Evidence-based understanding of Payments for Water Ecosystem Services: the Latin American experience

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Submission to the 14th Annual BIOECON Conference Resource Economics, Biodiversity Conservation and Development

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Abstract

Latin America has now more than two decades of experience in the implementation of payment for ecosystem services (PES) schemes, including importantly payment for water services (PWS). Existing reviews dedicated to the study of this policy instrument remain mostly theoretical and/or qualitative. This paper presents the most comprehensive and up-to-date quantitative compilation of PWS cases in Latin America, and is the first study that systematic analyses this experience. The objective is twofold: i) understanding the key features of reported PWS mechanisms based on quantitative evidence; and ii) identifying information needs for policy design and implementation. A database was constructed with 301 observations from 40 different schemes, starting up to from 1984. The outcomes of this analysis are presented in the form of key messages that serve for the formulation of an evidence-based conceptual model of PWS schemes.

Keywords: Payments for Ecosystem Services, water ecosystem services, Latin America

1. Introduction

Payments for Ecosystem Services (PES) schemes are attracting increasing interest as policy mechanisms to improve conservation and achieve sustainable development outcomes. PES initiatives aim to reach mutually beneficial agreements between providers and users of ecosystem services, entailing a reward mechanism for ecosystem managers for maintaining or improving the provision of the services valued by beneficiaries. For example, within a catchment, downstream water users would compensate managers upstream for land use change which results in improved water quality or supply. Ecosystem services are increasingly being incorporated on economic decision-making through the use of PES schemes (Gómez-Baggethun *et al.*, 2010).

The most cited definition of PES is that given by Wunder (2005), by which a PES is defined as: "(a) a voluntary transaction where (b) a well-defined environmental service (or a land use likely to secure that service) (c) is being 'bought' by a (minimum one) service buyer (d) from a (minimum one) service provider (e) if and only if the service provider secures service provision (conditionality)".

Engel *et al.* (2008) discuss a number of reasons why PES schemes are considered to overcome some of the limitations of other policy instruments for conservation. Compared to command-and-control regulation, PES schemes offer alternative livelihoods for local communities, are more flexible, and allow for better targeting (focusing on areas/ecosystems with higher value in terms of service provisioning). They are also said to be more efficient and apply better than *command-and-control* in contexts of weak governance settings. But PES schemes are also receiving criticism (Muradian *et al.*, 2010). Some authors have recently raised the concern that marketing ecosystem services can modify the way that humans perceive and relate to nature, and that this can be counterproductive for conservation purposes (Corbera and Pascual, 2012; Redford and Adams, 2009; Kosoy and Corbera, 2010).

Also, PES schemes have been seen as producing nature's commoditisation (Kosoy and Corbera, 2010).

The growing policy interest in PES schemes is supported by increasing attention in the scientific literature. Figure 1 presents the evolution of publications on PES covering the period 1993 to 2011, which shows and exponential increase from 2004.

INSERT FIGURE 1 HERE

The increasing experience of PES in the field and the accompanying literature is a valuable source of knowledge for improving the understanding of PES schemes and conservation programmes generally. A number of reviews and special issues have been dedicated to the study of PES schemes. The journal Ecological Economics allocated a full special issue to this topic in 2008 (*Ecological Economics (2008), volume 65, issue 4*), looking at new insights on design and implementation, and discussing these in the light of environmental economics. The same journal released another special issue on PES in 2010, with different perspectives on the market instrument: from a more traditional environmental economics perspective which encourages efficiency, to an ecological economics view looking at service flows (Farley and Costanza, 2010). The journals World Development (*World Development (2005), volume* 33(2)), Environment and Development Economics (*Environment and Development Economics (2008), volume* 13) Journal of Sustainable Forestry (*Journal of Sustainable Forestry (2007)* 28(3–5)), and more recently Environmental Conservation (*Environmental Conservation* (2011), volume 38) have all published special issues on this topic. The Spanish journal *Revista de Estudios Agrosociales y Pesqueros* also produced a special issue on the perspectives and challenges of PES (editorial from Pascual and Corbera, 2011). These reviews have deeply analyzed many dimensions of the PES design and implementation, representing a very significant effort on the understanding of these mechanisms. While valuable, may of these studies are theoretical and/or qualitative and/or focus on specific

aspects of PES schemes, such as their impact on poverty (Kosoy *et al.*, 2007), on deforestation (Daniels *et al.*, 2010), or additionality (Pattanayak et al., 2010); with fewer articles compiling in a systematic way knowledge on a wider range of issues. . One exception is Brouwer et al. (2011), who analyze through a meta-analysis the environmental performance of 47 worldwide PWS. To date, an in-depth and systematic regional analysis is lacking and the present study aims to fill this gap, by providing a detailed facts analysis of PWS reported in the literature.

The objective of this article is twofold. Firstly, we aim at increasing the understanding of key characteristics defining existing PWS mechanisms based on quantitative evidence. For this, we undertake a systematic review and analysis of key components of existing schemes reported in the literature. Secondly, we identify information gaps and needs for a better evidence-based policy design and implementation. The outcomes of this analysis are presented in the form of key messages that serve for the formulation of an evidence-based conceptual model of PWS in practice, and are expected to serve as operational sources of information for evaluation of existing schemes and the design of new ones. There are several reasons for focusing specifically in PWS. First, water services are involved in the large majority of current existing PES schemes (Locatelli and Vignola, 2009). Second, the water cycle reflects well an *ecosystem services approach*, as presented in the Millennium Ecosystem Assessment (MA, 2005). The water cycle provides a unique context in which to express the state of natural capital and flows between different ecosystems, and the effects they produce on human wellbeing. The provision of water related ecosystem services and their upstream-downstream dynamics are often used to illustrate the principles of the PES notion (Porras *et al*. 2008)[1]. Similarly, it should be noted that this is an analysis of the

[1] It should be noted, however, that this does not imply the presumption that the conclusions drawn here over PWS are fully representative of PES schemes in general, since there are some issues that are very specific for water services, as will be discussed here

literature, and that therefore the conclusions relate to the information published in existing papers and reports. Where possible, we have updated the information presented in the original papers with more up to date information on the current status of the analyzed PWS schemes, but changes in the schemes might still have taken place unnoticed by the literature. Additionally, we have gathered studies that identify the payment schemes as PES or PWS. In some cases, it is debatable whether some schemes are PES or PES like (Wunder et al. 2005), and not in all cases, the schemes are referred to as payment for ecosystem services by the local participants. However, and since this is an analysis of the literature, we have included schemes that are referred to as *payments for 'ecosystem', 'environmental' or 'watershed' services* in the studies where they are reported in.

