey respondents (n = 62). Note: [1]forest use is not included here; [2]one observation was removed as the respondent had a university degree in agronomy.

Variable	Mean/ Proportion	SE	SD	Range
Age	56	1.62	12.76	27 - 89
Female	0.11	0.04	0.32	
Years living in area	54.44	1.79	14.13	25 -89
Years of education	4.23	0.63	4.93	0 – 18
Family size	5.35	0.35	2.74	1 – 12
Productive land uses per farmer[1]	1.45	0.12	0.95	0 - 4
Days of agronomic training received[2]	34.73	12.04	94.79	0 – 481
Household income sources	2.53	0.22	1.71	0 – 7
Income contributed by landholder	74.80	4.34	34.21	0 – 100
Years owning land plots	17.78	1.44	11.32	0.5 – 50
Plots per farmer	1.13	0.07	0.58	1 - 4

The total amount of land owned by respondents varies widely between 0.7 and 126 ha, with a mean of 15 ha (Table 6.3). Land plot size has a similar range to land owned, but a smaller average of 9 ha. The most abundant land cover is forest (39%) which is relatively long-standing as landholders reported forests with an average age of 32 years, but up to 89 years for some. Among the productive land uses, cattle ranching (35%) is the most wide-ranging land use followed by much smaller extensions of coffee (8%) and crops (3%); and very small areas are dedicated to renting, loaning, and fallow. Land uses are similarly distributed among farmers: 43% had forest, 39% had cattle ranching, 29% had coffee and 25% had crops.

Table 6.3. Land and land use distribution for opportunity cost survey respondents (n = 62). Note: [1]Refers to percentage of net private land represented by each land use, i.e. when coffee is combined with maize or beans or when land was used for more than one season it was counted only once, as well as when a respondent used land of another respondent; [2]includes vegetables, maize, beans, improved grass and sugar cane; [3]Approximately 15 ha of vegetable land was used more than once in the year, and 5 ha of maize and beans were used more than once or overlapped with coffee.

Variable	Total ha (%[1])	Mean land area (ha)	SE	SD	Range	% Farmers
Land per farmer	--	14.7	3.01	23.72	0.7 – 126	--
Plot size	--	9.1	2.37	18.63	0.18 – 126	--
Forest	357.28 (39)	5.6	1.82	14.34	0 – 64.75	42.7
Cattle	319.2[9] (35)	4.9	1.38	10.86	0 – 70	38.5
Coffee	69.44 (8)	1.4	0.22	1.73	0 – 5.6	29.4
Rented	54.6 (6)	0.7	0.85	6.67	0 – 52.5	2.1
Loaned	41.86 (5)	0.7	0.33	2.6	0 – 18.2	13.3
Fallow	39.7 (4)	0.7	0.21	1.62	0 – 8.58	18.9
Crops[2,3]	32.2 (3)	0.7	0.12	0.92	0 – 4.2	25.2

6.3.2 Cost of taking land out of production

The opportunity cost of water conservation was estimated with the flow approach and the rent approach. Figure 6.1 shows the spread of flow opportunity costs or net returns per hectare for each productive land use. Cattle ranching and forest show the least spread of data and central values, due to low reported forest use and cattle farmers reporting a bad year. Also, only ten out of 52 forest plots were reported to be used in the study year. Coffee and crops show the widest spread of data and highest values, but both cattle and crops reported several negative values due to low market prices. Furthermore, the median net return of coffee is two orders of magnitude greater than the next highest median land use. Therefore,

[9] This amount only includes land used for cattle ranching within the study site, total cattle land including land borrowed or rented outside the study site amounted to 595.88 ha.

coffee provides the highest returns possible and largely determines the overall opportunity costs of water conservation at the study site.

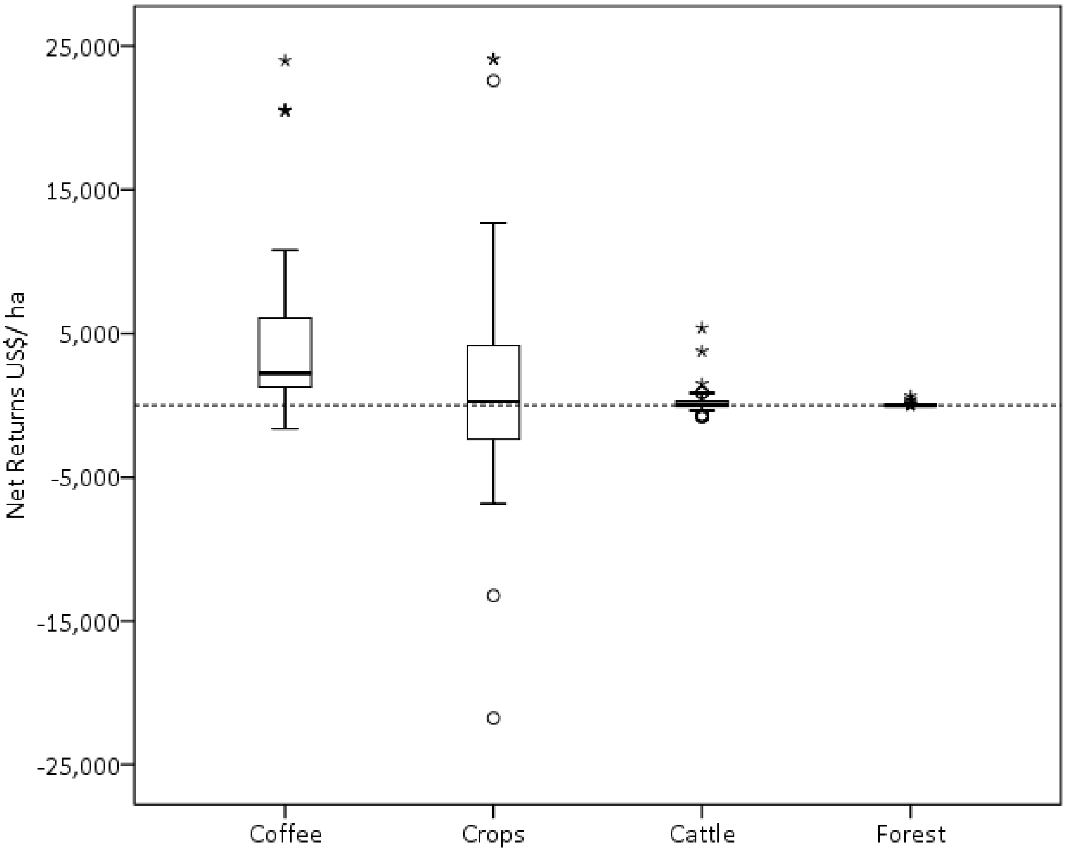

Figure 6.1. Net returns in US dollars ha^{-1} for each productive land use for the year 2010-11 at the study site; dotted line= origin 0; stars/circles= outliers as defined by IBM SPSS statistics 20 software; bold lines= median; forest N= 52, mean= US$35, median= 0; cattle N= 48, mean= US$ 282, median= US$ 44; crops N= 58, mean= US$ 1,501, median= US$261; and coffee N=28, mean= US$ 5,710 and median= US$2,248.

The mean overall net returns ha^{-1} using the flow approach is US$ 1,410 and the median is US$ 19 per hectare (Table 6.4). The flow estimates are skewed by the high coffee returns and by the negative returns of land uses making a loss and the zeros from non-used forests. Although the negative values reflect real market dynamics, they introduce high variance into the data, only represent the study year and provide an unrepresentative median. Hence, two variations of the flow approach are estimated, flow+, that only includes positive values and flow+ woc, that excludes coffee values. The flow+ and flow+ woc medians are a better comparison to the three rent values.

The rent approach is based on three per hectare values stated by respondents for each land plot: how much a landholder would rent land (R1), would sell land (R2), and actual purchase price (R3). The rent values revealed means that are substantially lower than those of the flow and flow+ estimates. However, the flow+ median is within the range of all three rent median values. Furthermore, the standard deviations show that, as expected, the flow estimates have the most variability of all measures and R1 is the least variable.

Table 6.4. Descriptive statistics of net returns ha^{-1} in US dollars with the flow and rent approaches. Note: flow estimates are per land use and include forest zeros; all R's included once, no matter how many land uses per plot; mean, median, minimum and maximum rounded to zero decimals to enhance clarity.

Values	N	Mean	Median	SE	SD	Range
Flow	186	1,410	19	402.86	5,494.21	- 21,757 – 24,086
Flow+	139	2,666	263	459.08	5,412.46	0 – 24,086
Flow+ woc	113	1,839	140	409.04	4,348.16	0 – 24,086
R1	39	245	151	38.72	241.83	4 – 1,134
R2	74	546	397	58.82	506.02	15 – 2,977
R3	56	425	160	92.97	695.74	1 – 2,977

Although the mean per hectare differs widely between estimates, it is possible that the approaches deliver estimates that are correlated, i.e. land plots with high value estimates in one approach also tend to have high estimates in the other approach and vice versa. A two-tailed Spearman's correlation of net returns per land use showed that all the rent values were significantly correlated (Table 6.5). This indicates a consistent response by landholders across the three rent values. Although the flow returns are not correlated to the rent values, flow+ and flow+ woc returns are (Table 6.5). The flow and rent estimates are therefore considered valid measures of landholders' opportunity costs.

Careful consideration has to be taken over choosing the most appropriate measure, as the flow and flow+ means provide annual estimates of over US$ 2 million for water conservation at the study site. These estimates are extremely high due to mean values influenced by outlying opportunity costs and are unlikely to represent long-term costs. Therefore, to take account of long-term variability the more representative flow+ median could be used. However, the effect of the extremely high opportunity costs of coffee, due to having an atypical good year, needs to be considered also. Thus, the flow+ woc estimate, excluding coffee, is used and is found to have stronger correlations with all rent values. The flow+ woc estimate provides a greatly reduced, but more realistic, cost of water conservation at the study site of US$ 257,057, which is comparable to totals obtained from R1 (US$ 278,308) and R3 (US$ 294,896), but less so for R2 (US$ 731,711).

Table 6.5. Spearman rho correlations of R1, R2, R3, Flow, Flow+, and Flow+ woc estimates. *** 0.01 significance level, ** 0.05 significance level

Spearman's rho		**R1**	**R2**	**R3**	**Flow**	**Flow+**	**Flow+ woc**
R1	rho	1.00	0.52***	0.51***	0.03	0.36***	0.39***
	N	86	86	67	82	64	61
R2	rho		1.00	0.47***	0.07	0.39***	0.43***
	N		146	106	139	104	84
R3	rho			1.00	- 0.03	0.24**	0.28**
	N			122	116	85	68
Flow	rho				1.00	1.00***	1.00***
	N				186	139	113
Flow+	rho					1.00	1.00***
	N					139	113

These results make sense as the flow values highlight local land use variability for the study year, while the rent values represent the more long-term average and variability. R1 or the would rent value is the equivalent of a stated WTA for setting-aside land without losing ownership or potential non-use benefits, R2 or would sell is the price of forfeiting all future streams of income and nonmarket benefits from the land, and R3 is an actual market transaction that reveals the market value, although land degradation or other factors may have reduced its value since purchase. Thus, R1 is a more comparable measure of opportunity costs for a land set-aside PES scheme in relation to the flow+ woc net returns.

6.3.3 Opportunity Cost Determinants

Opportunity costs can be associated with the landholder, biophysical and land use characteristics. To understand the factors associated with high and low opportunity costs, flow net returns were assessed per landholder, per plot, and by presence of each land use. A two-tailed Spearman's rho showed significant correlations between landholder net returns ha^{-1} (n = 59) and number of plots used (ρ = 0.412, p = 0.00), and number of land uses (ρ = 0.459, p = 0.00). Mann Whitney U Tests were conducted to compare the landholder opportunity costs to gender and the presence of each land use (i.e. categorical independent variables). There was only a significant difference in opportunity costs between farmers without coffee (median = 0.00, n = 36) and with coffee (median = 23,718.48, n = 23; U = 223, z = - 2.97, p = 0.00, r = - 0.39). Thus, higher opportunity cost landholders are more likely to grow coffee, use more plots of land and employ more land uses.

A two-tailed Spearman's rho was also applied to examine associations between plot net returns ha^{-1} (n = 75) and several variables, revealing a significant negative correlation with elevation (ρ = - 0.29, p = 0.01). Mann Whitney U Tests were also conducted to compare the plot opportunity costs to the presence of each land use, accessibility to the plot throughout the year and location. There was a significant difference in opportunity costs between plots with coffee (median = 28,727.52, n = 29) and without coffee (median = 282.64, n = 60; U = 388, z = - 4.22, p = 0.00, r = - 0.45); and between plots with access throughout the year (median =2,607.64, n = 59) and those without access throughout the year (median = 23,843.25, n = 28; U = 572.5, z = - 2.3, p = 0.02, r = - 0.25). Thus, higher opportunity cost plots are more likely to be located at lower elevations, without access throughout the year and, as mentioned above, have coffee.

Binary logistic regression was performed to assess the impact of five variables (elevation, time to road, access, time to water, and slope) on the likelihood that respondents would report growing coffee, crops and cattle. The full model for coffee was statistically significant, χ^2 (6, n = 101) = 65.19, p = 0.00, indicating that the model was able to distinguish between respondents who reported growing coffee and those that did not. The model as a whole explained between 48% (Cox and Snell R^2) and 74% (Nagelkerke R^2) of the variance in presence of coffee, and correctly classified 92% of cases. As shown in Table 6.6, four of the independent variables were significant predictors of the presence of coffee; the strongest were elevation and access (odd ratios of 0.99 and 0.04 respectively). This indicates that for every meter above sea level, respondents were 0.99 times less likely to report coffee; and if respondents reported access to their land throughout the year, they were 0.04 times less likely to report coffee, controlling for all other variables in the model. Likewise, for every minute farther from the road, respondents were over 1 time more likely to report coffee than those who were closer to the road; and for every minute farther from water, respondents were 0.73 times less likely to report coffee than those who were closer to water.

Table 6.6. Binary logistic regression predicting the likelihood of growing coffee. Note: slope 0 = flat, 1 = medium, and 2 = steep; *** 0.01 significance, ** 0.05 significance and * 0.10 significance level.

Variable	B	S.E.	Wald	df	Odd Ratios	95% C.I. for EXP(B)	
						Lower	Upper
Elevation	- 0.01***	0.01	6.88	1	0.99	0.98	1.00
Time to road	0.02*	0.01	2.99	1	1.02	1.00	1.04
Access (1)	-3.15***	1.03	9.33	1	0.04	0.01	0.32
Slope (0)			0.22	2			
Slope (1)	20.51	6,95 2.08	0.00	1	8.08E+8	0.00	
Slope (2)	20.97	6,95 2.08	0.00	1	1.28E+9	0.00	
Time to water	- 0.32**	0.16	4.02	1	0.73	0.53	0.99
Constant	0.89	6,95 2.09	0.00	1	2.45		

The binary logistic regression to predict the likelihood of reporting crops was statistically significant, χ^2 (6, n = 101) = 37.01, p = 0.00, indicating that the model was able to distinguish between respondents who reported growing crops and those that did not. The model as a whole explained between 31% (Cox and Snell R^2) and 42% (Nagelkerke R^2) of the variance in presence of crops, and correctly classified 75% of cases. As shown in Table 6.7, four independent variables were significant predictors of the presence of crops, the strongest was time to water (odd ratio of 1.10). This indicates that for every minute farther from water, respondents were more than 1 time more likely to report crops, controlling for all other variables in the model. Similarly, for every meter above sea level, respondents were 1 time more likely to report crops; for every minute farther from the road, respondents were over 1 time less likely to report crops than those who were closer to the road; and if respondents had a land use on steep terrain, respondents were 0.21 times less likely to report crops than those not reporting steep terrain.

Table 6.7. Binary logistic regression predicting the likelihood of growing crops. Note: slope 0 = flat, 1 = medium, and 2 = steep; *** 1% significance, ** 5% significance and * 10% significance level.

Variable	B	S.E.	Wald	df	Odd Ratios	95% C.I. for EXP(B)	
						Lower	Upper
Elevation	0.00*	0.00	3.24	1	1.00	1.00	1.01
Time to road	- 0.01*	0.01	2.89	1	0.99	0.98	1.00
Access (1)	0.64	0.72	0.80	1	1.90	0.46	7.82
Slope (0)			2.84	2			
Slope (1)	- 0.41	0.61	0.45	1	0.66	0.20	2.21
Slope (2)	- 1.59*	0.95	2.81	1	0.21	0.03	1.31
Time to water	0.09***	0.03	8.99	1	1.10	1.03	1.16
Constant	- 4.97**	2.56	3.76	1	0.02		

The binary logistic regression to predict the likelihood of reporting cattle was statistically significant, χ^2 (6, n = 101) = 15.31, p = 0.02, indicating that the model was able to distinguish between respondents who reported growing cattle and those that did not. The model as a whole explained between 14% (Cox and Snell R^2) and 19% (Nagelkerke R^2) of the variance in presence of cattle, and correctly classified 67% of cases. As shown in Table 6.8, two of the independent variables made a statistically significant contribution to the model. The strongest predictor of reporting cattle is accessibility, if respondents had access to their land throughout the year, they were more than 4 times more likely to have cattle, controlling for all other variables in the model. Similarly, for every minute farther from water, respondents were 0.94 times less likely to report cattle.

Table 6.8. Binary logistic regression predicting the likelihood of having cattle. Note: slope 0 = flat, 1 = medium, and 2 = steep; *** 1% significance, ** 5% significance and * 10% significance level.

