**Article:**

Ojea, E and Martin-Ortega, J (2015) Understanding the economic value of water ecosystem services from tropical forests: A systematic review for South and Central America. Journal of Forest Economics, 21 (2). pp. 97-106. ISSN 1104-6899

https://doi.org/10.1016/j.jfe.2015.02.001

Revised Article
Submission to Journal of Forest Economics

# Understanding the economic value of water ecosystem services from tropical forests: a systematic review for South and Central America

**January 2015**

**Abstract:**

There is a well-established body of literature on monetary valuation of water ecosystem services to support the case for sustaining tropical forests. However, this literature is heterogeneous in its purposes and approaches and has not been carefully compared, providing a fragmented view of the values of forest water services. This paper addresses this knowledge gap through an orderly review and a regression meta-analysis of existing valuation studies at the regional level in South and Central America. This analysis allows identifying some factors that systematically influence forest values. However, it also reveals a lack of a systematized approach to valuation and a lack of sufficiently coherent evidence. This represents a barrier for the incorporation of the values of water ecosystem services into decision-making.

**Keywords:** water services; meta-analysis; Latin America; in-stream water supply; extractive water supply; service users.

# Understanding the economic value of water ecosystem services from tropical forests: a systematic review for South and Central America

## 1. Introduction

The hydrological cycle is responsible for providing society with ecosystem services that are critical to human well-being (Acreman, 2001; Maltby and Ormerod, 2011). Changes in forest status can lead to significant changes in hydrological functions, altering run-off processes, flow regulation, flood control, groundwater recharge and water quality (Lele, 2009). Forest ecosystems are globally threatened by deforestation, climate and land use changes (FAO, 2012), compromising the services they provide (Turner et al., 2010) and threatening the livelihoods of more than half a billion people globally (Agrawal et al., 2011; Sunderlin et al., 2005).

Although there is longstanding concern about human life being critically dependent on a finite natural resource base (Meadows et al., 2004; Pearce and Turner, 1990), a milestone in the global debate about the consequences of ecosystems change for human well-being is found in the Millennium Ecosystem Assessment (MA, 2005) and subsequent associated international initiatives over the last ten years (e.g. TEEB 2010; UK National Ecosystem Assessment, 2011). These theoretical and practical initiatives have contributed greatly to a growing consensus over the need to incorporate the value of ecosystem services in conservation planning and environmental management in general (Plummer, 2009; Turner et al., 2010; Martin-Ortega et al., 2015) and in decision-making related to forests in particular (Stenger et al., 2009; Chiabai et al., 2011; Ojea et al., 2010) to mitigate the negative consequences for humans.

The predominant, albeit contested (Gómez-Baggethun, 2009; Spangenbergh and Settele, 2010; Nogaard, 2010) paradigm used to interpret the effects of environmental change in human-wellbeing has been that of neoclassical economics, based on the measurement of the welfare changes associated with changes in ecosystem status in monetary units (Pearce and Turner, 1990; Bateman et al., 2011). Efforts to estimate the monetary value of water-related ecosystem services have been taking place for over forty years (Loomis, 2000) and studies addressing this issue have increased progressively in the last decade (Fisher et al., 2009; Johnston et al., 2003).

In this context, an increasing number of Payments for Ecosystem Service (PES) schemes have also arisen (Camhi and Pagiola, 2008), accompanied by an expanding literature (Pascual et al., 2010; Pascual and Corbera, 2011; Martin-Ortega et al., 2013). PES schemes are advocated in situations in which an environmental externality (e.g. deteriorated water quality due to deforestation) can be re-dressed through the creation of ad-hoc markets (Engel et al., 2008; Fisher et al., 2010; Pagiola, 2008). For example, downstream users of water would pay for changes in forest practice and forest conservation that can sustain the required supply and quality of water. It has been suggested that PES schemes might overcome some of the limitations of traditional conservation instruments under certain conditions (Engel et al., 2008; Wunder et al., 2008).

There is then a well-established body of literature on monetary values for water services to support the case for sustaining tropical forest ecosystems. This might give the impression that there is a good understanding of the welfare benefits that forest conservation provides in relation to the water services and, as a corollary, the welfare loss associated with ecosystem status decline. However, this literature is very heterogeneous in purpose and approaches and has not been carefully compared, providing a very fragmented view of the value of forest water services (Lele, 2009; Ojea et al., 2012).