A database with information of 40 different water PWS studies in Latin America was constructed, starting up to from year 1984. To our knowledge, this represents the most comprehensive and up-to-date quantitative compilation of Latin American PWS schemes in the peer reviewed published literature [2]. As previously mentioned, the literature on PES is very extensive, however, there are not so many papers that include data on specific schemes; there are often repetitions, i.e. several sources referring to the same scheme, and often not providing detailed information.

Latin America has been selected as the area of study due to its more than two decades of experience in the implementation of PES schemes (Pascual and Corbera, 2011). Also, Costa Rica is the clear frontrunner in the implementation of PES, having implemented a national PES programme (PSA, *Pago por Servicios Ambientales*) since 1997. Its first phase, which lasted until 2000, covered more than 300,000 hectares (Sánchez-Azofeifa *et al.*, 2007).

[2] Landell-Mills and Porras (2002) compiled 18 cases in Latin America and the Caribbean; and Porras (2008) enlarged the analysis to 35 schemes. Camhi and Pagiola (2009) produced a World Bank Report with a compendium of programs in Latin America and the Caribbean, including a range of different services, but it does not include a systematic analysis as the one presented here.

The remainder of this paper is organized as follows: Section 2 describes the data collection and the methodology. Section 3 presents the results of the descriptive analysis. Section 4 presents the key messages and conceptual model. Section 5 presents the conclusions.

2. Data collection and methodology

A database of 310 observations (corresponding to 310 distinct PWS transactions) was constructed using information from 40 distinct PWS schemes, dating from up to 1984 and published up to 2011. Studies include both peer-reviewed (44.7%) and 'grey' literature (55.3%) (where the discussion of PES mechanisms has very largely taken place; Engel *et al.*, 2008). The database covers ten Latin American countries: Costa Rica, Ecuador, Bolivia, Brazil, Colombia, Mexico, El Salvador, Nicaragua, Guatemala and Honduras.

Relevant literature was identified via computerized searches[3], using the terms (in English and in Spanish and Portuguese) 'water', 'ecosystem service(s)', 'environmental service(s)', 'watershed service(s)', 'water service(s)', directly and coupled with the terms 'payment(s)', 'contract(s)', 'compensation' and 'fund(s)'. Abstracts of articles and reports identified using the keywords were reviewed, and apparently appropriate articles were examined in their entirety. Reference lists were scanned for other relevant articles. The Appendix presents the water PWS studies analyzed here, including some basic information.

In some cases, the schemes have changed since the time the articles were published. When this updated information was available, it has been incorporated to the database. However, it should be noted that this is an analysis of the literature, and therefore there might be cases for which changes on PWS have not been recorded by the literature. That is why we also pay important attention to literature information gaps in our analysis.

[3] Sciencedirect and Google Scholar search engines. General Google search engine was also used to identify grey literature.

Information from selected documents was tabulated and coded into a total of 120 variables, e.g. year of publication, scale, type of service, type of action, etc. A summary of the variables is presented in Table 1.

The literature is not consistent in the use of the terminology regarding *schemes* and *programmes*. In some cases, a distinction is made, for example, in Costa Rica there is reference to a *national programme*, which includes a number of local schemes (Rojas, 2003, Porras, et al. 2008), suggesting that programme is broader and overarching. However, in other cases, the terms scheme and programmes are used indistinctively or referring to the same thing (Kosoy, 2007). For consistency purposes, in this paper we refer to *programme* as a broader initiative (including eventually several schemes and/or more elements than just PES, for example, broader conservation activities) and to *scheme* as the specific setting of components defining the payment for ecosystem services. We also refer to *transaction* as a specific payment arrangement within one scheme.

INSERT TABLE 1 HERE

A descriptive statistical analysis of the variables employed the SPSS statistical software (version PASW Statistics 18). Three levels of analysis were applied: the *study level*, the *scheme level*, and the *transaction or observation level*. The *study level* corresponds to those variable values that vary across studies, e.g. whether a study is peer-reviewed or not, or the year of publication. The *scheme level* corresponds to those variables that are observed across schemes (e.g. whether there is a promoter or intermediary). Because one study can cover several PWS schemes and each scheme can include a number of payments, a third level of analysis is required at the *transaction* level[4], for example, the type of forests involved, the payment level or the type of action.

[4] One transaction corresponds to one observation in our database.

3. Descriptive analysis results

3.1. Context of PWS schemes

Around a quarter of the programmes analyzed are from Costa Rica (ten). Ecuador and Brazil follow, with six studies each. Bolivia, Colombia and Mexico have four programmes each, and two in El Salvador and Nicaragua, while there is one observation for Guatemala and Honduras.

Almost three quarters (73.3%) of the schemes were implemented at the local level, while 7.9% are at the national scale. For a substantial number of schemes (18.4%), the distinction between local and national is not straightforward. For example, in the PWS scheme mediated by FIDECOAGUA in Mexico, sellers are paid partly by a national project and partly by a local scheme (Porras *et al.*, 2006). In other cases, schemes follow general national rules adapted to local specificities. Overall, the large majority of the cases (92.1%) have a specific local component, while only a quarter of the schemes (26.3%) can be fully considered as of a national-scale nature.

There is a significant lack of information regarding the environmental threat lying behind the origination of the PWS schemes: for 39.5% of the schemes analyzed, the consulted sources do not offer information on this. For those cases for which there is information, about half (56.5%) report various threats acting simultaneously. Deforestation and land cover loss is by far the biggest reported threat to water services (77.3%), followed by water pollution other than by deforestation (33.3%) and excessive water use (22.7%). Cattle expansion is cited in almost 10% of the cases. Other threats (18.2%) include lack of water treatment facilities or lack of access to water, sanitation or forest fires. Besides missing information, the threat in almost 20% of the cases is reported non-specifically as “degraded ecosystem”.