Variable	B	S.E.	Wald	df	Odd Ratios	95% C.I. for Odd Ratios	
						Lower	Upper
Elevation	0.00	0.00	0.29	1	1.00	1.00	1.00
Time to road	0.00	0.01	0.41	1	1.00	.99	1.01
Access (1)	1.40**	0.62	5.16	1	4.07	1.21	13.66
Slope			1.49	2			
Slope (1)	- 0.70	0.58	1.49	1	0.50	0.16	1.53
Slope (2)	- 0.54	0.74	0.53	1	0.58	0.14	2.49
Time to water	- 0.06**	0.03	5.09	1	0.94	0.89	0.99
Constant	- 1.99	2.32	0.74	1	0.14		

Thus, the available variables to predict the presence of each productive land use best explain the presence of coffee, followed by crops and, to a lesser extent, cattle. At the study site, there is a greater probability of finding coffee at lower elevations, in areas without access throughout the year, farther from the road and closer to water. The presence of crops was more likely farther from water, at higher elevations, closer to the road and on flat to medium slope land. The presence of cattle was more likely on land with access throughout the year and close to water.

6.4 Discussion

The analysis of opportunity costs brings to the fore several issues that may arise when assessing the cost distribution of water service provision. First, identifying providers is challenging due to their spatial distribution and heterogeneity, i.e. also being beneficiaries of the service, residing far away from their land plots, owning several dispersed plots, and plots located in remote and hard to access areas. Second, determining the opportunity costs of providers is complex due to different land uses, market and social dynamics. Third, many people are unlikely to respond accurately, if at all, to questions regarding their economic affairs, e.g. household income.

An important contribution of this chapter is the use of two different approaches to estimate the opportunity costs of water conservation. The flow approach provides detailed insight into local micro level variability, market dynamics, and the influence of individual land user groups. The rent approach provides a less detailed, but longer-term and stable view excluding the effect of extreme, market dynamics. The use of both approaches adds confidence and robustness to estimates and consequently the claims made based on those estimates.

6.4.1 The Cost of Water Provision

The opportunity costs obtained represent the cost of improving drinking water quality through watershed conservation. Despite the Reserve's strict management category, private land opportunity costs within the Reserve reach extremely high values. The average flow net returns ha^{-1} for all land uses is US$ 1,410, mainly due to the good year for coffee growers and the losses experienced by crop and cattle farmers. This estimate is quite high and seems to be at the upper margin of other studies. For instance, Fisher et al., 2011c) found a mean of US$ 1,188 ha^{-1} from government census data for Tanzanian agriculture. Naidoo and Adamowicz, 2006) report net benefits of US$ 770 for smallholder agriculture and US$ 1,124 for cattle ranching at the Mbaracayu Biosphere Reserve in Paraguay based on secondary sources.

Some studies report extreme opportunity costs ranging between US$ 2,247 - 12,750 ha^{-1}, but they are often due to highly commercial cash crops such as oil palm, logging and soybean (Naidoo and Adamowicz, 2006; Bottcher et al., 2009; Börner et al., 2010; Fisher et al., 2011b). The average net returns of US$ 5,710 for coffee is within this range as a cash crop with high local and national importance, e.g. coffee is the main agro-export of Honduras and the study site (IHCAFE, 2012). For the study year, coffee was being bought in the international market at the highest price ever in the last ten years, at four times the lowest price (NASDAQ, 2014). Thus, the effect of coffee returns on the overall returns is evident, further seen when excluding coffee from the flow estimates. Vegetable crops can reach similar high values to coffee, as observed in Figure 6.1, but are riskier because losses are excessive due to high transaction costs associated with market access and substantial upfront investments (as observed in the inputs reported by crop farmers in comparison to the other land uses; Blandon et al., 2009; Hellin et al., 2009).

The flow average estimates are clearly high, thus the use of median values is required to obtain more long-term and stable measures. The median flow+, flow+ woc and rent net returns are in line with the opportunity costs reported in the literature for similar land uses. A large amount of studies report values ranging between US$ 39 and 509, for forested areas, cattle ranching, and different types of crops in developing countries (Cacho et al., 2005; Chomitz et al., 2005; Börner and Wunder, 2008; Wünscher et al., 2008; Bottcher et al., 2009). Thus, an average median estimate obtained from the would rent values (R1) and flow+ woc, US$ 145, is believed to be a valid and accurate measure of the overall cost of water conservation for one hectare of land at the study site.

Determining the opportunity costs of ecosystem service providers is essential for a PES scheme. However, the identification of a reliable, sufficiently accurate and cost-effective method to determine micro level opportunity costs is a complex and challenging process (Wünscher et al., 2011). At the study site two methods were applied. The flow approach required substantial assumptions (e.g. value of time), costly data collection and was time-consuming. Adjustments had to be done to account for one-off variability in the flow estimates and substantial knowledge of the local context was needed. The rent approach on the other hand is quite inexpensive, only required adjusting land values to 2011 values and needed to come from a reliable source. So, although several issues had to be considered carefully in order to estimate opportunity costs, both methods seem to be appropriate for areas where data is unavailable and opportunity cost heterogeneity is a key issue for conservation strategies. Both methods applied to determine opportunity costs provided valid and correlated estimates. This indicates that, in this case, the choice of opportunity cost method should not influence the general pattern of opportunity costs distribution obtained.

6.4.2 Cost Distribution and Implications for PES Scheme Contracting

As described in chapter 4, a PES scheme scenario was developed and proposed for the study site. This scheme proposed paying landowners for land purchase or land set-aside in order to ensure water conservation. Land purchase is costly and not all landholders are likely to be willing to sell (it also does not constitute a PES scheme); and land set-aside is more attractive to landholders. So, it is important to determine what are the opportunities and challenges of providers entering into potential contracts (Michael, 2003; Knight et al., 2011; Raymond and Brown, 2011) for a land set-aside PES scheme. Efficient schemes should ensure the compensation of upstream landholders should be at least equal to the opportunity costs of the promoted land use and the amount of the payment should be lower than the economic value of the environmental externality (Kosoy et al., 2007). However, exactly how this compensation will be or can be distributed among providers is a fundamental challenge in PES scheme design.

A particular concern that arises for contracting providers at the study site is the duality of providers being beneficiaries. This duality could be interpreted as an opportunity or a challenge for contracting, as it will have a lot of influence on providers' willingness to enter into contracts. It could be an opportunity if providers knowing the effect of upstream activities on their drinking water quality (as beneficiaries) may influence them in favour of more conservation-oriented activities on their land. On the other hand, it could be a challenge if providers' priority is land use and profit despite the water contamination suffered by themselves and other beneficiaries. A split between these two views exists at the study site, evident in the WTP results (see chapters 4 and 5). Thus, this is a reality that a potential PES scheme will have to deal with and could work in favour of securing the acceptance of the scheme. Generally water services are seen as providing directional benefits, where the service provision benefits a specific location due to the flow direction, but here we see that also in situ benefits are generated, where the services are provided and the benefits are realized in the same location (Fisher et al., 2009). The implications of this setting, a complex upstream-downstream framework, for PES scheme contracting is further discussed in chapter 7.

Another important concern for PES scheme contracting is land tenure security by service providers. Land tenure was reported to be formally secure and control over used land is quite effective at the study site. The PES literature highlights the importance of formal legal tenure over land for the successful contracting of providers (e.g. Bremer et al., 2014; Naughton-Treves and Wendland, 2014), but the challenges of monitoring legally owned non-used land have been less discussed (e.g. Kroeger, 2013; Segerson, 2013). The non-used land or forest land, especially public land in and around the Reserve, is hard to control and is often entered for extractive activities despite legally established land-use restrictions. If a land set-aside PES scheme were implemented it would require providers to guarantee the exclusion of others from modifying the service quality and provision on their land, often in remote areas. It would seem cost-effective to secure forested areas with low opportunity costs for water conservation; as the NGO AESMO has done so far through land purchase. However, controlling access to these areas is currently an issue for AESMO as the archaic approach of fencing has been implemented recently with little success. Thus, if this exclusion is possible, how it will be achieved and how it will be monitored are major concerns for contracting in PES schemes, especially for agricultural non-point pollution.

Opportunity costs at the study site varied among landholders depending on several landholder, plot, and land use characteristics. The literature generally agrees that with certain land uses and tenure, as slope and altitude increase, with higher precipitation, in poorer soils, as time increases to the main road and as farmers age, then associated net returns diminish (Chomitz et al., 2005; Naidoo and Ricketts, 2006; Wünscher et al., 2011). Some of these variables were excluded from analysis due to homogeneity (e.g. secure land tenure) or unavailable local scale data (e.g. precipitation). Although at the study site some characteristics do correspond with the above literature conclusions, this is not entirely so, with some unexpected findings.

The three main variables that are most likely to explain cost distribution at the study site are coffee plantations, number of land uses and number of plots used. The two novel variables of number of plots and number of land uses have rarely, if at all, been reported in the literature. These variables are somewhat related to each other and most likely represent proxies for farmers' wealth and/or entrepreneurship at developing diverse farming portfolios. For instance, farmers that can afford to have several plots on which to have the highly commercial cultivars of coffee and crops and also the locally important cattle ranching, will be better off than those limited to one plot or one land use. Also, farmers with more land plots and more land uses will be financially secure or at least less affected by the dip in market prices, such as was the case of crops and cattle during the sudy.

High opportunity cost coffee plots, generally small in size, tend to be located in remote and inaccessible areas, at lower elevations and closer to water compared to other land uses. This contrasts Wünscher et al., 2011) that claimed that all year accessibility with good road conditions and low transportation costs increase productive land use returns. It also indicates a possible threat to lower water sources due to their location close to water despite not requiring irrigation. So, although coffee can provide the highest returns, it is generally located at lower elevations and will not affect the upper water sources. It also means that they are likely to be located in the buffer zone of the Reserve which has laxer conservation legislation and allows for managed land uses. Coffee is also likely to have less impact on water quality than other land uses at the study site because of the lower use of herbicides and pesticides reported by respondents compared to crop cultivation. In addition, due to their remote and inaccessible location coffee plots would be harder to monitor if a PES scheme were implemented. So, if only coffee were considered for a PES scheme, water conservation would be prohibitively costly, would only protect a small mid- to downstream area, and would likely encounter lots of opposition from locals. All these attributes indicate that coffee would be too costly to cover with a PES scheme and needs to be managed in a different way from other land uses.

Vegetable plots, generally small in size, are the second highest opportunity cost land use and are likely to be located farther from water, closer to the road, on flat or medium slope terrain, and at higher elevations. The probability of crops being located farther from water is hard to explain as irrigation during the dry season was reported for crops, but they are favoured by the high levels of precipitation and cooler climate at the higher elevations were they are also located. This means that vegetable plots are mostly located in the core zone of the Reserve, conflicting with the zoning requirement of strict conservation. Vegetable production also has a heavy dependence on herbicides and pesticides (as reported by farmers in the opportunity cost survey in comparison to coffee; Moreno Mena and Lopez Limon, 2005; Prasannath and Prasannath, 2013) and the pollution due to these agrochemicals is likely to be enhanced by the runoff that high precipitation generates in the area. Both an upstream location and the heavy use of agrochemicals mean that vegetable crops are very likely to negatively affect water sources throughout the watershed. If only crops were considered for a PES scheme, water conservation would seem quite costly, and only a small but important proportion of the watershed would be protected.

Similar to the crop findings, most forested land is also located at higher elevations in the core zone of the Reserve due to private initiative and the NGO’s conservation efforts. This is a good starting point for further conservation in the core zone where strict conservation is required and where several water sources are found. Although not covered in this study due to time constraints, it is important to study the condition of these forests (i.e. degradation) and its impact on water quality.

Cattle ranching are one of the lowest opportunity cost land uses; it is generally carried out in large plots with access throughout the year and close to water. Thus, this subsistence and locally commercial land use is more widespread throughout the study site, at different elevations and on varied terrain, due to less land requirements. A widespread distribution of cattle ranching plots is also favoured by the extensive availability of water at the study site. Thus, cattle are likely to affect water sources due to their presence in varied locations, their use of streams for drinking which creates erosion, and contaminating water sources via animal faeces. However, if only cattle were considered for a PES scheme, water conservation would seem inexpensive and feasible. Thus, all land uses at a watershed need to be considered to accurately measure true opportunity costs, considering their distribution, to place conservation costs proportionately on all providers (Adams et al., 2010).

Often the most profitable land use is used as a basis to determine opportunity costs (Pirard, 2008). In the case of the study site this would mean applying the extremely high opportunity costs obtained from coffee to the entire area. However, if limited rationality is assumed for landholders and there are barriers to its realization (i.e. land is unsuitable), this is likely not the case. The findings for the study site show that each upstream hectare cannot be assumed to have the same opportunity cost or ecosystem service level due to differing location of plots in relation to water sources, the land use, and landholder and land characteristics. It is commonly suggested to discriminately align payments with opportunity costs, which is hugely cost-effective and more equitable, allowing the conservation of more land and spreading resources across a greater number of providers (Börner et al., 2010). Determination of appropriate payment for providers and its differentiation in a PES scheme has always been challenging and complex. However, at the study site this approach seems financially and practically unfeasible due to the inequity in opportunity costs across landholders and land uses, particularly where highly commercial cash crops are cultivated. Any PES scheme would need to consider any inequities that might arise for landholders for ethical and practical reasons, as inequities can generate opposition to the scheme.

Balmford and Whitten, 2003) highlight the importance of understanding how much land can be removed from production while still allowing income growth. Both cash crops at the study site, coffee and crops, cover a small proportion of land. However, crops seem to have an overall greater negative impact on water quality than coffee. Thus, a PES scheme, backed by the enforcement of conservation laws, might be the appropriate incentive for crop farmers in the core zone of the Reserve to set-aside land for water conservation to reduce one of the largest contaminating activities. PES scheme contracting would be better aimed at high environmental impact land uses, such as crops, and mid- to low-value agriculture, such as cattle ranching, where payments might provide enough incentive for water conservation.

Furthermore, due to the instability of coffee prices and the need to maintain income growth, sustainably managed coffee schemes could be encouraged in the area. This would be a more feasible approach to manage this high opportunity cost land use and at the same time safeguard water sources. Importantly, the availability and access to markets that are crucial for agricultural export crops such as coffee (Balat et al. 2009), already exist at the study site. Also, coffee growing is carried out by only a third of landholders and covers a small proportion of land which is unlikely to change much due to land unsuitability. Therefore, if coffee plantations are excluded from PES scheme contracting, which only cover 10% of land, the opportunity cost amounts to less than a fourth of the initial estimate (US$ 257,057 per year).

Within the above contracting proposal, subsistence and low income farmers would be included in the providers to be contracted. Poor farmers that depend on the purchase of basic food goods could live off payments aligned with their opportunity costs. Also, the annual and seasonal instability of agriculture net benefits might be another factor influencing farmers, especially poor ones, to contract in a water conservation scheme with a permanent, stable income. However, the opportunity costs of subsistence farmers might not adequately provide for a household to move and buy another parcel of land elsewhere, especially if the cost of land is high.

Therefore, mobility and access to resources need to be considered carefully to avoid detrimental effects on these stakeholder groups (McClanahan et al., 2008; Cinner et al., 2009). One way of dealing with this challenge is to promote sustainable income alternatives in the area (Balmford and Whitten, 2003).

Finally, it is important to acknowledge that more global, temporal and spatial feedbacks could affect the returns of farmers and their distribution (Wells, 1992; Chan et al., 2007; Tallis and Polasky, 2009). For the study year coffee prices were high and cattle and crops were low. However, if these prices remained the same or altered (increased or decreased), land use dynamics might change and the cost distribution with them. Thus, where data is available, as was not the case at the study site, these long-term feedbacks should be analysed in future research.

6.5 Conclusions

The cost of water conservation through a land set-aside PES scheme was estimated with the opportunity cost flow approach and the rent approach. An overall flow net return ha^{-1} of US$ 1,410 was obtained, with coffee and crops contributing the highest values, followed by cattle and forest use. However, due to the spread of the data and the losses reported, the median positive returns without coffee (flow+ woc), US$ 140, are used as more stable and realistic values. On the other hand, the median rent values ranged between US$ 151 – 397, were correlated between themselves and with the flow+ woc. The flow+ woc estimate provides a cost for water conservation of US$ 257,057 for the entire study site, which is comparable to totals obtained from the landholder would rent values (R1) and the actual purchase price (R3). These results make sense as the flow values highlight local land use variability for the study year, while the rent values represent the more long-term average and variability. Identifying a reliable, sufficiently accurate and cost-effective method to determine opportunity costs has always been challenging and complex. However, at the study site the two methods employed to determine opportunity costs provided valid and correlated estimates.

Two main concerns arise for contracting providers in a PES scheme at the study site, the duality of providers being beneficiaries also and the challenges of monitoring set-aside land. Furthermore, the distribution of opportunity costs was analysed for landholders, plots and by presence of each land use. Landholder net returns are correlated to the presence of coffee, number of plots used, and number of land uses. Plot net returns are correlated with altitude and coffee. Binary logistic regressions showed that the presence of coffee was more likely to be found at lower elevations, with limited access throughout the year, farther from the road, and closer to water. Crops were more likely to be located farther from water, at higher elevations, close to the road, and on flat to medium sloped terrain. Cattle was more likely to be found with access to their land throughout the year and close to water. These results evidence the greater effect of crops and cattle on water quality, due to location and other attributes.