There is an urgent need for a much clearer and more comprehensive understanding of the monetary values of the full suite of water-related ecosystem services associated with forests. In this paper we explore whether it is possible to identify key determinants that, according to existing evidence, systematically influence the monetary value of tropical forests' water services at regional level. We focus in Central-South America which, together with South-East Asia, is where the majority of water valuation studies and PES schemes of tropical forests are concentrated (Lele, 2009; Ojea et al., 2012; Brouwer et al., 2011).

## 2. The economic value of water services

### 2.1 Review of studies

Monetary values of water ecosystem services provided by forests in Southern and Central America have been estimated for a range of purposes. Some studies attempt to estimate the total economic value of a particular forest (Adger et al., 1995; Barrantes, 2006; Barrantes et al., 2006), while others focus on the assessment of the value of specific services, such as recreation (Menkhaus and Lober, 1996), potable water (Wittington et al., 1990) or hydropower production (Reyes et al., 2001). A number of studies are motivated by the assessment of the value associated with forest conservation or restoration practices and projects (Postle et al., 2005; Johnson and Baltodano, 2004; Martinez et al., 2009). Some values are estimated to be incorporated into cost-benefit analysis (Mejias et al., 2000; Veloz et al., 1985). Others try to value water services for internalizing costs (Barrantes and Castro, 1998a; Solorzano et al., 1995) and revisiting water tariffs (Barrantes and Castro, 1998a; Barrantes and Castro, 1998b). A few studies are aimed at providing values for the establishment of PES schemes (Koellner et al., 2010; Reyes et al., 2004; Munoz-Pina et al., 2008).

The review of this literature also shows how the definition and classification of water services across valuation studies is highly inconsistent. For example, water services have sometimes been valued at different stages of the same process (e.g. stream flow and hydropower supply), while other times one single value has been assigned to two services of different natures (e.g. in-stream use of water and damage mitigation, Ojea et al. 2012). This inconsistency makes comparisons across services and sites very difficult. Moreover, these estimates produce problems such as double counting, which has been one of the greatest sources of concern regarding the conceptualization of ecosystem services for valuation (Lele, 2009; Fisher et al., 2009; Fu et al., 2011; Fisher and Turner, 2008).

Monetary values have also been estimated using a range of valuation techniques. Cost-based methods (avoided costs, reforestation costs and opportunity costs) have been used (Adger et al., 1995; Barrantes et al., 2006; Reyes et al., 2001; Solorzano et al., 1995; Barrantes and Castro, 1998a;

Barrantes and Castro, 1998b), as well as other market-based methods (Postle et al., 2005; Mejias et al., 2000; Veloz et al., 1985). Non-market valuations predominantly use stated preference techniques (Menkhaus and Lober, 1996; Wittington et al., 1990; Johnson and Baltodano, 2004; Barrantes and Castro, 1998a; Solorzano et al., 1995; Koellner et al., 2010), although revealed preference methods (such as travel costs) and benefit transfer methods have also been applied (Menkhaus and Lober, 1996; Martinez et al., 2009).

Payments under PES schemes (Pagiola, 2008; Barrantes, 2006; Asquith et al., 2008; Chomitz et al., 1999; Corbera et al., 2007; Asquith et al., 2008) are theoretically expected to internalize the value of the externality through bargaining between buyers and sellers, directly or through intermediaries (Engel et al., 2008; Wunder et al., 2008). If so, payments should theoretically be set between opportunity costs and willingness to pay (WTP) for the service traded[1]. However, with a few exceptions, current PES schemes are hardly based on a priori primary valuation studies on buyers' WTP and sellers' opportunity costs, as payments are predominantly established through top-down processes in which buyers or sellers rarely take direct part (Martin-Ortega et al., 2013).

Monetary values of forest water services are predominantly expressed in monetary units per hectare per year[2], and range from a few cents of dollars (Adger et al., 1995; Postle et al., 2005) to several hundred (Martinez et al., 2009; Wittington et al., 1990). Previous efforts to understand the value of ecosystem services have put together a large set of values from original studies, such as in the TEEB database (Van der Ploeg et al., 2010). However, studies for water services in tropical forests amount to 22 records, from which only 6 observations come from Latin American countries. This evidence highlights that there is scope for a closer look at these services in Latin America, where the present study provides a comprehensive contribution.