3.2. Stakeholders

Among the sellers, it is difficult to identify distinctive categories, since the analyzed papers report generically on landowners or farmers, and it is not always clear whether the farmers are also landowners or not[5]. In any case, nearly all transactions (88.4%) involve landowners and farmers (mostly private, but in some cases public landowners or cooperatives). Other sellers are local and national NGOs and park administrations, involved as sellers in less than 3.2% of the transactions (for the rest of transactions the type of seller is unknown). The number of sellers in one PWS scheme ranges widely from a single seller to 2432 sellers, with a mean of 172 and a median of 18.

Among the service buyers, the most numerous transactions involve a hydropower producer (28.1%) or domestic water users (27.4%), amounting to almost 60% of the total number of transactions. Farmers are service buyers in 6.3% of the transactions, and national or international NGOs in about 7%. Other buyers (governments, municipalities, external donors, water utility companies, cooperatives and fishermen) are each present in less than 5% of transactions. The number of buyers involved in a PWS scheme also varies greatly, from a single buyer (e.g. a hydropower company) to 18,700 buyers (in the case of an association of domestic water users), with a median of eight buyers.

In the large majority of schemes, an intermediary exists (81.6%), while in the rest, direct transactions between buyers and sellers take place (i.e. buyers pay directly to the sellers). In 21.1% of the cases, various intermediaries are involved. Local NGOs are involved as payment intermediaries in 23.3% of the cases. Trust funds, such as FONAG in Ecuador and FIDECOAGUA in Mexico, act as intermediaries in 13.2% of the cases while the municipality and the government are involved in 10.5% and 7.9% respectively of the cases. Water companies are intermediaries only in 2.6% of cases. Other types of agents, such as semi-

[5] Farmers are explicitly mentioned as sellers in 14.6% of the studies, while landowners are reported in 77% of the observations.

autonomous agencies[6], water associations, private agents and river basin authorities, represent are present in around % of the schemes.

3.3. Ecosystem services and actions

Three quarters of the transactions include a bundle of services, and about half of the total transactions include not only water-related services, but also other types of services, such as carbon sequestration. Although a crucial element of PES schemes (and described by Wunder (2005) as a PES-defining element), the specific ecosystem service at stake is one of the less clearly defined elements of the reviewed studies. In some cases, the ecosystem services are specific and well defined, such as hydroelectricity production or drinking water supply. But in many others, the services are defined less clearly, such as 'improving watershed protection', and are often referred as intermediary rather than final services (e.g. water quality).

For the sake of clarity in the analysis, Ojea *et al.*'s (2012) output based classification is used here: i) improvement of extractive water supply (e.g. irrigation, human consumption, etc.), ii) improvement of in-stream water supply (e.g. transportation, hydropower and fish production), iii) water damage mitigation (e.g. flooding and sediment mitigation, saltwater intrusion, etc.), iv) provision of water-related cultural services (e.g. spiritual uses, aesthetic appreciation and tourism). Services as reported by the studies were recoded into these typologies. Table 3 presents the frequency with which each of the above categories of services is present. The large majority (88.7%) of the PWS schemes aimed at improving extractive water supply, both with a water quality and quantity drive (i.e PWS aimed at improving water quality and water supply). Improving the in-stream water supply (for example, water flow regulation for the

[6] An example of a semi-autonomous agency is FONAFIFO in Costa Rica, which is a national fund with an independent legal status that has been created specifically for the implementation of PES legislation (Pagiola *et al.* 2008).

production of hydropower) is the target in half of the transactions (52.3%). Damage mitigation (e.g. reduction of sediment loads) is the target in 10.5% of cases.

INSERT TABLE 3 HERE

Studies do generally supply information on the actions that take part of the schemes. The large majority (89.0%) of schemes indicate a combination of several actions for which the sellers are paid. Forest conservation and reforestation are by far the most relevant types of actions (involved in 60% and 54.3% of the transactions respectively). Forest management is present in 25.7% of the transactions. Watershed conservation and restoration is involved in 13.9% of the cases, while changes in agricultural practice and agro-forestry activities play a role in 19.4%. In the large majority of cases, the payment is determined directly by the action (input-related) and not by the results of the action on the ecosystem service (output-related). Some exceptions are, for example, Silvopastoral Project, which pays based on an index of environmental services produced (Pagiola et al, 2007), and just about every scheme implemented in Brazil, which use a formula designed to estimate (or at least be proportional to) service generation.

3.4. Contract duration and format

In 64.2% of the transactions, no information is reported regarding the duration of contracts[7]. For those cases for which there is information, contract duration ranges from 1 to 99 years, with a mean of 29.3 years (median 5 years). 79.4% of the contracts for which there is information have a fixed duration, while the rest are variable. 5.4 % of the contracts have no termination date, i.e. they were set to be perpetual.

[7] By contract, we mean the agreement that leads to transactions between buyers and sellers (directly or via an intermediary).

In more than half of the observations (59.4%), there is no information on the area (surface) under contract. For those cases where there is information, the area under contract ranges from 10hectares to 2,185,303 hectares, with a mean of 137,046 hectares and a median of 1,000 hectares.

3.5. Preparation and implementation process

In 68.4% of the cases, several agents promoted the start-up and implementation of the scheme. The most usual type of promoter is non-governmental in nature: in almost 40% of cases there is a national/local NGO at the origin of the scheme. This is followed by municipalities and by the government or a government agency, present in 28.4% and 21.1 % of schemes respectively. Semi-autonomous agencies follow, present in 15.8% of the cases. Water utility companies were promoters in 7.9% of the schemes, with international organizations such as the World Bank intervening[8]. Participants themselves (i.e. buyers and sellers) are among the promoters of the PWS only in 15.8% of the cases.

Of the 40 schemes analyzed only 8 (21.1%) report a willingness to pay (WTP) analysis carried out previously to implementation. In the other cases, this information is missing, but it is likely that there was simply no previous WTP study. From those cases where there was a WTP study, information on the actual WTP values is only given for 9 transactions in total. It is therefore not possible to compare reported WTP values way with actual payments in any significant. Technical studies prior to PWS implementation are also not very frequent, but were only reported for a third of the studies (10 cases). Similarly, the studies reviewed do not report any opportunity costs study.

[8] It should be noted, however, that the type of intervention of these promoters can be quite different. For example, the World Bank has been a provider of technical and financing support, which, while being an active role, is quite different of that of the semi-autonomous agencies.