The high value of coffee means that a PES scheme probably will not provide enough incentive for coffee growers to engage in land set-aside for water conservation. Also, coffee has many other attributes, such as being the main source of employment and having a smaller effect on water quality, that indicate that sustainable coffee schemes encourage income growth in the area. Thus, PES scheme contracting, backed by the enforcement of conservation laws, is best aimed at high environmental impact land uses and mid- to low-value agriculture where a PES scheme might provide enough incentive for water conservation and the most damaging land uses are included. Therefore, if coffee plantations, covering a small proportion of the study site, are excluded from contracting in a PES scheme, the mean opportunity cost amounts to US$ 257,057 per year. This amount proves more manageable for conservation practitioners to secure funds for contracting providers.

Chapter 7: Discussion

There is a growing interest in the economic side of conservation, and costs and benefits need to be understood to estimate the value of conservation lands and their services (Naidoo and Ricketts, 2006). In most cases, these benefits and costs are both poorly understood and quantified (Costanza, 2000), and they are not evenly spread over all people, places and time (Arrow et al., 2000; Chan et al., 2007).Thus, it is important to understand what the costs and benefits of a conservation policy are, how they are distributed, and the factors influencing this distribution and subsequent equity outcomes.

The aim of this thesis is to assess the costs and benefits distribution of a potential PES scheme for clean drinking water in Honduras. In order to achieve this aim, the specific objectives of this thesis are (1) to determine the costs and benefits of drinking water quality use in fifteen rural communities, their distribution and the factors determining this distribution; (2) to analyse how the distribution of costs and benefits may influence contracting Payment for Ecosystem Services schemes; and (3) to contribute to the understanding of different economic valuation methods and their use to determine the costs and benefits of ecosystem services.

The first and second objectives of this thesis are met by the three previous chapters covering two different measures of benefits (stated and revealed WTP, chapters 4 and 5 respectively) and costs (flow and rent opportunity costs of landholders; chapter 6) of improving drinking water quality. This chapter also contributes to objectives 1 and 2 by summarising the findings reported in the three previous chapters and further expanding on the benefits of water conservation (section 7.1), the costs (7.2) and the resulting financial feasibility of a PES scheme (7.3). Some key distributive issues that arise in this thesis are subsequently discussed (7.4), including the complex externalities framework, imperfect information, unequal water governance and fairness in targeting providers. These issues contribute to meeting objective 2 on analysing how the distribution of costs and benefits may influence equity. Objective 3, addressing the use of different methods to determine the costs and benefits of ecosystem services, is addressed in chapter 6 (estimating opportunity costs with the flow and rent approaches) and here, by discussing the use of stated and revealed approaches to estimate WTP measures (7.1). The chapter concludes discussing the implications of the results for PES scheme design (section 7.5) that brings together objectives 1 and 2.

7.1 Benefits of Water Conservation

The extensively used stated preference method of contingent valuation was applied to determine household WTP for a PES scheme that would improve drinking water quality. Contingent valuation responses to a well-designed survey question are usually assumed to be an unbiased measure equal to WTP (Laughland et al., 1996). This stated preference method offers many advantages, such as allowing a better control over the valuation scenario to measure ex-ante WTP, contributing insights into the feasibility of proposed projects and policies and is the only valuation technique for measuring altruism toward the health of others and other passive use values related to drinking water quality (Whitehead and Van Houtven, 1997). It is also expected to include the pain, suffering and lost leisure time linked to illness in the case of contaminated drinking water (Alberini and Krupnick, 2000). In this thesis the monthly WTP obtained per household with the contingent valuation survey was US$ 0.77.

Contingent valuation has infrequently been estimated alongside, and contrasted with, other valuation methods. Choe et al., 1996) applied contingent valuation and travel cost method to estimate the value that people in the city of Davao in Philippines, place on improving the water quality of rivers and the sea. The authors found that both estimates are very close to each other and are quite low, both in absolute terms and as a percentage of household income. Haq et al., 2007) used contingent valuation to estimate the WTP for a continuous and potable water supply and averting behaviour for water quality improvement in the district of Abbottabad, Pakistan. Findings mention that both methods revealed household WTP for improved water services and to adopt averting behaviour, but no comparison between the methods was attempted. In a different approach, Rosado et al., 2006) estimated WTP for drinking water quality in Brazil by combining averting behaviour and contingent valuation data, looking at two covariates, income and bid, to explain variance. The authors found that a common underlying preference structure behind the stated preference and the revealed preference data determines when a linear utility function was used, but significant differences between the two WTP estimates were found. Research into the relationships between contingent valuation and other valuation methods is still limited and needs to be further addressed as results have differed. This section presents and compares the WTP estimates obtained with a stated preference approach and a revealed preference approach.

The economic value of safe drinking water specifically includes changes in expenditure and well-being, such as medical costs, lost earnings, and defensive expenditure (Whitehead and Van Houtven, 1997; Haq et al., 2007). These values were estimated at the study site using the revealed preference approaches of averting behaviour and illness damage costs. These methods allow valid estimates of willingness to pay as they are based on actual choices built on perceived costs and benefits which better reflect the values of the population (Whitehead and Van Houtven, 1997; Whitehead et al., 2008).

The averting behaviour method is the most popular revealed preference approach to valuing safe drinking water as it more accurately estimates WTP values over other methods (Laughland et al., 1993; Whitehead and Van Houtven, 1997; Um et al., 2002). In order to avoid contaminated water, households carry out averting behaviours involving home water treatment or the purchase of bottled water. In cases when averting actions are not taken or are not efficient, households might incur costs to treat water borne illness. Jalan and Somanathan, 2008) found that averting expenditure probably provides only partial protection from unsafe water so it represents an incomplete measure of WTP. Therefore the true benefits associated with improvement in water quality equal the change in averting expenditure plus illness damage costs and the net direct disutility of illness (Harrington and Portney, 1987; Pattanayak et al., 2005; Jalan and Somanathan, 2008). In this thesis the monthly revealed WTP obtained per household by summing averting expenditure and illness damage costs, amounts to US$ 1.22. This estimate reflects households' true WTP for clean drinking water, after controlling for joint production of bottled water.

The estimates of household WTP obtained from the analyses of the contingent valuation and the revealed preference data were in the same order of magnitude. Overall, this increases the confidence that the general magnitude of the estimates of household WTP for water quality improvements is correct. Respondents seem to be underestimating their stated WTP by 60% compared to the revealed WTP. Harrington and Portney, 1987) demonstrated that the sum of changes in averting expenditure and illness damage costs might underestimate or overestimate WTP. The revealed WTP measure reported in this thesis would increase further if the monetary value of illness disutility is included (i.e. pain, suffering and lost leisure time) and if more information on health is provided to households, e.g. Jalan and Somanathan, 2008) found that providing information increases averting expenditure by 11%. The common perception that stated preference methods grossly overstate what people are willing to pay does not seem to be supported by this analysis.

A Spearman's correlation applied to the two non-normally distributed WTP estimates showed that there is no correlation between the stated and the revealed WTP. Furthermore, the results of a Friedman test indicates that there was a statistically significant difference between the two values X^2 (1, n = 352) = 38.44, $p < 0.01$) with a lower ranking mean for the stated WTP. The lack of correlation between the stated and revealed WTP means that the averting expenditure or the damage costs do not vary with, or are not nearly as responsive as the stated WTP, to the determinants of WTP (Laughland et al., 1996). Urama and Hodge, 2006) did find a strong correlation between stated WTP and averting expenditure, suggesting that these two measures relate to the same theoretical construct. Furthermore, most studies agree that averting expenditure is capable of yielding conceptually valid estimates of costs of environmental pollution and serve to inform policy alternatives (e.g. Abdalla et al., 1992). However, the results from this thesis support the literature explaining that in practice it is difficult to estimate averting behaviour and thus obtain a true revealed WTP. For averting behaviour to produce an exact welfare measure it would have to: (i) lack jointness in production, (ii) its rise would guarantee improved water quality, (iii) its change must be entirely due to a change in water quality, (iv) it is the final household good not the inputs used to produce it, and (v) it should enter directly into the consumers utility function (Bartik, 1988; Hanley et al., 1999; Abrahams et al., 2000).

The comparison of the stated and revealed WTP estimates also serves to test the criterion and convergent validity of the contingent valuation method. Criterion validity compares CV estimates either to a measurement that is external to the CV study, or to a behaviourally-based measure that directly represents the construct under investigation. This is considered the surest way to assess the validity of a stated preference measure. Convergent or construct validity investigates the consistency of CV estimates with estimates provided by another nonmarket valuation method (Brown, 2003). The findings reported here indicate that there is no convergence between the two methods, so neither the stated WTP nor the revealed WTP estimates are regarded as the criterion variable. Such comparisons must, however, be interpreted carefully, because the WTP estimates from the two valuation approaches are not measuring precisely the same thing. In this context, the revealed preferences approach estimates beneficiaries' actual market behaviour to avoid and treat the effects of contaminated water while the stated preferences approach reveals their intention to trade-off money for a PES scheme to improve drinking water quality.

There are several possible reasons to explain the non-correlation of these estimates, including the following: context-dependent preferences for each approach, the stated and revealed WTP values are not measures of the same construct, or one or both estimates are biased. Biases in the survey application or in timings can generate different limitations in survey results (Niemeyer and Spash, 2001; Urama and Hodge, 2006). However, the finding that the mean stated WTP was significantly lower than the mean revealed WTP makes the bias argument unlikely, as the main strength of stated approaches is the estimation of option and existence values in addition to direct use values (Bateman et al., 2002). An exception to this argument could be farmers' higher discount rates, greater risk aversion, or social conformance that could lower the stated WTP (Moser, 2001; Urama and Hodge, 2006). This is often observed for farmers or poor people that have short-term horizons, even living on a day to day basis (Holden and Shiferaw, 2002). Other reasons for under-valuation of ecosystem services can include imperfect information (in chapter 4 it was found that some respondents preferred to decide WTP in a community setting; and in chapter 5 the imperfect awareness and information on averting behaviour and water contamination is discussed), insecure land tenure (chapter 4 highlights tenure of water sources) and national government policy, among others (CAB-International, 2002). The higher revealed WTP in this study may therefore have been driven by one or several of these reasons. The researcher agrees with Urama and Hodge, 2006) and Choe et al., 1996) in that even though the revealed and stated approaches are conceptually similar based on the utility preference theory, they are contextually different being based on different market scenarios where respondents might have different preferences and hidden joint preferences (such as the joint production of bottled water accounted for in chapter 5).

7.2 Costs of Water Conservation

Cost-effective and precise estimation of site-specific opportunity costs is a major challenge (Wünscher et al., 2011). Many approaches have been used in the literature to estimate opportunity costs for PES schemes and other conservation initiatives. Some novel approaches, such as procurement PES auctions, promise to help reveal private landholders' opportunity costs (Jack et al., 2009; Khalumba et al., 2014). However, this thesis was limited in the methods that could be applied by a small sample size and the lack of data availability at the study site. More comprehensive studies utilise two or more approaches in order to obtain more accurate and robust opportunity cost estimates. This is because the estimation of opportunity costs may differ considerably, depending on the method used and the assumptions adopted. In this thesis the flow and the rent approaches were used. The flow approach, commonly used in PES scheme design, uses local level net returns from agriculture in order to obtain detailed insight into the heterogeneity of landowners and variability of opportunity costs (Wünscher et al., 2011). The rent approach is based on land values, and in this thesis specifically three stated land values that potentially reflect more stable longer term values. The use of land values to determine opportunity costs is commonly used, reveals landholders' true value for land and is quite straightforward.

The flow opportunity cost obtained from landholders varied widely with an overall average of US$ 1,410 ha^{-1} and a much lower median of US$ 19 ha^{-1}. Opportunity costs varied across individual land uses, and averaged U$ 5,710 ha^{-1} for coffee, US$ 1,501 ha^{-1} for crops, US$ 282 ha^{-1} for cattle, and US$ 35 ha^{-1} for forest. However, to account for context-specific factors the median positive returns without coffee (flow+ woc) were considered valid estimates and were correlated with the median rent values ranging between US$ 151 – 397.

The opportunity costs obtained represent the cost of improving drinking water quality through watershed conservation. The average flow net return ha^{-1} for all land uses reported above seems to be at the lower margin of other studies ranging between US$ 1,124 and 12,750 ha^{-1} (Naidoo and Adamowicz, 2006; Bottcher et al., 2009; Börner et al., 2010; Fisher et al., 2011b). The higher values are often due to highly commercial cash crops, such as was the case of coffee in this thesis. The flow average estimates are clearly high, thus the use of median values is required to obtain more long-term and stable measures. The average median estimate obtained from the "would rent" values (R1) and flow+ woc (US$ 145 ha^{-1}) is in line with the opportunity costs reported in the literature for similar land uses. A large amount of studies report values ranging between US$ 39 and 509 for forested areas, cattle ranching, and different types of crops in developing countries (Cacho et al., 2005; Chomitz et al., 2005; Börner and Wunder, 2008; Wünscher et al., 2008). Thus, the opportunity cost estimates from both approaches are considered valid and accurate measures of the overall cost of water conservation at the study site. The flow approach seems to be particularly appropriate for areas where opportunity cost heterogeneity is a key issue for conservation strategies, such as PES schemes. The rent approach is potentially an inexpensive and quick way of obtaining an overall opportunity cost estimate to inform conservation policy more broadly.

7.3 Feasibility of a User-based PES Scheme

The estimated WTP for watershed protection is significant and evidence that there is demand for clean water in the area. The results suggest that a substantial proportion of households may be willing to contribute to local watershed conservation. However, this demand is currently not adequately met by the supply-side providers who are mostly private landholders involved in productive land uses. The estimated stated WTP, if all 1545 households in the study site are required to pay, would amount to US$14,276 per year, or to US$ 22,619 per year with a revealed WTP. The private land of the watershed area above the lowest water source covers 1,843 ha and would cost over US$ 2 million to protect based on the mean flow opportunity cost estimates (including negative and coffee values). Thus, a user-based scheme at the study site seems highly unfeasible.

However, the high opportunity costs of coffee mean that a PES scheme probably will not provide enough incentive for coffee growers to engage in land set-aside for water conservation. Coffee also has many other attributes, such as being the main source of employment (PNUD, 2010b) and having a smaller effect on water quality (see chapter 6), that suggest sustainable coffee schemes should be promoted to encourage income growth in the area. Thus, contracting in a PES scheme, backed by the enforcement of conservation laws, is best aimed at high environmental impact land uses and mid to low-value agriculture where a scheme might provide enough incentive for water conservation and the most damaging land uses are included. Therefore, if coffee plantations are excluded from PES scheme contracting the (flow+ woc) opportunity cost amounts to US$ 236,492 per year.

Even considering the without coffee opportunity cost estimate, one year's increase to the water bills could not cover payments for the protection of the entire watershed. The stated WTP would only cover 6% of the estimated (flow+ woc) cost of the water conservation and the revealed WTP could cover up to 10%. The cost of water conservation through land set-aside can be disaggregated further under specific land uses with the highest environmental impact. The stated and revealed WTP estimates would be able to cover 38% or 61% of cattle opportunity costs (based on median values), and 42% or 67% of crop opportunity costs, respectively. These findings reinforce the claim that a user-based scheme is unfeasible at the study site. This could change in the future if environmental awareness is advanced in the area to increase WTP, external support is obtained for a third party-based scheme, or other measures for water conservation are explored.

Table 7.1 shows the Net Present Value (NPV) of a 25-year PES scheme based on the findings at the study site, calculated with a monthly per household stated WTP (US$ 0.77) and with a revealed WTP (US$1.22) as benefits. The NPV utilises an average opportunity cost for the flow and rent approaches (US$146 ha^{-1}) as cost, excluding negative values and coffee. The use of this average assumes a uniform, stable and positive opportunity cost over time, without drops or peaks in the market. The NPV thus shows the unfeasibility of a user-based scheme with a low benefit-cost ratio between 0.05 and 0.08. In order for a PES scheme to be feasible at the study site, Table 7.1 also presents the NPV of a funded scheme, requiring US$ 252,500 external funding per year and assuming that in year ten, 10 ha are donated to conservation and from then on 1 ha per year. The funded scheme would require external funding by the government or private firms operating in the area, as well as continuous environmental education campaigns to encourage landholders to donate land to conservation. The discount rates used are based on the literature on Latin American studies (Potvin et al., 2008; Fuenzalida and Mongrut, 2010; Rondon et al., 2010). Specifically, the mid-value (6.25%) is based on the Central Bank of Honduras' annualised interest rate for 2010 (BCH, 2011).

Table 7.1. Net Present Value (NPV) of a 25 year PES scheme at the study site with estimated values and an externally funded scheme.

Assumptions		**25 Year NPV (US$)**		
		SWTP user-based scheme	**RWTP user-based scheme**	**Externally funded scheme**
Discount Rate	3%	-4,658,042	-4,504,421	14,833
	6.25%	-3,411,409	-3,298,902	**7,161**
	10%	-2,549,226	-2,465,153	2,707
Benefit-cost ratio		0.05	0.08	1.00

7.4 Distribution of Costs and Benefits

Anthropogenic activities, such as farming, fuelwood collection, and cattle ranching conducted by different stakeholders and in different ways will have varying degrees of impact on conservation. Likewise, the type, quality, and quantity of services provided by an ecosystem are affected by the resource use decisions of individuals and communities. Thus, understanding how the costs and benefits of ecosystem service use are distributed is important for conservation and needs special attention (Spiteri and Nepal, 2006; He et al., 2008). There is an obvious unequal distribution of costs and benefits of water conservation at the study site. This cost-benefit imbalance is generated due to the existence of many forms of market failure, which include: externalities, public goods, imperfect property rights, and insufficient knowledge and information (Chan et al., 2007; Engel et al., 2008; Lant et al., 2008; Paavola, 2009). In the next three subsections the main market failures that arise in this thesis are discussed.