## 2.2 Meta-analysis

[1] In this context, opportunity cost refers to the foregone benefits in which the service seller might incur given the change of practices required by the PES scheme. WTP refers to the maximum amount of money that the service buyer is willing to trade-off in exchange of the service.

[2] Less often values are expressed per cubic meter of water supplied per year.

The systematic search identified 42 primary valuation studies that potentially match the objectives of the present review. These included both peer reviewed publications (76.7%) and grey literature (23.3%). Grey literature is particularly important in this context since a very significant share of the ecosystem services values used in policy making are produced outside the peer reviewed system. Ignoring this literature would undermine the potential for understanding the estimated monetary values in a policy context.

The selection of the original studies was conducted through a systematic search that is explained in greater detail in Ojea et al. (2012). Minimum requirements from the studies to be included in the database were: 1) specific information on the water ecosystem service; 2) specific geographical area covered by the study; and 3) accurate information on the valuation methodology. The relevant studies date from 1985 onwards and are distributed across ten countries. They collect different ecosystem services related to water and result in an original database of 108 observations where information was coded into 60 different variables. From this sample, a subsample of 25 studies of water services provided by tropical forests in South-Central America have sufficient information to be tabulated and coded for a meta-analysis, which we use in this paper to search for significant systematic determinants of value. This drop is justified by the service classification, where cultural values and mitigation services where removed from the sample due to the limited number of observations. The remaining 25 studies lead to 84 observations of services economic values. Basic information and references of the studies are available in the Annex. Intensive data codification and classification was needed to perform the meta-analysis.

We follow standard theoretical rules for meta-analyses in environmental economics, as stated in Florax et al. (2002) and Nelson and Kennedy (2009). Following previous studies in the field, the model specification includes three sets of characteristics affecting the dependent variable (see Lindjhem, 2007, Barrio and Loureiro, 2010, or Zandersen and Tol, 2009 for examples in forests). This is: the independent variables are grouped into three categories that include: characteristics of the study ($X_{st}$); site characteristics' ($X_{si}$) and the type of good, in this case, water ecosystem services ($X_{es}$).

Within each category, a number of variables are included (in italics in the following text): 'Study characteristics' include *study year* and *type of value*. Type of value corresponds to the origin of the value, from estimated values to monetary transactions in PES schemes. Estimated values include those elicited through valuation techniques, such as non-market methods like stated or revealed preferences techniques, and *market-and-cost-based* methods, which include market prices and cost-based methodologies, such as restoration costs or replacement costs. Figure 1 shows the distribution of values, in logarithm terms, for the different origin of the data.

**-Insert Figure 1 about here-**

'Site characteristics' include the area of the forest (*forestarea*) and the per-capita income at the country of study (WEO, 2014). 'Ecosystem services' characteristics includes the type of service beneficiaries, which includes the categories of *industrial beneficiary* (e.g. bottling company or hydropower producer) versus *farmer/landowner* and domestic consumer and the type of service. The types of services were categorized using an output-based classification: *extractive water supply* (municipal, agricultural, commercial and other extractive use values), and *in-stream water supply* (flow regulation for hydropower and transportation) –see Ojea et al. (2012) for a detailed justification on ecosystem services classification. It should be noted that this output-based classification also considers two other types of services: damage mitigation (from flood and sedimentation) and cultural/recreational services. Table 1 includes a description of each of these variables and how they were coded for the regression meta-analysis.

**Table 1. About here**

Equation 1 presents the meta-analytical model in which the dependent variable is a vector of the monetary values of the forest services (in US$ per hectare per year), expressed in logarithmic terms:

$$\ln y_i = \alpha + X_{sti}\beta_{st} + X_{sii}\beta_{si} + X_{esi}\beta_{es} + \varepsilon_i \quad (1)$$

where $\alpha$ is the usual constant term, $\beta$ vectors contain the coefficients associated with the explanatory variables to be estimated for the three sets of characteristics ($X_{st}$, $X_{si}$, $X_{es}$), and $\varepsilon$ is a vector of independently and identically distributed residuals. Subscript i stands for value observation.