In almost a third of the transactions, no information on how the payment levels are established. In the vast majority (76.9%) this is the result of a top-down decision, while only in 14.23% of the cases it is the result of a direct negotitation between buyers and sellers. In 10.5% of the cases it is a combination of both top-down and party negotiation. In 2.1% of the case the payment is decided by the buyer only.

3.6. Payments

Within one scheme, we often find different levels of payments, this is the so-called 'price differentiation'[9]. We distinguish five features determining such differentiation: i) the type of action: the sellers may receive different payments depending on the practices they apply to the land (e.g. whether it is expanding coffee shade or converting land to agro-forestry); ii) land feature: including type of forest (for example, if the intervention is regards a primary or secondary type of forest) or slope (whether the intervention is on a steep or shallow slope); iii) the number of actions involved, iv) the area covered; and v) other features, which include the ownership of the land, any previous intervention in the area, or the environmental quality status of that area. The type of action is the main defining price differentiation feature, present in 75.0% of the transactions for which there is price differentiation. The type of forest or other land features is the price differentiation determinant in 24.0% of the cases. The existence of a various activities is the defining feature in 7.9% of cases, while the area covered is in 4.4%, and other features play a role in 8.7%.

The number of different price levels range from one to twelve (i.e. twelve different payments within a single scheme), with a median of 3 differentiations per scheme.

PWS schemes in the field evolve over time. This often means that new differentiation features have been introduced, area has been expanded or new buyers or sellers have been incorporated. To take account of such changes, we distinguished different 'stages' in the

[9] The literature often restricts this to spatial differentiation (e.g. Munoz-Pina *et al*. 2008; Asquith *et al.* 2008), but as shown in our analysis there are other features determining price differentiation

PWS scheme. In our database, 42.1% of the schemes include several stages, while the rest saw no price changes over time. Stages range from one (when no change occurred) to eight, with a mean of two stages per scheme [10]. The duration of stages ranges from one to four years, with a mean of 2.1 years. This is, on average, PWS schemes suffer some kind of change every two years.

For buyers, we found three main payment types: cash (93.4%), in-kind payments (8.0%) and other financial arrangements[11] (3.6%)[12]. For a third (31.1%) of the transactions where we have information, water fees (for general or agricultural use) are the payment vehicle for service buyers (additional or new). Although there is monetary information for buyers' payments for 209 observations, this information is difficult to compare, since it refers to different units (monetary unit, monetary unit per hectare, year, m^3, etc.). However, we were able to homogenize the information into comparable monetary values ($ per hectare per year) in 154 cases[13].

Amongst service sellers, cash payments are also the most frequent (76.5% of the transactions for which there is information). However, in-kind payments to sellers are much more frequent than in the case of buyers (23.6% of the recorded transactions). An example is Los Negros in Bolivia, where landowners providing the service are paid in beehives, as a support to starting alternative livelihoods (Asquith *et al.* 2008). Financial arrangements as ways of payments are present in 10.6% of the transactions. For more than 10% of transactions, there is no information on the payment type. Monetary information for sellers is available in 211 cases, and is in almost all cases available in (or convertible to) per hectare per year units.

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[10] Regarding the duration stage, in some cases it is not clear in the paper whether a certain stage lasts the full period between two reported dates (e.g. there is information concerning year 2000 and information concerning year 2004) In such cases, we assume continuity (i.e. that during those four years the contract details reported for year 2000 last fully until 2004).

[11] This is the case, for example, of Fuquene in Colombia, where an international NGO provides low-rate loans to farmers (Greiber, 2009).

[12] Percentages do not add to 100 because one same scheme can include more than one payment vehicle.

[13] Homogenization is done taking into account total area under contract and/or total duration of the contract.

Table 4 presents basic statistics of monetary buyer payments and seller receipts. The mean value of payments for sellers is more than 60% higher than the average payment for buyers. There is great variation of monetary rates in both the case of buyers and sellers.

INSERT TABLE 4 HERE

The frequency of payments to sellers is reported in less than half of the cases (45.5%). For those transactions for which there is information, about half the payments occur annually and a quarter with lower frequency (once every 2 or 5 years, for example). In the rest of the cases, several payments are made to sellers with a higher frequency (monthly, or every several months). In two of the examined transactions, sellers are paid in a lump sum.

4. Evidence-based understanding of PWS in Latin America

Table 5 synthesizes the key messages derived from the descriptive analysis. Figure 2 provides the graphical representation of a conceptual model, showing the structure and functioning relationships of PWS in practice, as derived from this study. Existing and consistent relationships are represented by filled arrows, while dotted arrows are used for relationships that are supposed to exist in PWS theory, but that do not occur in reality or do so in an inconsistent or ambiguous way. The model is specific to the PWS evidence analysed here, and although it can be useful or the understanding of other PES schemes, this does not imply the presumption that this can be fully representative of PES schemes in all respects, as it will be discussed next.

INSERT TABLE 5 HERE

INSTER FIGURE 2 HERE

The conceptual model is built around three key PWS components as observed from the previous analysis: *stakeholders, service delivery* and *contract*, which surround the central

notion of *payments.* The above systematic review has shown that these components interact at both *national* and *local scales*, but that the distinction between local and national is not straightforward. A proper representation of the scale of PWS therefore requires a certain level of overlapping between these scales, as shown in the figure.

Various environmental *threats* (mostly related to deforestation) and *promoters* (mostly NGOs, but also governmental) act as drivers of the implementation of PWS schemes.

Within the *stakeholders* component, sellers (essentially land managers) and buyers (essentially service users) can interact directly, but in practice, they often interact via an intermediary. In some cases a distinction between 'beneficiaries' and 'buyers' exists. For example, in the case of Los Negros (Bolivia), the actual service buyers are the municipality, a NGO and an external donor, while the beneficiaries are the local population more broadly (Asquith *et al*. 2008)[14]. In general, this is the case for the government financed typology of PES. But even in user-financed schemes, the buyers are often a subset of the beneficiaries. However, as reflected in the model, this distinction is either not always clear or not present in all of the studies.