7.4.1 Complex Externalities Framework

The general claim that drinking water is based on an upstream-downstream externalities framework is not as straight-forward as was originally thought (Van Hecken et al., 2012). The water service at the study site reveals that hydrological services can be omni-directional at a local level. Beneficiaries at the study site are not only located downstream but occur throughout the study region, including at some distance from their water sources (Figure 7.1). This dispersed spatial location of beneficiaries encourages irregular benefit distribution, especially for the more distant communities, even more so if those communities lie in a different political municipality. Access to water sources and the distance or time from beneficiary communities to water sources have been mentioned as key determinants of benefit distribution (Naidoo and Ricketts, 2006; Tallis and Polasky, 2009).

There is also an asymmetrical benefit distribution between large (downstream) and small communities (mostly in upstream areas) at the study site. Larger communities were less willing to pay for improved drinking water quality despite their vulnerable position in the externalities framework. This is probably due to the many advantages accruing to larger communities, e.g. access to alternative sources of water. Smaller communities close to water sources are more aware of water contamination and depend directly on them. Local benefit estimates such as those reported in this thesis can provide the economic value of an ecosystem service and locate the inequity or disconnection of benefits across the landscape. Understanding the distribution of costs and benefits in space can inform where management interventions should be concentrated (Chan et al., 2006; Naidoo and Ricketts, 2006; Fisher et al., 2009; Tallis and Polasky, 2009).

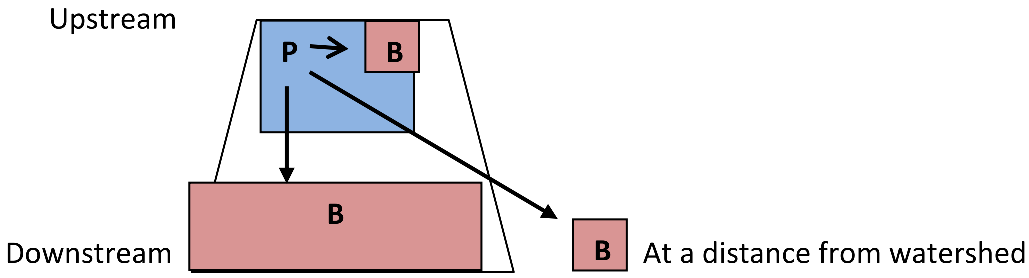

Figure 7.1. Diagram exemplifying the complex externality framework at the study site; note: P = providers and B = beneficiaries.

In this thesis, most landholders are also beneficiaries of the service which has important implications for any water conservation strategy. This duality creates a conflict of interests for landholders, who on the one hand want to ensure the continuation of their livelihoods and on the other they want to obtain clean drinking water. This duality will likely complicate decision making in a PES scheme and probably already creates conflicting dynamics in existing conservation efforts. For instance, the managers of the service at the study site are in conflict, as the NGO managing the Reserve aims to conserve ecosystem services and promote sustainable development, and the private landholders are focused on farming activities that are uncontrolled and cause substantial negative externalities to beneficiaries of the ecosystem services.

7.4.2 Imperfect Information

Perceptions and preferences of drinking water quality are a vital factor determining households' health behaviour, and how they value water quality improvements. If awareness and information of health risks is incomplete or erroneous then the possibilities of implementing policies to improve water quality will be limited (Fisher et al., 2008). Much of individuals' perceptions on water quality-related health risk at the study site were based on incomplete information or misinformation. For instance, many people in this study considered "dirt" as the main form of water contamination and lacked awareness of water test results. Individuals' health risk perceptions were also often contradictory, similar to numerous studies in experimental economics and psychology that have found that perceived risks are often inconsistent with actual risks (Um et al., 2002). For instance, most respondents expressed satisfaction with their water board's work despite believing their drinking water was contaminated. Thus, it is important to enhance people's health risk awareness. Information about water quality and health risk provided through home visits, health education classes, awareness campaigns or hygiene promotion programs has been shown to be an effective instrument (Cairncross et al., 2005; Nauges and Van Den Berg, 2009). Thus, the success of a PES scheme would be greatly enhanced for locations such as the study site by the provision of non-biased information beforehand to any project or scheme implementation (as found by Jalan and Somanathan, 2008).

Perceptions determine both the values and preferences of people, informing the stated preferences approach to WTP, and the health behaviours carried out, inform the revealed preferences approach. The valuation of a PES scheme to improve drinking water quality (chapter 4) demonstrated that the most significant variable for respondents' WTP was if they thought the scheme was important for the study site. However, although a lack of environmental awareness provides a lower WTP, the value that people have for co-benefits associated with the ecosystem service might also play a role in determining WTP and the acceptance of a scheme. This also supports the recommendation of contracting multiple services in bundles (de Groot et al., 2010; Onaindia et al., 2013). For instance, if forests qualify for a Reduced Emissions from Deforestation and Forest Degradation (REDD+) project (see Börner et al., 2010 for discussion on additionality of protected areas; Rendón Thompson et al., 2013) the high economic value of standing forests could greatly enhance conservation financing. Notwithstanding, previous studies have found contradictory results when accounting for several ecosystem services. Fisher et al., 2011a) found that even adding the values of several ecosystem services for a region in Southeast Asia, did not meet opportunity costs of oil palm and timber. However, Naidoo and Ricketts, 2006) found that by considering several ecosystem service values in a Paraguayan Reserve, 98% of forest land benefits exceeded opportunity costs. Thus, bundling ecosystem services could complement beneficiaries WTP for improved water quality if their aggregated value exceeds landholders' opportunity costs.

7.4.3 Unequal Water Governance

The feasibility of a PES scheme is mediated and constrained by the local socio-institutional context, a claim that is increasingly recognised among PES practitioners and scholars, but remains under-researched in the PES literature (Muradian et al., 2010; Vatn, 2010). Institutional governance, as well as access to networks, plays an important role in the distribution of costs and benefits from ecosystem services (Igoe, 2006; Paavola, 2007; Cárdenas, 2008). The study site's water governance was characterised by individual community water boards. The small pseudo-markets created in each community to charge for piped water have almost complete autonomy from each other and the government. This means that communities vary according to user fee, level of participation, type of infrastructure (e.g. water source and water interruptions), and water source property rights. Watersheds with such disconnected water governance present many opportunities and challenges for water conservation. Self-governance could lend itself to more discrimination in user fees within the communities, to enhance benefit distribution, due to its reduced scope. Currently, a uniform user fee per community is the status quo, either for practical or equity reasons. In contrast, state governance can be more cost-effective due to economies of scale, and can access more funds for conservation (Paavola, 2009). The state's involvement also entails a different distribution of power than self-governance, focused on promoting national agendas (Paavola, 2007). Both approaches have their limitations and have been found wanting in the literature (e.g. Chan, 2009; Jimenez and Perez-Foguet, 2010; Bollig and Menestrey Schwieger, 2014). One option to manage watersheds with independent community water management is to bring them together through an association of water boards for joint management and conservation, with state support. Overall, it is believed that a combined approach to water governance involving local water boards, the NGO managing the Reserve and the municipalities, as proposed in the PES scheme scenario (chapter 4), would be most effective at achieving water conservation in the study site[10].

Two features for which a combined governance approach would be particularly effective are securing water sources and controlling the influence of powerful individuals. Those communities with entitlements to their water source, generally the larger ones, often have municipal support and expect enforcement of rights in access and protection of water sources. However, irrespective of water source entitlement, de facto use of water source land was widespread at the study site, with frequent incursions affecting all water sources. The community water boards do not have sufficient authority or capacity to secure water sources and would benefit from the support and authority of the NGO and the municipalities. Furthermore, members of local groups, which represent the community at

[10] The General Honduran Water Law (La Gaceta No. 32,088, 14th December 2009) allows for the creation of watershed, sub-watershed and micro-watershed councils formed by public and private multi-sector actors involved in watershed management.

municipal level, are more likely to benefit from projects. These individuals in powerful and decision-making positions in the community will influence the governance of benefits distribution (Igoe, 2006; Sommerville et al., 2010a). It is believed that a combined governance approach could control powerful individuals and allow for more participatory water conservation bringing together all relevant actors.

7.4.4 Fairness in Targeting Payments to Landholders

Each hectare of the water conservation area does not provide the same level of ecosystem service. Closely aligning payments with providers' opportunity costs is considered hugely cost-effective and more equitable, allowing the conservation of more land and spreading resources across a greater number of providers (Wünscher et al., 2008; Börner et al., 2010). However, if payments at the study site are distributed according to opportunity costs, most money would go to high opportunity cost earners and would only conserve a very small area of the watershed. If payments are distributed equally across landholders, complete watershed conservation might not be achieved and high opportunity cost earners might not be incentivised to contract in a scheme.

Another approach is to ensure high opportunity cost providers cover a proportion of their total opportunity costs. A reduced payment to high opportunity cost earners would be fairer for beneficiaries as then they would not have to pay for the entire opportunity costs, especially high ones, and would, to some extent, get the polluter to pay. Dual providers, as reported in the study site, could be induced to cover part of the costs of conservation by appealing to their dual position as beneficiaries. Some ways of encouraging dual landholders include constant environmental and health campaigns, by gradually increasing the application of command and control in the Reserve, promoting organic farming or other environmentally friendly schemes (e.g. ecotourism, carbon projects).

7.5 Implications of Results for PES Scheme Design

PES has been recommended in developing countries where regulatory and taxation systems, to account for externalities, are likely to be weak (Fisher et al., 2008). Carefully designed PES schemes can help overcome many of the weaknesses that continue undermining water management, poverty eradication and equity, such as low quality of water services, difficulties targeting the poor and incomplete information systems (Jimenez and Perez-Foguet, 2010). At the study site, it is obvious that a stand-alone user-based PES scheme is out of the question. As Börner et al., 2010) have highlighted, few places have developed PES locally without external support.

Other methods mentioned in the literature to achieve water conservation include taxing pesticides, water treatment, among others. However, these alternatives, as well as PES schemes, have been at times found to be unfeasible at certain locations, not cost-effective or hindered by several factors (e.g. Zilberman and Millock, 1997; Mackintosh and Colvin, 2003; UNICEF and WHO, 2012). For example, at the study site water treatment at source (see section 3.2) and at point of use (see chapter 5), as well as tax payment (see section 6.2.4) were irregular despite being required by law. Thus, water conservation at the study site is more likely to be possible if substantial external support is obtained for a third party-based scheme or a different kind of scheme is considered, such as a sustainable land management-based (SLM) one.

As any human or domestic animal use of upstream land is likely to generate faecal contamination of water (Arby, 2008; Jewitt, 2011), the PES scheme in this thesis was designed to remove land from production entirely. However, to protect hydrological services, incentives can be offered to landholders to apply more sustainable land use practices. These sustainable practices would also require on-going monitoring and enforcement costs (Kaplowitz et al., 2012). In this thesis coffee has been proposed to be managed outside of a PES scheme, mainly due to its local importance and relative low environmental impact compared to other land uses at the study site. However, the other land uses at the study site still remain too costly to be covered by a user-based set-aside PES scheme. The findings in this thesis thus support the development of a SLM PES scheme instead, of which several examples currently exist (e.g. Nelson et al., 2010; Moreno-Sanchez et al., 2012; To et al., 2012). SLM PES schemes could ensure the provision of ecosystem services, improve livelihoods and alleviate poverty (Bulte et al., 2008; Corbera et al., 2009). Still, the water quality effects of specific sustainable practices would need to be assessed and probably coupled with enforced water disinfection at source. Likewise, landholders' willingness and capacity to contract in sustainable practices for improved drinking water quality would need to be determined. SLM-based schemes may provide a pragmatic solution that helps to balance providers' costs and beneficiaries' benefits by providing providers with incentives to implement sustainable land practices (covering some of their opportunity costs) and thus improving drinking water for beneficiaries.

Chapter 8. Conclusions

8.1 Summary of Contributions

This thesis has assessed the costs and benefits distribution of improving drinking water quality through a land set-aside PES scheme in Honduras. Additionally, this research contributes to the debate on the use of different methods to value ecosystem services. The research design combines the ecosystem services framework, distributional issues, valuation and payment for ecosystem services approaches, with a mixed-methods approach to guide overall data collection and analysis. This integrated approach has enabled the investigation of local level supply and demand for a potential PES scheme, while embedding them into the broader distributional and PES context, emphasising scheme opportunities and challenges. Data was collected using focus groups, semi-structured interviews, community mapping, and household surveys, as well as using secondary data. The use of a mixed-methods approach throughout the thesis has contributed to the robustness and validity of results through triangulation of data sources and gathering in-depth data to deepen the understanding of the research issues.

While assessing the stated WTP of beneficiaries for improved drinking water quality through a contingent valuation method, chapter 4 shows that there is affordability and a substantial WTP for clean drinking water at the study site. However, some of the poorest households are already paying above the affordability threshold for water and if it were increased, 11% of households would not be able to cope. The benefits reflected in the WTP are distributed as a function of respondents' socioeconomic characteristics, spatial location, and environmental awareness. The wide range of factors reported in the literature and results of this study indicate that case by case analysis is needed when trying to understand benefit distribution due to highly context-specific determinants.

The assessment of a revealed WTP for improved drinking water quality through averting behaviour and illness damage costs methods (chapter 5) shows that there is WTP for clean drinking water through avoiding or dealing with contaminated water. If water bills were increased by the revealed WTP, approximately 20% of households would not be able to afford water bills. Users' benefits from the revealed WTP were found to be distributed as a function of their health risk awareness, perceptions and socioeconomic characteristics. Informing the design of a potential PES scheme through a revealed WTP provides a different distribution of benefits from a stated WTP, as it is based on actual market expenditure. The researcher is not aware of any other study using a revealed WTP to inform the demand-side of PES scheme contracting.

The two WTP measures obtained for improving drinking water quality (chapters 4 and 5) showed no correlation. The non-correlation could be due to many reasons, including context-dependent preferences for each approach, the stated and revealed WTP values are not measures of the same construct, or one or both estimates are biased. However, the finding that the mean stated WTP was significantly less than the mean revealed WTP makes the bias argument unlikely. Other reasons for under-valuation of ecosystem services can include imperfect information (in chapter 4 some respondents wanted to decide WTP in a community setting, and in chapter 5 the imperfect awareness and information on averting behaviour and water contamination), and insecure land tenure (chapter 4 for water sources). The revealed and stated approaches are conceptually similar based on the utility preference theory, but they are contextually different being based on different market scenarios.

The cost of water conservation was determined through both flow and rent opportunity cost methods (chapter 6). An overall flow net return of US$ 1,410 ha^{-1} was obtained, with coffee and crops exhibiting the highest opportunity costs, followed by cattle and forest use. However, due to the spread of the data and the losses reported, the median positive returns without coffee (flow+ woc), US$ 140, are used as more stable and realistic values, which are correlated to the median rent values. Identifying a reliable, sufficiently accurate and cost-effective method to determine opportunity costs has always been challenging and complex, but the two methods employed at the study site provided valid estimates. The flow approach seems to be particularly appropriate for areas where opportunity cost heterogeneity is a key issue for conservation strategies, such as PES schemes. The rent approach seems to be an inexpensive and quick way of obtaining an overall estimate to inform conservation policy more widely. Two main concerns arose for contracting providers in a PES scheme at the study site, the duality of providers being beneficiaries and the challenges of monitoring set-aside land. Furthermore, landholder net returns showed correlation with coffee and crops, number of plots used, and number of land uses. Land uses were associated to particular land attributes that allowed distributing opportunity costs across the watershed. The results evidence that contracting is best aimed at high environmental impact land uses and mid- to low-value agriculture. The high value of coffee and other attributes indicate that a PES scheme probably will not provide enough incentive for coffee growers to engage in water conservation, but sustainable coffee schemes should be promoted to encourage income growth in the area.

Based on the findings of this study it was concluded that the WTP for improved drinking water quality is not sufficient to compensate the opportunity costs of landholders. The stated WTP would only cover 6% of the estimated (flow+ woc) cost of the water conservation and the revealed WTP could cover up to 10%. Thus, a user-based scheme at the study site seems highly unfeasible. Furthermore, this study identifies several factors that affect and could help address distributional issues for PES scheme contracting at the study site, and beyond. The findings are of particular relevance to developing country areas where small community water systems and uncertain water quality prevail (see section 3.2).

First, the upstream-downstream externality framework for water was found to be more complex than previously reported. Hydrological services can also be omni-directional at a local level, as the water service at the study site revealed. There can also be an asymmetrical benefit distribution between large (downstream) and small communities (mostly upstream) and based on the distance from water sources. Thus, the local benefit estimates reported in this thesis not only provide the economic value of the ecosystem service, but uncover the inequity and disconnection of benefits across the watershed. Second, peoples' perceptions determine the values and preferences, and their health behaviour. At the study site these perceptions were based on incomplete information or misinformation. Thus, it is important to enhance people's health risk awareness, particularly in areas where demand for improvements is low due to long-standing contamination, as is common in developing countries. Third, the feasibility of a PES scheme is likely to be influenced by the local socio-institutional context. The study site's water governance was characterised by disconnected water governance through independent community water boards. One way of improving water management and conservation is to create an association of water boards. Nevertheless, a combined approach to water governance involving local water boards, the NGO managing the Reserve and the municipalities, as proposed in the PES scheme scenario (chapter 4), would be most effective at achieving water conservation in the study site.