The next relevant component in the conceptual model is *service delivery***.** As mentioned, a PES has been defined as a transaction where a *well-defined* environmental service(s) is 'bought' by service buyers, via the *payment* to a seller who secures the provision of the service through the undertaken of a certain *action or actions* (mostly agro-forestry related in practice). The payment is in theory conditional on the provisioning of the service (*conditionality*) (Wunder *et al*. 2005). However, our results provide quantitative evidence to Engel *et al.'s* (2008) assertion that most PES schemes base payments on the adoption of land practices and not on the outputs provided by those actions. Recent research has questioned the assumptions at the basis of many hydrological PES schemes, such as the belief that

[14] As discussed by the authors, it was intended in the programme that the final beneficiaries would actually make the payments, but (up to date of publication) this had not yet happened.

forests always increase total flows of water (Kosoy *et al.* 2007; Locatelli and Vignola, 2009). Our analysis shows that conditionality may be theoretically a key relationship in PWS but is not necessarily present in practice. This is where PWS might differ from other PES schemes due to the difficulty of verifying service delivery. For example in carbon projects; for instance, it is much more common to directly measure conditionality in terms of carbon stocks.

In addition to the issue of conditionality is the problem of service definition. As described in our analysis, one of the less clearly defined elements of the reviewed studies is the specific ecosystem service(s) at stake. A variety of definitions of ecosystem services are used in the literature reporting in PWS, including some ill-defined services. Also, PWS practice is often referred to intermediary services or status or ecosystem status (e.g. water quality), rather than to outputs (e.g. water supply) as prescribed by the economic literature (see for instance Fisher *et al.* 2009; Ojea *et al*. 2012; Fu *et al*. 2011).

As a result, our analysis confirms the proposition of some authors (Muradian *et al.*, 2010; Van Hecken and Bastianensen, 2010) that there are few PWS schemes fulfilling all the definition criteria by Wunder *et al*. (2005). This does not imply that Wunder et al.'s definition is wrong from a theoretical point of view, but that the criteria are not always met in practice.

The connection between buyers and sellers in practice is also not as theoretically expected. Payments should be determined by mutual willingness, i.e. at the meeting point(s) between the *opportunity cost* of the seller and the buyer's *willingness to pay*. There is a great lack of information in the reviewed studies with regard to these two aspects, but the evidence suggests that they are largely neglected (i.e. almost no economic study made prior to the set of the scheme is reported). Although buyers and sellers have some kind of input in a number of the schemes, the vast majority of processes imply top-down decisions on the level of payment. These two facts suggest a weak relationship between the stakeholder component

and the service delivery component of PWS schemes. Additionally, the mean value of payments for sellers is more than 60% higher than the average payment for buyers, suggesting that additional funding is financing PWS schemes, via intermediaries, or other sources. This supports Ioris' (2010) assertion that payments for environmental services are not the outcomes of a free market dynamic.

The third main component relates to the *contract* and its details, and includes two sub-components: the concerned *ecosystem*, which determines the services delivered, and the *format* of the contract, which shapes the payments. The *type of ecosystem* (e.g. forest), *ecological status*, *land use type* and very importantly, *surface under contract*, determine, together with the type of *action* (e.g. reforestation), price differentiation. While being crucial to the comparability of payments and the surface under contract is often not reported. Such information is crucial not only for understanding the geographical extent of the schemes, but also to compare payments in monetary terms (e.g. $ per hectare).

Key elements of the contract format shaping the payments are the *payment vehicle*, the *frequency* of payment and the *duration* of contracts. PWS schemes in the field evolve over time, due to changes in the number of buyers, surface under contract, etc. and therefore different *stages* can be identified.

Finally, a very significant number of studies fail to report the actual amount of payment (monetary information), limiting the possibility of regressing monetary values on possible explanatory factors in order to understand the observed levels of payment.

5. Conclusions

In this paper, we have analyzed more than twenty years of reported experience on the implementation of PWS schemes in Latin America, on the basis of a comprehensive collection of studies from the literature (peer-reviewed and grey). The descriptive analysis

provides quantitative evidence on a number of issues, confirming previous considerations (e.g. that deforestation and forest management are at the heart of the majority of ongoing PWS schemes), and revealing new ones (e.g. the average receipts for sellers is 60% larger than the average amount that buyers pay for the service).

The main contribution of this work is the identification of a set of key messages about PWS practice in Latin America, together with a conceptual model representing current functioning of these schemes that distinguishes theoretically expected relationships from relationships in practice. These outputs are expected to serve as operational sources of information for the evaluation of existing schemes and the design of new ones.

Three elements are considered to be crucial for PWS efficacy (Engel et al. 2008): i) action-service conditionality, ii) a good definition of the ecosystem service, and iii) a level of payment which accords with the opportunity costs of the service providers and buyers' willingness to pay. Our analysis shows that PWS schemes in practice are not solidly rooted with respect to these three elements.

Although not all conclusions on PWS can be taken as fully representative of PES in general, due to the particularities of water services, considering that PWS are the most abundant PES applications, the results from the present analysis can serve as a reference for the development of future PES dealing with water and other services.

This article does not aim at discussing whether PES schemes are better than other policy instruments, but whether the current existing (and accessible) information on PWS schemes can help improving their implementation and efficacy. We endorse the position which considers that PES is not a 'silver bullet' that can address any environmental problem, but rather a tool that needs to be tailored for situations where ecosystems are mismanaged because benefits are externalities from the perspective of land managers. It is precisely for

such a tailoring process that a clear understanding of each of the components discussed here is necessary.

It should be reminded, however, that this is an analysis of the literature, and therefore some of these 'weakness' do not necessarily relate, in all cases or to a full extent, to the schemes themselves, to the way they are reported in the literature. Our analysis has also shown that there are currently important information gaps in the reporting of PWS practice, limiting the evaluation of current schemes and the design of future ones. Often, the available sources simply do not provide some of the data required on the schemes they cover, or do not provide it in a form that allows comparison to other schemes. This problem affects some of the conclusions about relative prevalence of certain features.

A related problem is that some papers may even cite incorrect information that is not possible to detect (for example, it is not always clear if the available sources describe proposals for schemes rather than active schemes). This lack of accurate and reliable information is definitely one of the peculiar challenges involved in working on PES

Further development of this work will include a meta-analysis of the PWS transactions for the identification of determinants of payments (i.e. the factors that determine monetary values of payments and the significant differences between buyers, sellers and different groups within them).