It is obvious that a stand-alone user-based PES scheme at the study site is out of the question. Water conservation at the study site is more likely to be possible if substantial external support is obtained for a third party-based scheme or a different kind of scheme is considered, such as a sustainable land management-based (SLM) one. SLM-based schemes may provide a pragmatic solution that helps to balance providers' costs and beneficiaries' benefits by providing providers with incentives to implement sustainable land practices (covering some of their opportunity costs) and thus improving drinking water for beneficiaries.

8.2 Limitations and Further Research

While assessing distributional issues in PES scheme contracting is crucial, this research highlights that these schemes need to consider other important contracting aspects such as efficiency and effectiveness, and their interaction with equity. More generally, the focus of this thesis is water conservation through a land set-aside PES scheme. It is important to acknowledge that other types of PES schemes exist and are implemented with success, as well as other policy approaches to water conservation.

This study had specific reasons to employ the selected methods to determine the cost and benefit distribution of improving drinking water quality. The mixed-methods approach used in this study does not preclude the use of other, perhaps more novel approaches, such as using procurement PES auctions to determine landholders true opportunity costs (Ferraro, 2004) or deliberative valuations to obtain social values (Kenter et al., 2011). This study found that a sustainable land management-based PES scheme (SLM) is more feasible for the study site. An interesting step forward in research would be to carry out a procurement PES auction to contract providers in a SLM PES scheme for water conservation.

Research also needs to look at how the implications suggested in this study fit into the wider conservation and development arena. For example, this study highlighted the potential of informing PES scheme WTP through revealed preference approaches, considering that they are contextually different from stated preference approaches being based on different market scenarios where respondents might have different preferences and hidden joint preferences. More research is needed with different case studies to determine if this method is reliable to inform WTP. Furthermore, the correlation of the rents approach to the flow approach to determine opportunity costs indicates that the former could be an inexpensive and straightforward method of determining opportunity costs. This is another issue that requires further research due to the complexity involved in estimating opportunity costs.

Finally, to draw together detailed insights into the cost and benefit distribution of improving drinking water quality to inform PES scheme contracting, this research has focused at the local scale on small communities in a rural developing country setting. In order to draw more general lessons to scale up conclusions on distributional issues and PES scheme contracting, a broader range of comparable, in-depth case studies in diverse settings and at different stages of development, as well as broader scale studies, would be required. Specifically, much more research is needed on the distribution of both costs and benefits of ecosystem services enhanced by the use of spatial tools that highlight geographical distributional issues for local stakeholders that can make local planners' conservation efforts more effective.

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Appendix 1 Photographs of study site landscape and forest type

a) Landscape near El Portillo community at approx. 2,100 m showing forest and agricultural plots.

b) View of local inhabitant walking through subtropical humid forest type near La Granadilla community.

Appendix 2 Photographs of community water source infrastructures

a) El Portillo water source consisting of a bucket and plastic pipes.

b) Santa Cruz community well.

c) Open air dam-style water source of Llano Largo community.

d) Closed box-style water source of La Labor community, with overflow at left-hand side.

e) La Granadilla community box-style water source with stone filter covered by sack cloth.

f) Las Flores community water tank located near the international highway.

Appendix 3 Photographs of main land uses at the study site

a) Coffee plantation near La Ruda community.

b) Young corn plantation near Las Flores community.

c) Young workers harvesting carrots near La Granadilla community.

d) Cabbage plantation near Rio Chiquito community.

e) Cattle ranching near La Granadilla community.

f) Harvested firewood at a house of the Rio Chiquito community.

Appendix 4 Focus group invitation

UNIVERSITY OF LEEDS

INVITACION
UNIVERSIDAD DE LEEDS/AESMO

San Marcos de Ocotepeque, Miércoles 6 de abril del 2011.

Sr./ Sra. Virgilio Alvarado

Junta Administradora de agua de la comunidad: El Anicillo

Estimado señor (a):

Por este medio tenemos el agrado de invitarle a para una reunión de discusión sobre diferentes aspectos relacionados con el uso del agua en la zona de la Reserva Biológica de Güisayote; Reunión que será coordinada por la Investigadora Olivia Rendón de la Universidad de Leeds, Inglaterra, en alianza con AESMO.

Mucho le agradeceremos traer listados actualizados de las personas que están conectadas al servicio de agua en su comunidad.

Su participación en este evento es de mucha importancia para realizar un proyecto participativo que incluya las opiniones y realidades de todas las comunidades de la zona de la Reserva Biológica Güisayote.

Al final de la sesión se les brindará un rico almuerzo y se les cubrirán los gastos de transporte de ida y vuelta a su hogar.

Día: Viernes 15 de abril del 2011.
Hora: 9:00 am
Lugar de reunión: Casa de la Cultura, La Labor (esquina del parque central)

Atentamente,

Victor Saravia
Director Ejecutivo AESMO

Olivia Rendón
Investigadora de Doctorado
Universidad de Leeds

Appendix 5 Three lists of participants for the focus groups

AESMO

UNIVERSITY OF LEEDS

GRUPO FOCAL SOBRE EL AGUA EN LA RESERVA BIOLOGICA GUISAYOTE

Organizadores: Universidad de Leeds y AESMO

Lugar: Casa de la Cultura, La Labor Fecha: 15 de Abril 2011 Hora: 9am Facilitadora: Olivia Rendon (estudiante de Doctorado

No.	NOMBRE	COMUNIDAD	PUESTO EN JUNTA DE AGUA	FIRMA
1	Marita Matilde Coto	El Anicillo	Vice. Presidenta	mariamatildecoto
2	Virgilio Alvarado	El Anicillo	Presidente	Vorgiiio Alvarado
3	ROSA DELIA GOMES	El Anicillo	Representante	Rosa Delia
4	Alfredo Garcia	El Anicillo	Representante	—o
5	Fredy Gomez	El Anicillo	Representante	—o.
6	Oscar Peña	llano largo	Tesorero	[illegible]
7	José Manuel Ramirez	Montepeque	Presidente.	-
8			[illegible]	
8	Jacobo Arita Ramirez	Los Amates	Presidente	Jacobo Arita R
9	Feliciano Santos	El Ingenio	Presidente.	[illegible]
10	Manuel Gomez	El Anicillo	Auxilear	—o

AESMO

UNIVERSITY OF LEEDS

No.	NOMBRE	COMUNIDAD	PUESTO EN JUNTA DE AGUA	FIRMA
11	Francisco Gomez	El Anicillo	Vocal III	Francisco Gomez
12	José Manuel Gomez	El Anicillo	Vocal II	—o .
13	Jorge A. Romero	Cerro Grande	Presidente	Jorge Alb. Romero
14	Pedro Pinto	Lalabor	Presidente Bo la Mesa	[illegible]
15	Agustin Mejia	Santa Cruz	Repres. Presidente.	[illegible]
16	Alejandro Villatoro	Santa Cruz	Representante.	[illegible]
17	Enrrique Mejía Coto	Santa Epigenia	Presidente	[illegible]
18	Ramiro Mejía Melgar	Santa Cruz	Presidente. Patronato	[illegible]
19	Mario Rodrigues	Lalalabor Bo El Centro	Tesorero.	[illegible]
20	José Faustino	Santa Lucia	Vocal IV	Jose

UNIVERSITY OF LEEDS

GRUPO FOCAL SOBRE EL AGUA EN LA RESERVA BIOLOGICA GUISAYOTE
Organizadores: Universidad de Leeds y AESMO

Lugar: Casa de la Cultura, La Labor Fecha: 15 de Abril 2011 Hora: 12:00. Facilitadora: Olivia Rendon (estudiante de Doctorado

No.	NOMBRE	COMUNIDAD	PUESTO EN JUNTA DE AGUA	FIRMA
1	Elmis Arnaldo Paz Jordan	El Azufrado	Presidente.	[signature]
2	Ovidio Antonio Paredes	La Ruda	Presidente.	Ovidio Antonio
3	Maria Carmela Herrera	Rio Chiquito	Presidenta.	Carmela Herrera
4	Luis Antonio Mejía	La Granadilla	Presidente	Luis Antonio Mejía
5 x	Denis Mauricio Mejía	Nueva San Antonio	Representante.	
6	Antonio Mejía	Nueva San Antonio	Presidente	ANTONIO MEJÍA
7	Edgardo Antonio Villanueva Aguilar	Pashapa	Presidente.	[signature]
8	Marcos Antonio Sandoval	El Portillo	Presidente	[signature]
9	José Armando Guevara	Rio Chiquito Las flores	Presidente	— °
10				
11				

Appendix 6 Focus group questions and information, English translation

(PP indicates a PowerPoint slide needs to be shown and M indicates a map needs to be shown)

Section A. Environmental Perceptions

A1. In your opinion, what is the purpose of a protected area?

A2. Did you know that you live within/close to the Güisayote Biological Reserve? *(PP: show map of protected area and location of communities)*

A3.In your opinion, do the households in your community receive any benefit or damage from the existence of the Güisayote Biological Reserve? Which one(s)?

A4. Did you know that the El Idolo, El Chupadero and El Potrero rivers originate in the Güisayote Biological Reserve? *(**PP:** show map of protected area and location of rivers)*

A5. How would you describe the area that surrounds the El Idolo, El Chupadero and El Potrero rivers?

A6. In your opinion and in order of priority, which are the most important environmental problems in the area surrounding the El Idolo, El Chupadero and El Potrero rivers? *These three rivers and their surrounding areas are within the Güisayote Biological Reserve, which means that they should be protected. Why do you think that environmental problems, like those you mentioned, persist?*

A7. What drinking water sources do you use in your community, mention them in order according to use? *Does use vary with the seasons?*

A8. Who owns your community water source? *(Map on A4 paper handed out to a representative of each waterboard (M): participants are asked to locate landowners on map) How much time do you invest to obtain drinking water for your household and what treatment do you give it? (collection, maintenance and treatment)*

A9. Do you think that the drinking water used by your community is contaminated? How do you know? (taste, colour, odour, waste/debris) Which are the main contamination sources of your drinking water?

M: Participants are asked to locate water sources on map.

A10. What are the effects caused by the contaminated drinking water in your community? (less biodiversity, more work for water, illness, work days lost, expenses, visits to the clinic). What obstacles keep your household from getting water of better quality?

A11. Do you consider that drinking water supply in your household is fair? Please explain.

A12. Do you think that all the community should have equal access to drinking water or should it be according to the needs of each household? Why?

A13. In your opinion, how can the water quality of the El Idolo, El Chupadero and El Potrero rivers be improved? What conflicts has your household and community had to obtain drinking water? Please describe.

Section B. Study Site Description

Now I am going to describe the area surrounding the El Idolo, El Chupadero and El Potrero rivers, please tell me if I am mistaken or if anything is missing.

These three rivers originate in the core zone of the Güisayote Biological Reserve and extend towards La Labor community where they form the Tilo river. The area of these three rivers covers almost 5,000 hectares and is characterised for having rain forest in its upper part. These watersheds are formed by a network of rivers and streams that benefit 15 communities: La Labor, Llano Largo, Santa Lucia, Cerro Grande, El Ingenio, El Portillo, La Granadilla, Rio Chiquito, La Ruda, Santa Efigenia, Montepeque, El Azufrado, Nueva San Antonio, Los Amates y Santa Cruz, for a total of 7,000 inhabitants.

Generally, communities obtain water through pipes connected to a collection box, a small dam, a sand remover, a tank and a chlorinator.

Other means of obtaining water include hoses coming directly from a spring or river, a well, collection from a river or rainwater, purchase of bottled water or in wholesale.

Currently, the land round these rivers is used for different activities, mainly agriculture, like potato, cabbage, coffee and corn, as well as cattle ranching. The rivers and streams are used as wáter sources for human consumption, animal consumption, subsistence fisheries and material extraction (e.g. chalk).

It has been observed that these rivers are contaminated by chemicals used in agriculture, human faeces, animal faeces and agriculture residue. Thus, the water is contaminated and is under the national water quality standards for drinking water. The government hasn't been able to solve this problem and this causes gastrointestinal and skin illnesses.

Section C. Proposed Scenario

We are proposing to solve the problem of water contamination through a Payment for Ecosystem Services (PES) Scheme. An ecosystem service is any benefit that we get from the environment, like water, biodiversity, fresh air and timber.

C1. Had you previously heard about Payment for Ecosystem Services schemes?

PP of PES: In a Payment for Ecosystem Services scheme there are beneficiaries of the service and providers of the service. There is an activity of activities affecting the quality or quantity of the service. So, the beneficiaries can offer a payment to providers with the aim of changing or completely halting the activities that affect the service.

The payment is possible when both parties agree to participate voluntarily. This type of Project is being implemented in different parts of the world, including Honduras, for several environmental services, both in cities and in rural areas.

With the aim of improving the water quality of the Idolo, Chupadero and Potrero rivers, we are proposing a Payment for Ecosystem Services scheme. We will carry out this survey to find out if this scheme would be valued by your household if implemented. This is how it would work:

The Municipality would charge residents an additional amount on top of the current water bill and would use the money to pay upstream landowners that are affecting the quality of the water you receive. The payment would serve to buy land off those willing to sell and to pay others to stop carrying out activities that contaminate the water. This amount would be payed by all residents that use water from the Idolo, Chupadero and Potrero rivers. The Municipality and AESMO would ensure that upstream landowners comply with the Project through periodic monitoring of the area by park guards.

This Project would be voluntary for both parties: beneficiaries and providers; and would be implemented after careful negotiations and signing of contracts.

C2. What do you think of the project I have described?

Do you think that the Payment for Ecosystem Services scheme would be fair? Why?

As the majority of people that use the water in this area will have to cover the cost of the payment for ecosystem services, we are using this survey to ask you if you would accept to pay if you had the chance. We have found that some people would be in favour of it and others against it.

Sometimes people say they are in favour of the scheme in order to please the interviewer or for some other reason, but they can’t really afford it. Some people are against the payment because they need the money for other things that are more important to them, like clothes or food. And some people say that the money they would have to pay is more than they can pay. Before answering, please think carefully about your financial capacity. No answer is right or wrong and I don't have a preference for any answer. I remind you that you can obtain drinking water from other sources, such as bottled water.

This payment for ecosystem services scheme proposal is not real at this moment. No one is paying money at the end of this survey. However, I ask you to answer the following questions as if the result would involve a real monetary payment from you. Please, only agree to pay according to what you can afford to pay. This payment will ensure that your home and the rest of the communities receive clean drinking water quality all the time. For the payment to be implemented it is necessary that 80% of water users agree to pay.

Section D. Willingness to Pay

D1. Would you vote in favour of this payment for ecosystem services project if it were free?

D2. Would you vote in favour of this payment for ecosystem services Project if it cost you 2 Lempiras per month? How much would you pay each month above your current water bill, to implement this PES project? (*range*)

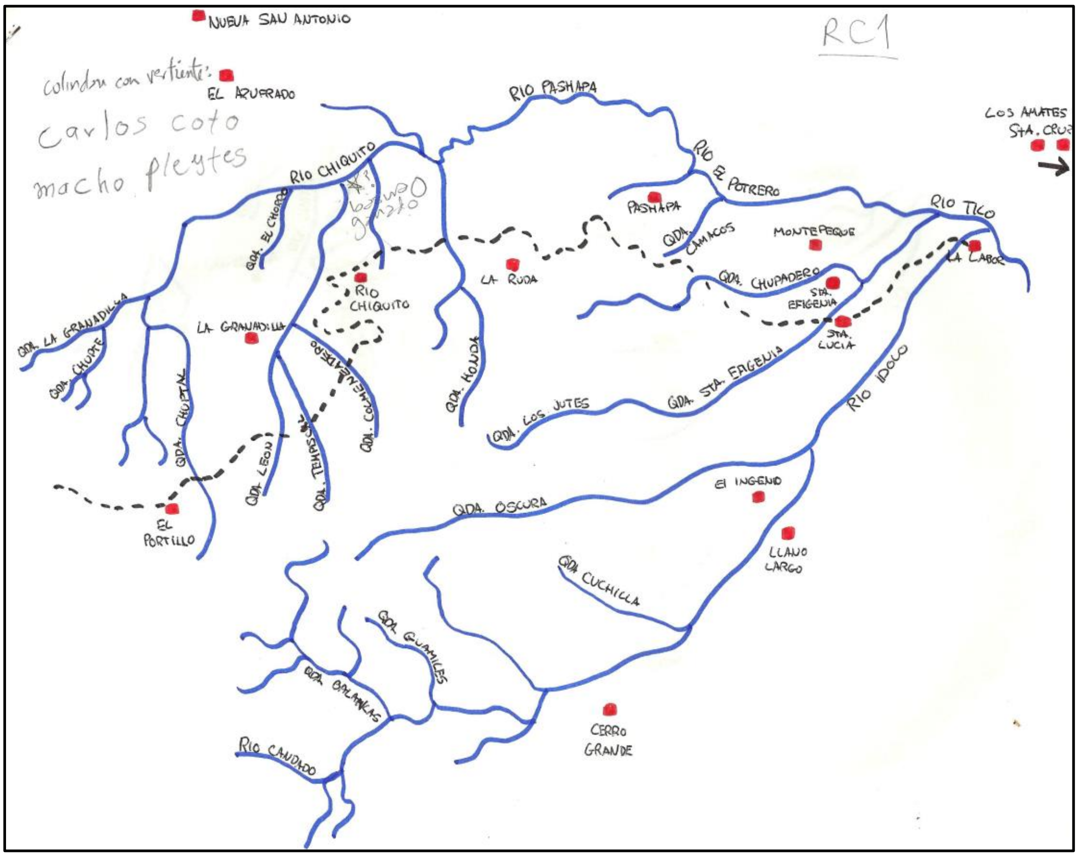
Section E: Socioeconomic Characteristics

E1. What communities do not have electricity? *(Even if it is only one house).*

E2. How do you measure the level of wealth of the different families in your community?

(PP with options: monthly income, size of house, material of house, size of land plots, land uses, vehicles, electrical appliances- colour TV with cable connection, microwave, heated showers, maid, type of mobile phone, amount paid into mobile phone).

Appendix 7 Map used during Focus Groups



Appendix 8 Water board structured interview, English translation.

A. Water board committee

1. What member types are there in your water board committee?

Member (Yes or No)	Gender	Education Level	Works within/ outside community
President			
Vice-president			
Secretary			
Treasurer			
Treasurer controller/ assistant			
Substitute member I, II, III			
Other			

Member	Very rich, rich, middle, low	Community leadership: high, medium, low, none	Past or present training/ relevant experience
President			
Vice-president			
Secretary			
Treasurer			
Treasurer controller/ assistant			
Substitute member I, II, III			
Other			

2. Do you have any support committees in the following areas:

Operation and maintenance, sanitation and user education, micro-watersheds, other

3. Do you have a full-time plumber? (describe arrangement)

4. What experience and training does the plumber have?

B. Operational and organizational activities

5. How do you elect the plumber?

6. How often does the committee meet?

7. What are the rules for assigning responsibilities among the different committee members?

8. What are the rules to expel a committee member?

9. How often do the support committees meet?

Operation and maintenance, sanitation and user education, micro-watersheds, other

10. What are the rules to gain access to the water system for the first time? (water connection)

11. Is there a clearly established place, day and payment method for users to pay?

12. Do you have an up-to-date list of beneficiaries? How many beneficiaries are there?

13. What are the water consumption rules? (wasting)

14. What is considered a delay in payment by users?

15. What sanctions exist for delays in payment? (fines, cut-offs)

16. Do you have an up-to-date register of fines and delays?

17. How do you ensure that water is not used for irrigation and animals?

18. If an irrigation project exists, what are the usage rules?

19. How do you get the community to participate in water board activities?

20. What rules exist for the maintenance, repairs and protection of the wáter system?

C. Participation and Accounting Mechanisms

21. How often do you have general assembly meetings of users?

22. What percentage of the population attends user meetings?

23. How are the water board committee members elected? (assembly voting/selective)

24. How often do you have water board elections?

25. What percentage of the population participates in elections?

26. Do you have an up-to-date budget for the water board?

27. Does the water board present annual reports to water users? Are they publically audited?

D. Financial Sustainability

28. With what funds was the current water system built?

Community, donor, central government, local government

29. Who is considered the owner of the water system?

30. What is the basis for defining the connection and water price? (including irrigation)

31. How much do you charge for the household and irrigation water, if any?

32. Do you manage to cover all maintenance and repair costs for the water system with what you charge or do you have to ask for extra payments when something arises?

33. Do you have money to invest in improving the water system and other community needs?

34. What percentage of the population pays regularly/on time?

E. Ecological Sustainability

35. What rules exist for the maintenance and protection of the natural areas surrounding your water source?

36. How has water quality varied in the past? How is it now?

37. How do you monitor water quality? (testing?)

38. How has water quantity varied in the past? How is it now?

39. What ecological and human factors are affecting the water?

F. Networks and Links

40. Do you have links with: (describe) central or local government, NGOs, donors

41. Is there any other organization or group doing water-related work in your community?

42. What objectives are the water board lacking in order to provide a good and complete water service?

G. Water Source and System

43. When was the current water system established?

44. Was there another water system before the current one?

45. How long does it take to get to the water source from the community? Is Access easy or difficult?

46. At what elevation are the water source, the tank and the community?

47. What kind of infrastructure do you have at the water source? (dam or box, filter, fencing, piping)

48. How old is the water source infrastructure?

49. What is the condition of the water source infrastructure?

Very good, good, average, bad, very bad

50. What type of infrastructure is there between the water source and the community? (type of piping, under or aboveground, size of tank, connections)

51. What is the condition of the pipes? Very good, good, average, bad, very bad

52. What is the condition of the tank? Very good, good, average, bad, very bad

53. How often is the tank cleaned? Who does it and how?

54. How often do you add chlorine to water in the tank and in what quantities?

H. Final Evaluation

55. Are the water board rules formal or informal?

56. Comments?

Appendix 9 Sample size formula following Yamane (1967)

$$Sample\ size = \frac{N}{1\ + N(e)^2}$$

$$Sample\ Size = \frac{1545}{1 +\ 1545\ (0.05)^2} = 317.74$$

$$Sample\ Size\ including\ non - response = (318 * 30\%) + 318 = 413$$

Appendix 10 Survey including contingent valuation, averting behaviour and damage costs

Note: bold text, except titles, is emphasised; italic text is not read, it is instructions to the interviewer

Code __________ Date of Interview ________________ Interviewer _________

Community ________ Gender _____ Start time ________ End time ____________

Section A. Perceptions about the Protected Area

A1. Did you know about the existence of the Güisayote Biological Reserve here in the area?

1 Yes 2 No *(go to A6)*

A2. Is your community inside or outside the Güisayote Biological Reserve? *(Write answer and circle the option that applies)* _______ 1 Yes 2 No 3 Does not know

A3. In your opinion, what benefits does your community obtain from the Güisayote Biological Reserve?

(Circle all options mentioned, but do not suggest answers)

1 Water

2 Fresh air/good climate

3 Less deforestation/protection of forest or plants

4 Conservation of animals

5 Visitors to the Reserve

6 Telephone services

7 Vegetable crops/ other crops

8 Does not know

9 Other *(Write)* _______________

A4. Has your community experienced any damage or negative effect from the existence of the Güisayote Biological Reserve? 1 Yes 2 No *(go to A6)*

A5. What damage or negative effect has your community experienced from the existence of the Reserve? 1 We are not allowed to extract firewood 2 None

A6. What do you think about the work carried out by the Asociación Ecológica San Marcos de Ocotepeque – AESMO – managing the Reserve? *(Read options and circle one)*

1 Excellent 2 Good 3 Average 4 Bad 5 Does not know AESMO *(go to A9)*

A7. In your opinion, what could AESMO do to improve the management of the Reserve? ____

A8. Have you attended any meeting or event organised by AESMO in the last year?

1 Yes 2 No

A9. Do you know the land that AESMO bought in the Reserve and that are now registered to the municipalities of La Labor and Sinuapa? *(if they know a part, it is equal to a yes)*

1 Yes 2 I have only heard of them 3 No

A10. Did you know that all the water sources of the La Labor municipality, including your community's, originate in the Reserve? 1 Yes 2 Some, not all 3 No

CARD 1. Map of the study site *(show part of the Güisayote Biological Reserve in green, international highway, location of the interviewee's community; mention that La Labor and all the communities upwards to El Portillo, and Santa Cruz and Los Amates, totalling 15 communities shown by the yellow dots, are all the communities that we are including in this study).*

A11. In your opinion, what is the most serious environmental problem in the study site that I have just shown you? *(Read options 1 - 5 and circle one; most serious refers to the problem with the greatest impact on humans and thus needs attention)*

1 Agrochemicals
2 Rubbish/litter
3 Deforestation *(any forest loss)*
4 Human faeces
5 None *(go to section B)*
6 Does not know *(go to Section B)*
7 *Other* ____________________

A12. Ahora, en su opinión, cuál es el **segundo** problema ambiental más grave en la zona que le acabo de mostrar? *(leer opciones 1-5 y circular una; no leer respuesta de A11)*

1 Agrochemicals
2 Rubbish/litter
3 Deforestation *(any forest loss)*
4 Human faeces
5 None
6 *Does not know*
7 *Other*_________________

Section B. Perceptions and Current Water Use

B1. What water sources do you use for **all** your household activities? *(Read options and circle those mentioned by respondent; sources used for drinking, washing, bathing, watering garden, toilets, etc.)*

1 Piped system
2 Hose
3 Bottled water
4 Neighbour's connection
5 Well
6 Other_____________

B2. What water sources do you use in your house **to drink**? *(Only read the options selected in the previous question and circle those mentioned by the respondent)*

1 Piped system
2 Hose
3 Bottled water
4 Neighbour's connection
5 Well
6 Other ___________

[If piped system is used:]

B3. How much do you **normally** pay for the piped water? *(Ask if he/she pays monthly or annually; what is paid for the actual service, excluding loans and initial connection)*

1 ____Lps/month 2 ____Lps/year 3 Does not pay 4 Does not know or remember

B4. Have you noticed any difference in the piped water between summer and winter?

(Circle those mentioned)

1 Scarcity/ less water in the summer

2 Dirty water in the winter *(any dirt)*

3. System gets obstructed or breaks in the winter

4 None

B5. In the last year, have you participated in maintenance activities of the piped system when you are asked? *(de cualquier forma)*

1 Yes 2 No *(go to B8*) 3 Has not been called *(go to B8)*

B6. How do you participate in the maintenance activities when you are called?

(Read options and circle those mentioned)

1 Pays monetary requests by the water board *(includes paying the plumber)*

2 Sends someone of the house or a relative

3 Pays labourers

4 Personally carries out the activities

B7. How often do you participate in the maintenance activities when you **are called**? *(Read options and circle one)*

1 Always 2 Almost always 3 Occasionally 4 Rarely

B8. What do you think about the work of your water board? *(Read options and circle one; it refers to the committee of the water board)*

1 Excellent 2 Good 3 Average 4 Bad

B9.What could the water board do to improve their work? (the committee*)*

____

B10. How many water board meetings have you or someone from your house, attended in the last year? *(Read options and circle one)*

1 All 2 Some 3 Few 4 None 5 There are no meetings

B11. Have you ever been delayed in paying for the piped water?

1 Yes 2 No *(go to B13)* 3 Does not pay *(go to B13*)

B12. Are you currently up-to-date with your water bills? 1 Yes 2 No

B13. Have/are you or a relative in the water board? *(Circle those mentioned)*

1 I was 2 I am 3 Relative was 4 Relative is 5 None

B14. Do you think the piped water is contaminated?

1 Yes 2 No *(go to next source or B51)* 3 Does not know *(go to next source or B51)*

B15. How do you know the piped water is contaminated?

(Circle those mentioned)

1 Water test results

2 Someone told her/him *(or heard)*

3 Colour or something visible in the water

4 Odour or taste of the water

5 Sees or knows about the contamination near the water source

6 Does not know

7 Other___________________________

B16. What type of contamination do you think is in the piped water?

(Circle those mentioned)

1 Agrochemicals

2 Human faeces

3 Animal faeces

4 Dirt of any kind *(mud, leaves, Little animals, etc.)*

5 Does not know

B17. In your opinion, how can the water quality of the piped water be improved?

____ *(go to next source or B51)*

[If hose is used:]

B18. Besides this house, with how many houses do you share the hose?__________

B19. Have you noticed any difference in the hose water between summer and winter?

1 Scarcity or less water in the summer

2 Dirty water in the winter *(any dirt)*

3. System gets obstructed or breaks in winter

4 None

B20. Do you or someone from your house , carry out maintenance activities for the hose supply? *(it refers to the source and the hose)* 1 Yes 2 No *(go to B22)*

B21. How often do you or someone from your house carry out maintenance activities of the hose supply?_________

B22. Do you think the hose water is contaminated?

1 Yes 2 No *(go to next source or B51)* 3 Does not know *(go to next source or B51)*

B23. How do you know that the hose water is contaminated?

(Circle those mentioned)

1 Water test results

2 Someone told her/him *(or heard about it)*

3 Colour or something visible in the water

4 Odour or taste of water

5 Sees or knows about the contamination near water sources

6 Does not know

7 Other ________________

B24. What do you think is the type of contamination in the hose water?

(Circle those mentioned)

1 Agrochemicals

2 Human faeces

3 Animal faeces

4 Dirt of any kind *(mud, leaves, Little animals, etc.)*

5 Does not know

B25. In your opinion, how can the quality of the hose water be improved?

____ (go to next source or B51)

[if bottled water is used:]

B26. How much do you pay for the bottled water you purchase? ___Lps *(per unit)*

B27. What size is the container of bottled water you purchase?

1 Five gallon container 2 Other ___________________________

B28. How many five gallon containers (or other) do you buy per month? ________

B29. If you have to travel outside your community to buy bottled water, how long does it take you in total?

1 ____minutes 2 Does not travel outside community *(go to next source or B57)*

[If neighbour's water is used:]

B30. Have you noticed any difference in the neighbour's water between summer and winter?

1 Scarcity or less water in the summer

2 Dirty water in the winter *(due to any substance)*

3. System gets blocked or breaks in the winter

4 None

B31. Do you think the neighbour's water is contaminated?

1 Yes 2 No *(go to next source or B51)* 3 Does not know *(go to next source or B51)*

B32. How do you know the neighbour's water is contaminated? *(Circle those mentioned)*

1 Water test results

2 Someone told her/him *(or heard about it)*

3 Colour or something visible in the water

4 Odour or taste of water

5 Sees or knows about the contamination near water sources

6 Does not know

7 Other ________________

B33. What do you think is the type of contamination in the neighbour's water?

(Circle those mentioned)

1 Agrochemicals

2 Human faeces

3 Animal faeces

4 Dirt of any kind *(mud, leaves, little animals, etc.)*

5 Does not know

B34. In your opinion, how can the quality of the neighbour's water be improved?

____ (go to next source or B51)

[If well water is used:]

B35. Besides this house, with how many houses do you share the well water? _____

B36. Have you noticed any difference in the well water between summer and winter?

1 Scarcity or less water in the summer

2 Dirty water in the winter *(any dirt)*

3. System gets obstructed or breaks in winter

4 None

B37. If you have to travel outside your community for well water, how long does it take in total? 1 ____ minutes 2 Well in community

B38. Do you or someone in your household carry out well maintenance activities?

1 Yes 2 No *(go to B40)*

B39. How often do you or someone in your household carry out the well maintenance activities? _________________

B40. Do you think the well water is contaminated?

1 Yes 2 No *(go to next source or B51)* 3 Does not know *(go to next source or B51)*

B41. How do you know that the well water is contaminated? *(Circle those mentioned)*

1 Water test results

2 Someone told her/him *(or heard about it)*

3 Colour or something visible in the water

4 Odour or taste of water

5 Sees or knows about the contamination near water sources

6 Does not know

7 Other ________________

B42. What do you think is the type of contamination in the well water?

(Circle those mentioned)

1 Agrochemicals

2 Human faeces

3 Animal faeces

4 Dirt of any kind *(mud, leaves, little animals, etc.)*

5 Does not know

B43. In your opinion, how can the quality of the well water be improved?

____ (*go to next source or B51*)

[If another source is used:]

B44. Besides this house, with how many houses do you share the other source? ___

B45. Have you noticed any difference in the other source's water between summer and winter?

1 Scarcity or less water in the summer

2 Dirty water in the winter *(any dirt)*

3. System gets obstructed or breaks in winter

4 None

B46. If you have to travel outside your community for the other source's water, how long does it take in total? 1 ___ min. 2 Does not travel outside community

B47. Do you think the other source’s water is contaminated?

1 Yes 2 No *(go to B51)* 3 Does not know *(go to B51)*

B48. How do you know that the other source’s water is contaminated? *(Circle those mentioned)*

1 Water test results

2 Someone told her/him *(or heard about it)*

3 Colour or something visible in the water

4 Odour or taste of water

5 Sees or knows about the contamination near water sources

6 Does not know

7 Other ________________

B49. What do you think is the type of contamination in the other source’s water?

(Circle those mentioned)

1 Agrochemicals

2 Human faeces

3 Animal faeces

4 Dirt of any kind *(mud, leaves, little animals, etc.)*

5 Does not know

B50. In your opinion, how can the quality of the other source’s water be improved?
____

[All, except if they only drink bottled water:]

B51. Which of the following drinking water treatments do you use at home?

(Read options 1, 3, and 4, and circle those mentioned)

1 Boils it for the whole family

2 Boils it only for the children

3 Adds chlorine

4 None *(go to B57)*

[If water is boiled:]

B52. How often do you boil drinking water? *(Read options and circle one)*

1 Always 2 Almost always 3 Occasionally 4 Rarely

B53. Normally, for how long do you boil the drinking water?

1 __Min. 2 Does not know

B54. What fuel do you use the most to boil drinking water? *(Read options and circle one)*

1 Firewood 2 Electricity 3 Gas *(go to next treatment or B57)*

[If chlorine is added:]

B55. How often do you add chlorine to drinking water? *(Read options and circle one)*

1 Always 2 Almost always 3 Occasionally 4 Rarely

B56. How much do you pay for the chlorine your household uses in a month?