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Tables

Table 1. Summary of variables included in database

Type of variable	Examples of variables
Identification variables	Observation ID, study ID, scheme ID, researcher ID
Study variables	Year of publication, year of study, peer reviewed, country, reference
Context variables	Scale, environmental threat, site
PES variables	Type of service, actions, promoters, intermediaries, type and number of buyer and sellers, scheme stages, differentiation factors, payments, area, contract characteristics
Other information	Existence of WTP/technical study, negotiation process

Table 2. Key messages extracted from descriptive analysis of reported studies of existing PWS schemes in Latin America

	Key messages
Context	**Ecuador, Bolivia, and Honduras follow Costa Rica** in the number of existing PWS schemes. There is a major lack of information regarding the **type of threat** producing the loss of ecosystem services. Various threats often act simultaneously. **Deforestation** is by far the biggest threat to water resources. The large majority of PWS schemes have a **local-scale component**. Some schemes follow a mix of national and local rules.
Stakeholders	**Landowners and farmers** are the key service sellers, but there is scarce information regarding the distinction between them. **Hydropower companies and domestic water users** are the key service buyers. Most of schemes involve at least one **intermediary**. **NGO** is the leading intermediary and water companies play a marginal role.
Services and actions	The large majority of transactions include a **bundle of services**. Half include not only water-related services (e.g. carbon sequestration), but services are often poorly defined. **Improving extractive water supply** is the targeted service in the very vast majority of the existing PES transactions. Payments are, with very few exceptions, mostly based on **input (actions)** rather than outputs (service delivery) **Transactions** usually include several actions. **Forest conservation, forest management and reforestation** are the main actions paid for.

Contract duration and format	Three quarters of contracts include **periodical payments** (vs. one-off payments), but there is lack of information. There is a significant lack of information regarding the **duration of contracts**. Average duration is 24 years There is a great lack of information regarding the **area under contract**. Median area is 1,000 hectares. PES schemes **change every 2 years on average** due to changes in the area under contract or the entry of new buyers and sellers.
Preparation and implementation process	The vast majority of payments are established through **top-down decisions** rather than party negotiations. **Various promoters** are present in most schemes. **National/local NGOs** are leading promoters. There is a dramatic lack of **WTP and opportunity costs** estimates to be compared with actual payments.
Payments	About half of the transactions include different **level of payments (differentiation).** The type of activity is the main defining feature for differentiation, followed by type of forest. There is lack of information regarding the **frequency of payments**, but in the majority of cases, they are periodical (annual or higher frequency predominates). The very large majority of transactions involve **cash payments from buyers**. A third of transaction use water fees as buyer payment vehicles. **Cash payments** are also the most frequent among sellers, but in-kind payments are also important. A significant amount of studies fail to report **monetary information on buyers' payments**. Buyer payment units vary greatly across PES schemes making it difficult to compare the information. **Payments to sellers are** homogenously presented in monetary units per hectare per year. There is a **great variance of per hectare/year payments** across PWS schemes. Average **sellers' receipt is more than 60% greater** than the average payments made by buyers

Table 3. Frequency of water-targeted services in PWS transactions. Output-based classification based on Ojea *et al*. (2012).

Service category	Frequency	%*
Extractive water supply	**275**	**88.7**
Water quality driven	*112*	*36.1*
Water quantity driven	*105*	*33.9*
In-stream water supply	**162**	**52.3**
Water quality driven	*32*	*10.3*
Water quantity driven	*26*	*8.4*
Damage mitigation	**32**	**10.5**
Cultural	**131**	**42.3**

**Note that variables are not exclusive and a single observation/transaction can be related to more than one service. Therefore, percentages do not necessarily add to 100.*

Table 4. Basic statistics of monetary information on buyer payments and seller receipts (in 2011 USD * per year per hectare).

		Buyer payments in USD2011/year/ha**	Seller receipts in USD2011/year/ha
N	Valid	153	205
	Missing	134	82
Mean		38.54	63.22
Std. Deviation		91.66	91.30
Minimum		0.004	1.98
Maximum		1,120.98	1,140.78

* Local currencies converted to USD of the year of the study using historical market conversion rates and then updated to 2011 with the Consumer Price Index from Heston *et al.* (2011).
** Buyer payments are also made per cubic meter. Average payment per cubic meter is 0.0077 USD2011/m^3, with a standard deviation of 0.0026.

Figures

Figure 1. Number of scientific papers using the terms "payment(s) for ecosystem service(s)", "payment(s) for environmental service(s)", identified in a ScienceDirect search up to December 2011.