___ Lps *(If needed, calculate total based on monthly use and unit price)*

[All:]

B57. How many cases of **stomach pain, diarrhoea or vomit** have thre been **in your household** in the last six months? *(if they associate illness to food, do not include; if the patient was a child, ask if any adult lost work days to look after the child,* *indicate with "A"; calculate expenses to doctor or health clinic by considering the total number of visits; "M"= shared transport; "?" =does not know).*

Stomach pain, diarrhoea, vomit	Age	Lost work days (or of carer = A)	Expenses for health clinic and doctor visits, plus transport	Expenses for hospital stay	Expenses for medicines and transport to buy them

B58. Which of the following do you have *(Read options 1, 3, and 5; then as kif inside or outside and circle those mentioned):*

1 Flushable toilet *(inside the house)*

2 Flushable toilet *(outside the house)*

3 Latrine *(inside the house)*

4 Latrine *(outside the house)*

5 None

B59. How often do you urinate or defecate out in the open? *(Read options and circle one)*

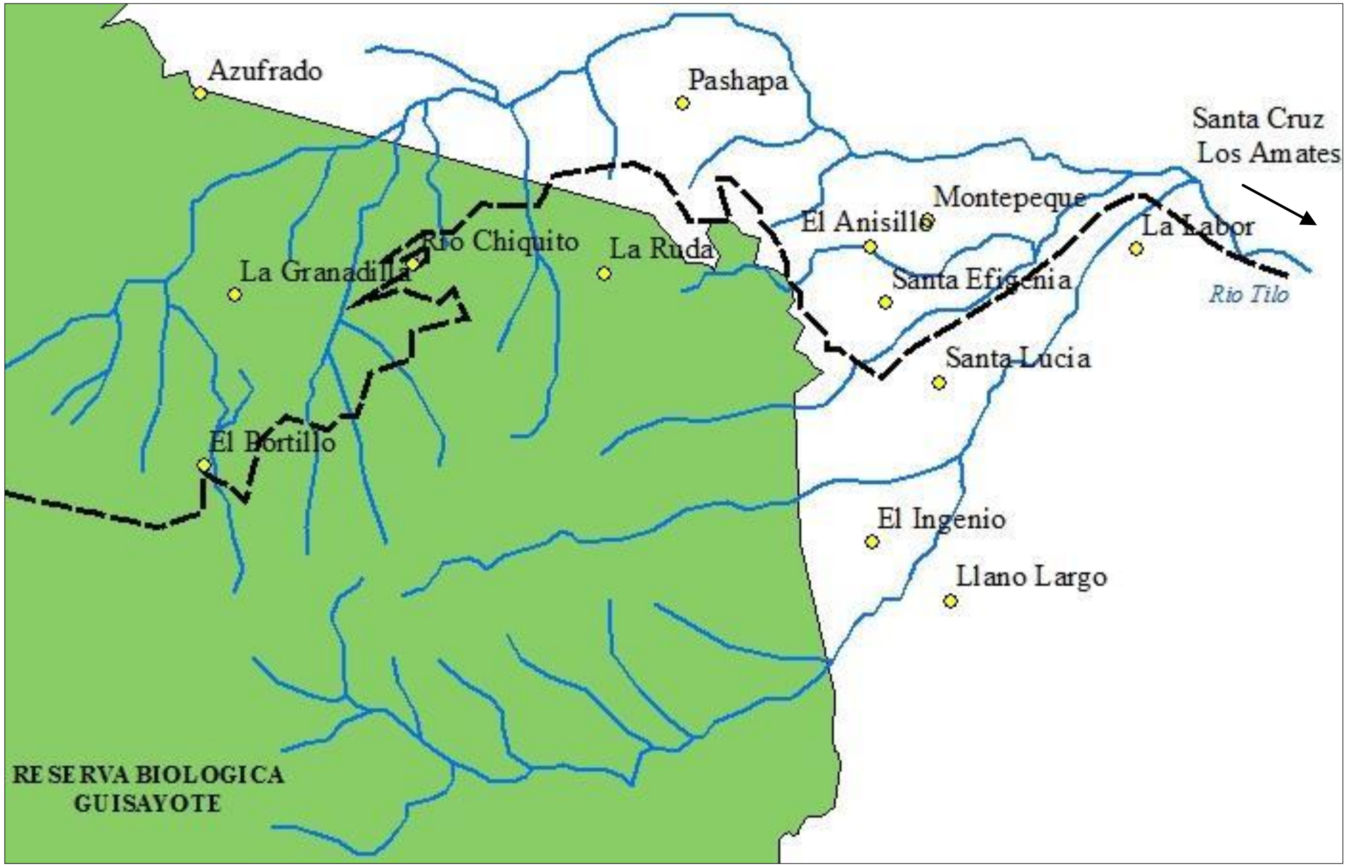
1 Always 2 Almost always 3 Occasionally 4 Rarely 5 Never

Section C. Description of the Area and the Water Problem

Allow the interviewee time to think between text segments and cards, and ensure the interviewee understands the information given.

Now I will tell you a Little about the area covered in this study. Maybe you know something or everything of what I am about to tell you but we need to ensure that everyone being interviewed has the same information for this survey.

CARD 2. Map used to describe the study area *(Show the green area representing the Güisayote Biological Reserve, the main road, the location of interviewee's community, reinforce the area included in this study). The rivers and streams, the blue lines,* originate in the Reserve and extend towards La Labor where they form the Tilo River. These rivers and streams supply water to 15 communities with 7,000 inhabitants and their animals; and they also are used for the extraction of materials, such as sand and stone.



Generally, the communities obtain water through a small dam or collection box at the water source, then the water is transported through piping to a tank where it might be chlorinated and then it finally reaches the houses by taps.

CARD 3. Photos of the water systems *(as you read the above, show images).*

Other means of obtaining water in this area include hoses to a source, wells or bottled water.

Currently, different activities are carried out in this area, mainly agriculture – such as cabbage, potato, coffee, beans and maize – as well as cattle ranching.

CARD 4. Main activities of this study area *(Read the above and show images).*






Experts and community representatives think that the water sources are contaminated by chemicals used in agriculture, and by human and animal faeces. Several water tests carried out to water sources in the area have reported contaminated water. The Health Department has registered people with intestinal parasites and diarrhoeas in several communities.

We are proposing to solve the problem of water contamination through a payment for ecosystem services. The idea behind a **payment for ecosystem services** is to give farmers a payment so that they do not contaminate, and for them to look after the area that is important for water conservation. This money would come from the families that would benefit from the improved drinking water quality. Your family could be one of the families that benefits.

C1. Had you previously heard about payments for ecosystem services?

1 Yes 2 No

Section D. Scenario

With the aim of improving water quality in this area, a payment for ecosystem services is being proposed; this is how it would work:

The water board of each community would charge a monthly amount to all those that benefit from the water in this area. The families that are connected to the piped system would pay this increase of money **above** their current water bill. This money would be used for two things: **to buy land or top provide a monthly payment to upstream landowners that are affecting water quality**. This amount would be paid by all those who benefit from the water in this area. The water boards and AESMO, with the support of the municipality, would frequently monitor the area to ensure that those landowners who are receiving a payment comply with water conservation. This payment would be approved after careful negotiations and signing of contracts *(pause).*

D1. Do you have any question about the payment for ecosystem services that I have just explained to you? *(Write and answer any questions or misunderstandings about the PES)* ____

D2. After what I have explained to you, do you think that the PES is important for this area? *(Why do you think it is [not] important?)*

1 Important because _________2 Not important because _______ 3 Not sure

Since the majority of people that use the water in this area **will have to pay** for the PES, we are using this survey to ask you if you would accept to pay if you had the opportunity. We have found that some people would be in favour of the payment and some would be against it.

Sometimes people say they are in favour just to please the interviewer o for some other reason, but they cannot really afford it. Some are against the payment because they need the money for other things that are more important to them, such as food and clothes. And some say that the money they would have to pay is more than they can afford. **I ask that you answer thinking carefully about your economic capacity.** No answer is right or wrong and I do not have a preference for an answer. I remind you that you can get water through other means, such as buying bottled water.

This proposal of PES is not real at this moment. Nobody will pay money at the end of this survey. However, I ask you to answer the next questions as if the result would involve an actual payment for you. **Please, only accept to pay according to what you could pay**. This payment would ensure that your household and the rest of the communities in this area receive **better water quality all the time.** For this payment to be implemented it is necessary that 80% of users accept to pay *(Pause).*

Section E. Willingness to pay

E1. If the implementation of this payment for ecosystem services to improve water quality would cost your household # Lempiras [increase on your water bill] every month, equal to # Lempiras per year, would you accept to pay?

1 Yes   2 No *(go to E3)*   3 Does not know *(go to E3)*

Section F. Understanding and Motivation

F1. Can you tell me why you answered the way you did (*yes/no*)? ____________

F2. How sure are you about your willingness to pay answer? (*Read options and circle one)* 1 Very sure   2 Half sure   3 Unsure   4 Very unsure

F3. Do you or someone in your household, own land near a water source in this area? *(source for human consumption)*   1 Yes   2 No

F4. Do you belong to any municipal or communal group? (*If yes, ask groups and positions)* 1 Yes; Groups_______   Positions ________   2 No

Section G: Socioeconomic characteristics

G1. How old are you? _________________

G2. How long have you lived in this area? _______ Years *(confirm previous address)*

G3. What do you do for a living? *(Circle those mentioned)*

1 Government employee

2 Private employee

3 Owner of informal business *(at home or on the road, small scale, occasional)*

4 Owner of formal business *(shop, large scale, permanent)*

5 Owner of pulpería (Little community shop)

6 Farmer

7 Labourer *(temporal/occasional work for other, farming, building, driver, etc.)*

8 Does not work *(housekeeper, elderly, etc.)*

9 Other ____________________

G4. What is your civil status? *(Read options and circle one)*

1 Single (*go to G6)*

2 Widow *(go to G6)*

3 Separated *(go to G6)*

4 Living together

5 Married

G5. What does your partner do for a living? *(Circle those mentioned)*

1 Government employee

2 Private employee

3 Owner of informal business *(at home or on the road, small scale, occasional)*

4 Owner of formal business *(shop, large scale, permanent)*

5 Owner of pulpería (Little community shop)

6 Farmer

7 Labourer *(temporal/occasional work for other, farming, building, driver, etc.)*

8 Does not work *(housekeeper, elderly, etc.)*

9 Other ____________________

G6. What education level have you achieved? *(Circle one)*

0. None 1. < 6th grade 2. 6th grade

3. Incomplete ciclo común (1 – 3 high school) 4. Ciclo común

5. Incompleto diversifiedd (4 – 6 high school) 6. Diversified

7. University

G7. How many children under 15 years of age are there in your household?

1 Boys _____ 2 Girls _____

G8. How many adults are there in your household? 1 Women ___ 2 Men ___

G9. Your house is: *(Read options and circle one)*

1 Owned 2 Rented

3 Not owned *(relatives or friends)* 4 House watcher

G10. How much land do you and your household own? ____ manzanas

G11. Besides this house, how many houses and empty plots do you and your household own? 1 ____ empty plots 2 ____ houses

G12. How much did you pay in your last water bill?

1 ___ Lempiras 2 Just connected ___ Lempiras (connection cost)

3 Does not pay 4 No connection 5 Does not know/does not remember

G13. How much did you pay in your last electricity bill?

1 ____ Lempiras 2 Just connected *(no payment yet)*

3 Uses neighbour's 4 No connection *(go to G15)*

5 Does not know/does not remember

G14. If you have cable or satellite television, how much did you pay in your last bill?

1 ___ Lempiras 2 Just installed __ Lempiras *(cost of installation)*

3 Not owned 4 Does not know/does not remember

G15. How many working cars does your household own?

1 None *(go to G17)* 2 Number of cars _________

G16. What year are your cars from? ____________

G17. ***[If house is owned*:]** What is the value of your house?

[If renting:] How much do you pay per month?

1 House value ___ Lempiras 2 Rental Price ___ Lempiras/ month

3 House watcher/does not pay 4 Does not know/does not say

Now, the last questions…

G18. Considering all the people earning an income in your household, what is the household income before any expenditure? *(wages, rentals, relatives, etc.).*

1 ___ Lps/month 2 ___ Lps/year 3 Does not know/does not say *(go to G20)*

G19. How sure are you about the income just mentioned? *(Read options and circle one)* 1 Very sure 2 Half sure 3 Unsure 4 Very unsure

G20. Do you owe money to any person or institution? 1 Yes 2 No

G21. Do you have a phone number in case we need to contact you later on? ___

WELL, THE SURVEY HAS ENDED, THANK YOU FOR YOUR TIME AND PARTICIPATION. GOOD DAY! *(note end time and hand in information sheet)*

Section H. Interviewer Evaluation

H1. How would you judge the overall quality of the survey? (*Circle one)*

1 Excellent 2 Good 3 Average 4 Bad 5 Unsure/ difficult to say

H2. Were there people listening in on the survey? 1 Yes, # _____ 2 No

H3. Did other people participate in the survey?

1 Yes, household members; # _____

2 Yes, non-household people; # _____

3 No *(go to H5)*

H4. When did these other people participate?

1 Throughout the survey 2 At the beginning 3 At the end

4 Varied questions 5 Willingness to pay 6 Many questions

7 Few questions

H5. Do you think the interviewee thought carefully about the willingness to pay question and made an effort to provide truthful answers? *Circle one.*

1 Definitely yes 2 Probably yes 3 Unsure/ difficult to say

4 Probably no 5 Definitely no

H6. Was the interviewee the head of the household? 1 Yes 2 No 3 Unsure

H7. Add any comment about the survey ___________

Appendix 11. Opportunity cost survey, Spanish version.

Hoja Informativa/Consentimiento

Buenos días/tardes, me llamo _____________ y estoy trabajando para la Universidad de Leeds de Inglaterra. Lo(a) estamos invitando a participar en una entrevista que busca conocer la práctica y los costos y beneficios de los diferentes usos del suelo en la zona de Güisayote.

Sus respuestas y comentarios serán utilizados para la investigación académica y podrían ayudar a informar a las autoridades y organizaciones locales. Su opinión honesta es esencial para entender el uso del suelo en Güisayote. La entrevista es totalmente confidencial, o sea, no daremos a conocer sus datos personales a nadie y sus respuestas solo se conocerán por un código. La entrevista durara aproximadamente 40 minutos.

Debo hacer énfasis en que no hay ninguna desventaja para usted al participar en esta entrevista. Tampoco hay beneficios inmediatos, pero se espera que este estudio contribuya a mejorar el manejo de la Reserva Biológica Güisayote.

Si desea contactar a la investigadora encargada del estudio (Olivia Rendón) aquí en esta hoja le dejo el número telefónico (3251-7068). Por favor pregúnteme si algo no está claro o si quiere más información (Pausa).

Formulario de Participación

1. Estoy de acuerdo en tomar parte en esta entrevista.
2. Confirmo que me han leído y entiendo la información de la entrevista.
3. Afirmo que he tenido la oportunidad de hacer preguntas.
4. Entiendo que mi participación es voluntaria.
5. Comprendo que mis respuestas se mantendrán estrictamente confidenciales.

____________________________	______________________________
Nombre completo del participante	Firma/huella del participante
____________________________	______________________________
Nombre de la entrevistadora	Firma de la entrevistadora

CUESTIONARIO SOBRE EL USO DEL SUELO EN LA RESERVA BIOLOGICA GUISAYOTE Y SUS ALREDEDORES

Code___ Date _____ Interviewer____ Start time____ End time ________

GPS point at centre of plot___ Altitude ___ Gender___ Address ___Phone _____
Years of schooling___ Age ___ Years living in the Ocotepeque department ______

Sección A. Datos Generales de Uso de Suelo y Tenencia

A1. Cuantas propiedades [posee/usa] usted en el área de Güisayote y sus alrededores? *(clarificar que no es para impuestos)*

No. Propiedad	A1. Tipo propiedad *(propiedad privada, alquilada, prestada, prestada)*	A2. Posee *(manzanas)*	A3. Usa *(manzanas)*	A4. Años de propiedad
P1				
P2				
P3				
P4				

Distancias	No.	Kilómetros *(u otra unidad)*	Minutos a pie	Entrada vehículo todo el año? *Explique si no.*
A5. Distancia desde la propiedad a la calle transitable más cercana? *(Antes de llegar a la carretera)*	P1			
	P2			
	P3			
	P4			
A6. Distancia desde la propiedad a la carretera internacional? *(que corre de la frontera a SPS)*	P1			
	P2			
	P3			
	P4			
A7. Distancia desde la propiedad a la fuente de agua más cercana? *(agua que usa)*	P1			
	P2			
	P3			
	P4			

A8. Favor dibuje la propiedad, incluya calles, construcciones, nacientes, quebradas, nombre y residencia de vecinos; y ubique las parcelas para sept. 2010 – agosto 2011: bosque (BL=latifoliado, BP=de pino, BM=latifoliado y pino), animales (A), maíz (M), frijol (F), café (C), hortaliza (P=papa, R=repollo, Z=zanahoria, Rm=remolacha, etc.), en descanso (D); poner código a cada parcela de uso; y Norte o salida/ puesta de sol. Mencionar actividades de conservación de suelo y agua.