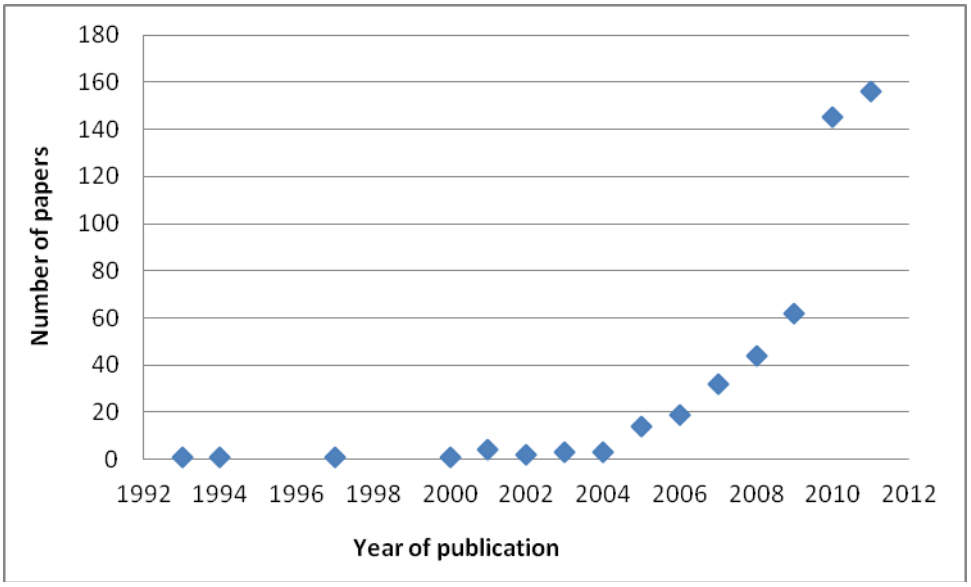
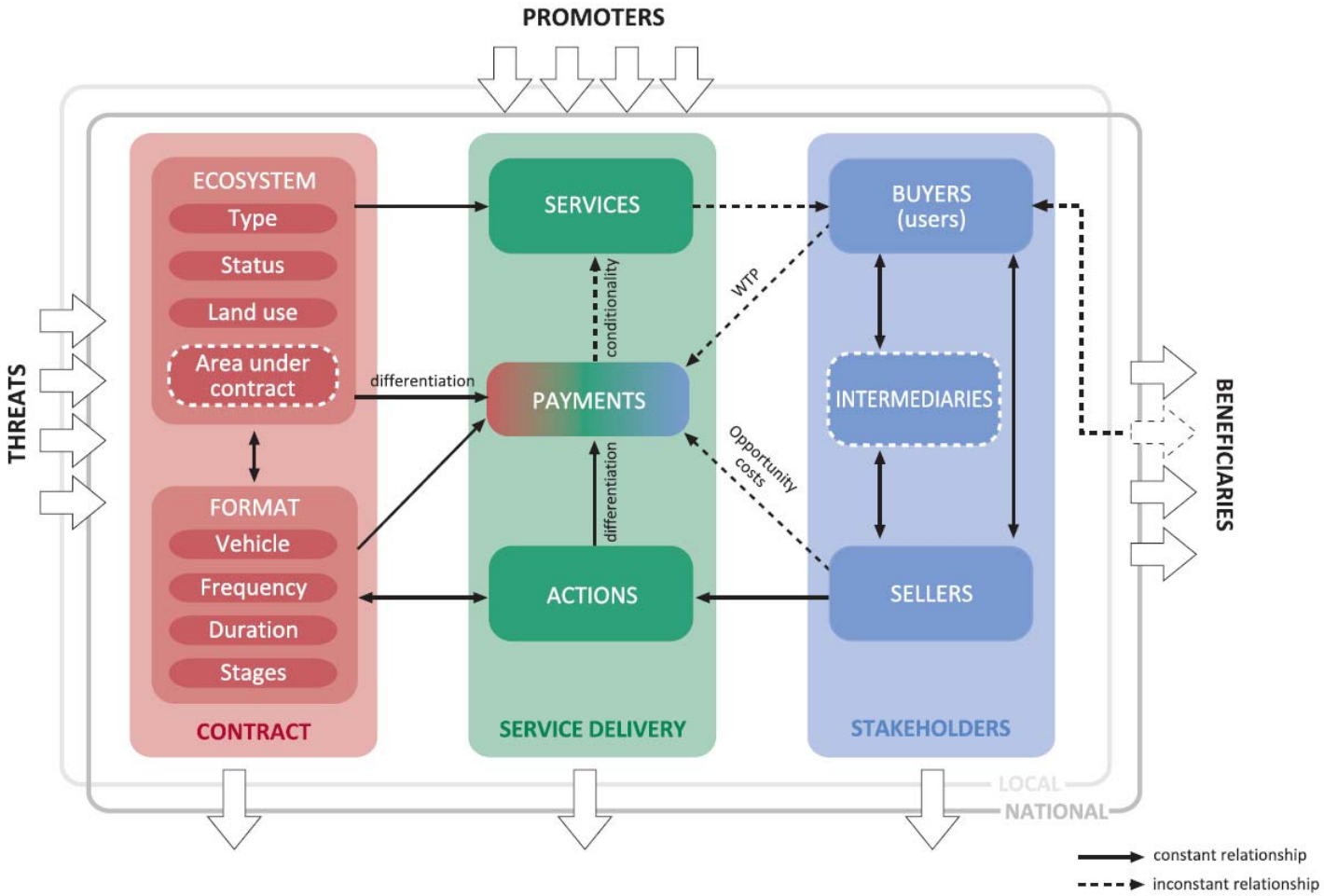


Figure 2. Evidence-based conceptual model PWS schemes in Latin America experience



Appendix. Table I. Details of analyzed PWS studies in Latin America

References*	Study year	Country	Site	Scale	Targeted service	Action	Sellers	Buyers
Robertson and Wunder (2005); Asquith e*t al*. (2008)	2005 2007	Bolivia	Los Negros	Local	Extractive quantity	Forest protection	Landowners	External donor, local NGO, municipality
Robertson and Wunder (2005);	2004	Bolivia	La Aguada	Local	Extractive quality and quantity	Forest regeneration, land use change	Landowners, farmers	Water cooperative, local NGO
Greiber (2009) Vargas et al. (2010)	2009	Bolivia	Comarapa	Local	Extractive, quality and quantity	Various activities and projects	Landowners	Domestic water users, local NGO
Greiber (2009)	2009	Bolivia	Mairana	Local	Extractive, quality and quantity	Various activities and projects	Landowners	Domestic water users, local NGO
Veiga (2007) Greiber (2009)	2008 2009	Brazil	Extrema, Minas Gerais	Local	Extractive, quality and quantity, carbon storage	Forest protection, reforestation, other	Farmers	Municipality
Veiga (2007)	2007	Brazil	Paraiba do sul	Local	Extractive, quality and quantity	Forest conservation, forest restoration	Landowners	
Porras and Neves (2006) Porras *et al*. (2008)	2006 2008	Brazil	PCJ	Local	Extractive, quality, damage mitigation	other	Landowners	Water utility
Greiber (2009)	2009	Brazil	Greater Sao Paulo	Local	Extractive, quality and quantity	Forest protection	Landowners	International NGO
Tognetti and Johnson (2008); Greiber (2009)	2009	Colombia	Fuquene	Local	Extractive, damage mitigation	Agricultural practices change	Farmers	International NGO
Porras et. Al (2008)	2008	Colombia	Plan Verde	National	In-stream	Reforestation, restoration,	Landowners	Farmers, hydropower

management government

Table I. Detail of the PWS studies analyzed (cont.)