A9. Usos de Suelo

Uso del Suelo	Código	Área Actual (Mz)	Cultivos combinados (% c/u)	Meses	Años experiencia	Días Asesoramiento técnico en vida	Fertilidad suelo	Pendiente	Riego (%)	Uso 2009 -10	Uso 2008 -09
Café											
Hortaliza											
Maíz											
Frijol											
Animales											
En descanso											
Bosque											
Total											

Seccion B: Costos e Ingresos de Café

B1. Mano de Obra Café

Código Parcela			Total de procesos
Año cafetal			
Valor Jornal/Día			
Semillero	Actividad		
	Días		
	Costo total		
Vivero	Actividad		
	Días		
	Costo total		
Preparación (examen de suelo)	Actividad		
	Días		
	Costo total		
Trasplante	Actividad		
	Días		
	Costo total		
Fertilización	Actividad		
	Días		
	Costo total		
Eliminación malezas	Actividad		
	Días		
	Costo total		
Eliminación de plagas	Actividad		
	Días		
	Costo total		
Regulación de sombra, manejo suelo	Días		
	Costo total		
Cosecha	Actividad		
	Días		
	Costo total		
Total por parcela			

B2. Insumos para café (vivero, preparación de la tierra, trasplante/ siembra, control de malezas y plagas, riego, cosecha)

Código Parcela			Total de procesos
Vivero (Semilla café, plántulas, sombra)	Insumo		
	Cantidad		
	Costo total		
Trasplante (semilla de sombra)	Insumo		
	Cantidad		
	Costo total		
Fertilizantes (en todo el proceso)	Insumo		
	Cantidad		
	Costo total		
Pesticidas (en todo el proceso)	Insumo		
	Cantidad		
	Costo total		
Materiales	Insumo		
	Cantidad		
	Costo total		
Total por parcela			

B3. Producción y uso de residuos de Café

Código Parcela			
Cosecha 2010-11 (húmeda-seca/unidad)			
Cosecha consumida (%)			
Cosecha vendida (%)			
Cosecha regalada (%)			
Cosecha almacenada (%)			
Residuo producido (Kg)			
Residuo en suelo (%)			
Residuo para animales (%)			
Residuo para leña (%)			
Residuo quemado (%)			
Cosecha 2009-10 (húmeda-seca/unidad)			
Cosecha vendida 2009-10 (%)			
Cosecha 2008-09 (húmeda-seca/unidad)			
Cosecha vendida 2008-09 (%)			

B4. Mercadeo de Café

Código Parcela			
Calidad Producto			
Precio/Unidad			
Impuesto venta			
Impuesto Tierra/año			
Mercado			
Comprador			
Periodo Pago, días			
Tiempo vender (min.)			
Tiempo al Mercado (min.)			
Modo de transporte			
Costo transporte (Ida y vuelta)			

Seccion C. Costos e Ingresos de Cultivos

C1. Mano de Obra de cultivos (Maíz, frijol, hortaliza)

Código Parcela			Total de procesos
Valor Jornal/Día			
Semillero/ Vivero	Actividad		
	Días		
	Costo total		
Preparación	Actividad		
	Días		
	Costo total		
Trasplante/ Siembra	Actividad		
	Días		
	Costo total		
Fertilización	Actividad		
	Días		
	Costo total		
Eliminación malezas (limpia y fumigación)	Actividad		
	Días		
	Costo total		
Eliminación de plagas	Actividad		
	Días		
	Costo total		
Actividades Especificas	Actividad		
	Días		
	Costo total		
Riego	Actividad		
	Días		
	Costo total		
Cosecha (+ vigilancia)	Actividad		
	Días		
	Costo total		
Total por parcela			

C2. Insumos para Cultivos (Maíz, frijol, hortaliza)

Código Parcela			Total de procesos
Semilla o plántula, y de barrera viva	Insumo		
	Cantidad		
	Costo total		
Preparación (cal, fertilizante, otros)	Insumo		
	Cantidad		
	Costo total		
Trasplante/ Siembra (semilla, solución arrancadora)	Insumo		
	Cantidad		
	Costo total		
Fertilizantes (todo el proceso, excepto preparación)	Insumo		
	Cantidad		
	Costo total		
Pesticidas	Insumo		
	Cantidad		
	Costo total		
Riego (agua, cloro, melaza)	Insumo		
	Cantidad		
	Costo total		
Materiales	Insumo		
	Cantidad		
	Costo total		
Total por parcela			

C3. Producción y uso de residuos de cultivos (Maíz, Frijol, Hortalizas)

Código Parcela	Cosecha producida (cantidad/Unidad)	Cosecha consumida (%)	Cosecha Vendida (%)	Cosecha regalada (%)	Residuo producido (Cantidad/ Unidad)	Residuo quemado (%)	Residuo para leña (%)	Residuo en suelo (%)	Residuo para animales (%)	Residuo otro (%)

C4. Mercadeo de cultivos (Maíz, Frijol, Hortalizas)

Código Parcela			
Calidad Producto			
Precio/Unidad			
Impuesto venta			
Impuesto Tierra/año			
Mercado			
Comprador			
Periodo Pago, días			
Tiempo vender (min.)			
Tiempo al Mercado (min.)			
Modo de transporte			
Costo transporte			

Seccion D. Costos e Ingresos de Animales

D1. Producción de Animales

Tipo de Animal	Código parcela	Cantidad a la fecha	En cuanto vendería una?	Salida sin Venta				Compra	
				Cantidad consumida	Cantidad Regalada	Cantidad Muerta	Cantidad Robada	Cantidad comprada	Precio/ unidad
Vaca madura criolla									
Vaca madura hibrida									
Vaca madura exótica									
Terneros/ novillas									
Toros									
Bueyes									
Caballos									
Burro/mula adulto									
Burro/mula joven									
Gallinas maduras									
Cerdos Maduros									
Cerdos jóvenes									

D2. Mercadeo de animales

Tipo de Animal	Venta			Mercadeo						
	Cantidad Vendida	Precio/ unidad	Calidad Producto	Mercado	Comprador	Impuesto de venta/ tierra	Periodo Pago, días	Tiempo vender (min.)	Modo Transporte	Costo Transporte
Vaca madura criolla										
Vaca adulta hibrida										
Vaca adulta exótica										
Terneros/ novillas										
Toros										
Bueyes										
Caballos										
Burra/ mula adulto										
Burra/mula joven										
Gallinas maduras										
Cerdos Maduros										
Cerdos jóvenes										

D3. Mano de Obra Animales

Código Parcela			Total de procesos
Valor Jornal/Día			
Manejo (alimentación, apartar, ordenar, chapear, manejo suelo y agua)	Actividad		
	Días		
	Costo total		
Veterinario (vacunar, desparasitar, etc.)	Actividad		
	Días		
	Costo total		
Destace	Actividad		
	Días		
	Costo total		
Total por parcela			

D4. Insumos para animales

Código Parcela			Total de procesos
Alimentación	Insumo		
	Cantidad		
	Costo total		
Suplementos	Insumo		
	Cantidad		
	Costo total		
Medicina	Insumo		
	Cantidad		
	Costo total		
Agua	Insumo		
	Cantidad		
	Costo total		
Materiales	Insumo		
	Cantidad		
	Costo total		
Total por parcela			

D5. Producción y Mercadeo de Sub-productos

Sub-producto	Código Parcela	Salida sin Venta		Venta				Mercadeo						
		Cantidad consumida	Cantidad Regalada	Cantidad Vendida	Unidad	Precio/ unidad	Calidad Producto	Mercado	Comprador	Impuestos/ cargos de venta	Periodo Pago, días	Tiempo vender (min.)	Modo transporte	Costo transporte
Leche														
Huevos														
Mantequilla														
Queso (varios)														
Carne														
Abono														

Seccion E. Costos e Ingresos de Bosque

E1. Beneficios del Bosque

Código Parcela	Mano de Obra		Leña		Material construcción		Pasto/ follaje		Medicina		Frutas		Animales		Conservación suelo/agua	Otro
	Días	Costo total	Cantidad (cargas)	Costo total	Cantidad	Costo total	Cantidad	Costo total	Cantidad remedios	Costo total	Cantidad	Costo total	Cantidad	Costo total	Si o No	

[Si tiene bosque]

Código parcela	E2. Porque ha mantenido el bosque?	E3. Desde que año existe este bosque?

Seccion F. Tenencia Especifica

[Para los que alquilan:]

No. Propiedad	F1. Cuanto paga de alquiler por propiedad? *(Lempiras/unidad)*	F2. Cuantas veces al año alquila esta propiedad?	F3. Si fuese a comprar la propiedad, cuanto cree que costaría? *(Lempiras)*
P1			
P2			
P3			

[Para dueños:]

No. Propiedad	F4. Como adquirió esta propiedad? (Ocupación, herencia, comprada a un tercero, otro)	F5. Cuanto le costó la propiedad cuando la adquirió? (Lempiras)	F6. En cuanto vendería esta propiedad si tuviera la oportunidad? (Lempiras)	F7. En cuanto alquilaría esta propiedad si tuviera la oportunidad? (Lempiras/año)
P1				
P2				
P3				

F8. Parcelas alquiladas:

Nombre a quien le alquila	Residencia	Tamaño de la parcela *(manzanas)*	Código de parcela	Valor de alquiler *(Lempiras/unidad)*
1.				
2.				

F9. Parcelas prestadas (sin cobrarles):

Nombre a quien le presta y relación *(pariente, amigo, etc.)*	Residencia	Tamaño de la parcela *(manzanas)*	Código de parcela	Por cuánto tiempo presta la parcela *(unidad)*
1.				
2.				

Seccion G. Preguntas Finales

No. Propiedad	G1. Tiene previsto usted algún cambio en el patrón de uso de suelo de su propiedad en los próximos años? Cual?	G2. Porque prevé el cambio en el patrón de uso de suelo?
P1		
P2		
P3		

G3. A que se dedica usted y las personas de su casa?

Persona (Anotar parentesco)	Actividad	Porcentaje de Ingreso Total	Ingreso en especies
1. Entrevistado	1.		
	2.		
	3.		
	4.		
2.			
3.			
4.			
No trabajan #			

G4. Donde está su propiedad: en la zona núcleo de la Reserva Biológica Güisayote, en la zona de amortiguamiento de la Reserva Biológica Güisayote, o fuera de la Reserva? *(Marcar con una X)*

No. Propiedad	Dentro de la Zona núcleo	Dentro de la Zona amortiguamiento	Dentro de la Reserva	Fuera de la Reserva
P1				
P2				
P3				

G5. Conoce usted las tierras que AESMO compro en la Reserva y que ahora están a nombre de la Municipalidad de La Labor y de Sinuapa? *(si conoce una parte, equivale a un sí)*

1 Si 2 Si he escuchado, pero no conozco 3 No

Seccion H. Evaluacion de la Entrevistadora

H1. Cree usted que el entrevistado(a) pensó cuidadosamente sobre las preguntas e hizo un esfuerzo por dar respuestas verdaderas? (*Circular una*)

1 Definitivamente Si

2 Probablemente Si

3 Inseguro(a); Difícil de decir

4 Probablemente No

5 Definitivamente No

H2. La persona entrevistada manejaba toda la información solicitada?

1 Si 2 No 3 Insegura

H3. Agregar cualquier comentario sobre aspectos resaltables de la entrevista (*describa lo bueno/malo; si lo/la conoce, estado de ánimo del entrevistado, confusiones, etc.).*____

Appendix 12 Respondent’s and partner’s work categories

Work categories	Percent Respondent	Percent Partner
0= non- stable	37	76.6
No work	20.7	60.8
Owner of informal business (at home or road seller, small scale, or occasional)	4.6	5.8
Pulpería owner (small neighbourhood shop for basic items)	1.7	4.2
Labourer (temporary/occasional worker for other in farming, construction, etc.)	8.5	5.8
A combination of the above	1.5	0
1= stable	63	23.5
Government employee	2.8	1.9
Private employee	2.8	3.8
Owner of formal business (shop, large scale, permanent)	3.7	5
Farmer (own crops and/or cattle)	42.5	5
Working in the USA	0	5.4
A combination of the above, with at least one stable category	11.2	2.4

Appendix 13 Probit model of CV WTP to check for interviewer bias

Note: n = 352; the interviewer variable was also significant in a model including income; *** 1% significance, ** 5% significance, and * 10% significance level

Variable	**Coefficient**	**SE**	**P value**	**Mean of X**
Constant	- 0.31	0.52	0.55	
Bid	- 0.02***	0.00	0.00	35.78
Age	- 0.01	0.01	0.13	46.05
Education is high	0.49**	0.23	0.03	0.15
Child	0.03	0.19	0.86	0.74
Community size	- 0.00	0.00	0.11	231.15
Contamination	- 0.25	0.17	0.14	0.63
Group member	0.44**	0.19	0.02	0.20
Number of cars	0.23***	0.09	0.01	0.41
Water bill	- 0.00	0.00	0.35	247.12
Importance of PES	1.20***	0.28	0.00	0.88
NGO1	- 0.19	0.22	0.39	0.24
NGO2	0.01	0.22	0.96	0.26
NGO3	0.04	0.22	0.87	0.24
Water board1	0.14	0.22	0.52	0.25
Water board2	0.10	0.22	0.64	0.27
Water board3	0.12	0.22	0.59	0.25
Interviewer	0.36**	0.16	0.02	0.46
Chi^2 test	94.54			
Prob[ChiSqd > value]	0.00			
McFadden Pseudo R^2	0.20			
Correct Predictions	74.72%			

Appendix 14 Probit model of CV WTP including income variable

Note: n = 305; the estimated WTP basedon this model is Lps. 15.68 with a SD of 28;
*** 1% significance, ** 5% significance, and * 10% significance level

Variable	Coefficient	SE	P value	Mean of X
Constant	0.08	0.55	0.88	
Bid	- 0.02***	0.00	0.00	36.85
Age	- 0.01	0.01	0.13	45.26
Education is high	0.41*	0.24	0.08	0.16
Child	- 0.01	0.22	0.97	0.76
Community size	- 0.00*	0.00	0.06	230.60
Contamination	- 0.20	0.18	0.26	0.64
Group member	0.57***	0.20	0.01	0.21
Number of cars	0.16	0.12	0.32	0.42
Water bill	- 0.00**	0.00	0.04	249.49
Monthly income	0.58	0.12	0.62	5369.21
Importance of PES	1.08***	0.31	0.00	0.89
NGO1 NGO2 NGO3	- 0.22 - 0.03 0.18	0.24 0.23 0.23	0.36 0.90 0.43	0.26 0.26 0.24
Water board1 Water board2 Water board3	0.30 0.28 0.24	0.24 0.23 0.24	0.21 0.22 0.33	0.25 0.28 0.23
Chi^2 test	80.81			
Prob[ChiSqd > value]	0.00			
McFadden Pseudo R^2	0.20			
Correct Predictions	74.10			

Appendix 15 Descriptive statistics for diarrhoea cases per household and per patient

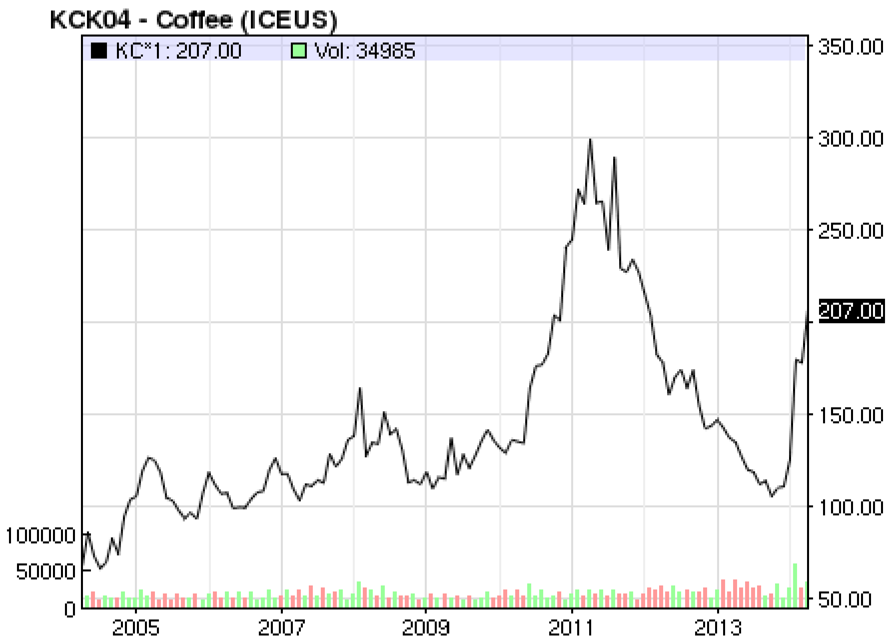
Note: for the six months prior to survey delivery; all costs in Honduran Lempiras (n = 48).

Characteristic	**Mean**	**Range**	**SE**	**SD**
Age of patient	20.28	1 – 83	3.13	21.70
No. patients under five years old (n = 23)	0.48	0 – 3	0.14	0.65
No. of cases per household	1.4	1 – 3	0.09	0.61
Households with at least one patient under five years old (% yes; n = 20)	0.42	0 – 1	0.11	0.50
Per patient:				
Lost work days	2.19	0 – 50	1.04	7.20
Indirect costs	131.64	60 – 3,000	102.48	710
Direct costs	801.99	0 – 20,000	408.60	2,830.89
Per household:				
Lost work days	3.06	0 – 50	1.25	8.63
Indirect costs	183.75	0 – 3,000	74.72	517.68
Direct costs	1,168.11	0 – 20,500	489.12	3,388.72

Appendix 16 Coffee Prices between 2004-2014

(Source accessed 30th April 2014:

http://www.nasdaq.com/markets/coffee.aspx?timeframe=10y)



Appendix 17 Consumer Price index for Honduras

(Honduran Central Bank, source accessed 30th April 2014: http://www.bch.hn/indice_precios_pub.php)

Consumer Price Index 1979 - 2011		
Year	**Mean**	**Base =2011**
1979	7.95	3.38
1980	9.39	3.99
1981	10.27	4.37
1982	11.20	4.76
1983	12.12	5.15
1984	12.69	5.40
1985	13.12	5.58
1986	13.69	5.82
1987	14.03	5.97
1988	14.66	6.24
1989	16.11	6.85
1990	19.86	8.45
1991	26.61	11.32
1992	28.94	12.31
1993	32.05	13.63
1994	39.01	16.59
1995	50.51	21.48
1996	62.55	26.60
1997	75.17	31.97
1998	85.46	36.35
1999	95.41	40.58
2000	105.97	45.07
2001	116.21	49.43
2002	125.15	53.23
2003	134.75	57.31
2004	145.68	61.96
2005	158.52	67.42
2006	167.36	71.18
2007	178.97	76.12
2008	199.38	84.80
2009	210.33	89.46
2010	220.22	93.67
2011	235.11	100.00