Reference*	Study year	Country	Site	Scale	Targeted service	Action	Sellers	Buyers
Corporación Andina de Fomento (2008)	2007	Colombia	Procuenca	Local	Extractive, quality and quantity	Forest conservation, Reforestation	Landowners	Water users, government, external donor
Corporación Andina de Fomento (2008); Greiber (2009)	2007 2009	Colombia	Valle de Cauca	Local	Extractive, quality and quantity	Various activities and projects	Landowners	Water users
Rojas and Aylward (2003); Pagiola (2008); Blackman and Woodward (2010)	2003 2007 2010	Costa Rica	Volcán, Don Pedro/San Fernando	Local-national	In-stream, damage mitigation	Forest conservation, restoration	Landowners	Hydropower producer
Rojas and Aylward (2003); Pagiola (2008)	2003 2007	Costa Rica	Platanar	Local-national	In-stream, damage mitigation	Forest conservation	Landowners	Hydropower producer
Rojas and Aylward (2003); Pagiola (2008)	2003 2007	Costa Rica	Platanar (independent)	Local	In-stream, damage mitigation	Forest conservation	Landowners	Hydropower producer
Rojas and Aylward (2003);	2003	Costa Rica	Monteverde	Local	In-stream, damage mitigation	Forest protection, conservation, management, other	Local NGO	Hydropower producer
Kosoy et. al. (2007); Barrantes and Gómez (2007)	2007	Costa Rica	Heredia	Local	Extractive quality	Forest conservation, reforestation, regeneration	Landowners	Domestic water users

Kosoy *et al*. (2007)								
Barrantes and Gómez (2007)	2007	Costa Rica	Rio Segundo	Local-national	Extractive	Forest protection, regeneration	Farmers	Domestic and other commercial users

Table I. Detail of the PWS studies analyzed (cont.)

Reference*	Study year	Country	Site	Scale	Targeted service	Action	Sellers	Buyers
Rojas and Aylward (2003); Porras and Neves (2006); Pagiola (2008)	2003 2006 2007	Costa Rica	Rio Aranjuez	Local-national	All services, instream quality and quantity	Forest conservation, management, reforestation	Landowners	Hydropower producer
Rojas and Aylward (2003); Porras and Neves (2006); Pagiola (2008)	2003 2006 2007	Costa Rica	Rio Balsa	Local-national	All services, instream quality and quantity	Forest conservation, management, reforestation	Landowners	Hydropower producer
Rojas and Aylward (2003); Porras and Neves (2006); Pagiola (2008)	2003 2006 2007	Costa Rica	Rio Laguna Coste	Local-national	All services, in-stream quality and quantity	Forest conservation, management, reforestation	Landowners	Hydropower producer
Pagiola (2008)	2007	Costa Rica	National	National	All services	Forest conservation, protection, reforestation, management	Landowners	Several hydropower producers, domestic and other commercial water users, farmers, recreation
Camacho (2008) Corporación Andina de Fomento (2008)	2007	Ecuador	Celica	Local	Extractive	Forest restoration, other	Landowners	Domestic water users
Camacho (2008) Corporación	2007	Ecuador	El Chaco	Local	Extractive	Forest conservation and	Landowners	Domestic water users

Andina de Fomento (2008		restoration

Table I. Detail of the PWS studies analyzed (cont.)

Reference*	Study year	Country	Site	Scale	Targeted service	Action	Sellers	Buyers
Porras and Neves (2006) Porras et. Al (2008)	2006 2007	Ecuador	Cuenca	Local	Extractive, quality and quantity, in-stream, damage mitigation	Forest protection, conservation, management, other	Farmers, park administration	Hydropower producer, domestic water users
Porras and Neves (2006) Lloret (2008) Camacho (2008)	2006 2008 2007	Ecuador	Quito	Local	In-stream and extractive, quality and quantity, cultural	Forest protection, management	Farmers	Hydropower producer, water utility, farmers, recreation, commercial water users
Wunder and Montserrat (2008); Camacho (2008)	2007	Ecuador	Pimampiro	Local	Extractive, quality and quantity	Forest protection and regeneration	Landowners	Domestic water users
Porras and Neves (2006)	2006	Ecuador	Pedro Moncayo	Local	Extractive quantity, damage mitigation	Reforestation, management	Public, private and cooperative landowners	Water utility, farmers
Porras and Neves (2006) Rosa *et al*. (2003)	2006 2003	El Salvador	El imposible	Local	Extractive, quality and quantity	Forest protection, conservation	Park administration	Domestic water users
Porras and Neves (2006)	2006	El Salvador	Lake Coatepeque	National	Extractive, in-stream quality, damage mitigation, cultural	Agricultural practices change, other	Public, private and cooperative landowners	Domestic water users, recreation, fishers
Corbera et. al	2006	Guatemala	Las Escobas	Local	Extractive, in-	Agricultural	National NGO	Domestic water

(2007)			(Cerro San Gil)		stream, damage mitigation	practices change,		users, hydropower

Table I. Detail of the PWSstudies analyzed (cont.)

Reference*	Study year	Country	Site	Scale	Targeted service	Action	Sellers	Buyers
Kosoy *et al.* (2007)	2004	Honduras	Jesús de Otoro	Local	Extractive, quality	Forest conservation, better environmental practices	Farmers	Domestic water users
Muños-Piña *et al.* (2007)	2007	Mexico	National	National		Reforestation and forest conservation	Public, private and cooperative landowners	Government
Porras and Neves (2006) Manson (2004)	2006 2004	Mexico	Coatepec	Local-national	Extractive	Reforestation and forest conservation	Farmers	Domestic and other commercial water users, government
Porras and Neves (2006) Manson (2004)	2006	Mexico	Coatepec (FIDECOAGUA)	Local	Extractive	Reforestation and forest conservation	Farmers	Domestic and other commercial water users
Porras and Neves (2006) Porras et. Al (2008)	2006 2008	Mexico	Zapalinamé	Local	Extractive, quantity	Improved management practices, conservation of existing ecosystem	Landowners	Water users
Talavera (2007)	2007	Nicaragua	El Regadio:	Local	Extractive			
Kosoy *et al.* (2007) Martinez-Tuna (2008)	2004 2008	Nicaragua	San Pedro del Norte	Local	Extractive, quality and quantity	Agricultural practices improvement, soil conservation practices	Landowners	Domestic water users

Hall (2009), Greiber (2009)	2009	Brazil	Amazon	Local	Extractive, in-stream quality, damage mitigation	Agroforestry and other forms of traditional production	Rural producers	Water users and external donnors

** When several studies are cited for the same PWS scheme, indicates that more than one source has been used.*