## 3. Results and Discussion

Table 2 shows the results for a fixed Generalized Squares model following equation 1, controlling also for authorship of the study. By clustering per authorship, we control for the effect of having several observations from a common case study, as recommended by Nelson and Kennedy (2009) in their review of good practices for meta-analyses. The meta-regression allows us to observe certain systematic determinants of monetary values of water ecosystem services in tropical forests, and reveals some interesting relationships across factors. For example, we find that extractive water supply services show higher values than in-stream water services. Additionally and although an industrial beneficiary by itself does not show a significant effect in relation to the farmer or domestic user (omitted variable), the interaction variable between extractive water supply and industrial beneficiary shows a significant negative effect. This reveals a complex relationship between the type of value and the type of service, suggesting that the higher value associated with provisioning type of services might be due to non-industrial uses, such as agriculture and household consumption. In contrast, in-stream services (omitted variable of service) show lower values than extractive, also ceteris paribus. In stream water refers basically to hydropower generation enabled by the flow regulating service provided by forest, of which industrial agents are the generally the service buyer.

No significant difference in value estimations is found when the value is obtained via non-market valuation techniques and market-and-cost-based methods (omitted variable). Although non-market values are found to have higher ranges and average value in Figure 1, this does not result into a statistically significant effect in the model. On the other hand, values reflecting PES payments are found to range between market-and-cost-based and non-market values (Figure 1). The meta-analytical model confirms that PES payments are significantly higher than market-and-cost-based estimates, but not significantly different from non-market estimates[3]. This leaves the question open as whether PES payments are internalizing the value of externalities. On the one hand, it could be argued that since they are not significantly different from non-market estimated values, which are based on beneficiaries' WTP, and since they are higher than market-and-cost-based estimated values (which should, in principle, incorporate suppliers' opportunity costs), PES payments might be internalizing the value of the externality. However, we know from in-depth study of water PES in the region (Martin-Ortega et al., 2013) that payments levels are mostly set in top-down decisions (76.9%) rather than through direct buyer-seller negotiations (14.2%), without hardly any of these decisions being backed up with an a priori economic study of WTP or opportunity costs. Hence, further research will be needed to understand these differences and whether PES schemes are currently internalizing the value of the externality.

Looking now at country's forest area (taken as a proxy of potential service supply) shows a negative relationship with value, but this relationship is not significant for this dataset. Finally, a variable controlling for the effect of income on the value was introduced, showing the theoretically expected positive relationship between higher per capita income and higher value of services.

**Table 2. About here**

## 4. Conclusions

The analysis conducted here has allowed us to identify some factors that systematically influence ecosystem services values at the regional level in South and Central America. However, the analysis has also revealed a lack of a systematized approach to the valuation of ecosystem services and a certain lack of evidence that represents a barrier for their incorporation into decision-making.

[3] One reviewer of this paper suggested that there could be risk of endogeneity regarding the PES scheme payments as it might be endogenously determined by the value of a water service. Although this calls for precaution in drawing strong conclusions, and more research on PES values is needed, the fact that PES payments are often determined by top-down process and not by party negotiation provide grounds to think that endogeneity is not occurring.

From the available dataset, we are able to identify how the variables type of service, beneficiary and method, as well as some context variables, influence the value of the service. The analysis showed that the relationship between value and type of service is complex and is mediated by the type of beneficiary. Extractive water supply services (involving mostly agricultural and human water consumption) have, in general, relatively high values; although the value of flow-regulating services (in-stream water supply) when the beneficiary is an industrial user (i.e. mostly used for hydropower production) is significantly higher than when used for agricultural and human consumption (but not as high as extractive water supply generally). No comparison has been possible in relation to damage mitigation and water cultural related services due to lack of sufficient estimates. This is consistent with the idea that more tangible services are easier to attach a value to. This is important, since the tendency to avoid services that are difficult to measure may bias resultant policy choices.

Our analysis also provides feed to the debate on the existing miss-match between PES theory and practice. The current speedy expansion and policy enthusiasm for PES schemes need to be accompanied by a reflection on whether the existing values of ecosystem services exchanged respond to supply and demand, and how they compare to the values of the same services estimated through different methodologies. More research is needed to understand these questions. Overcoming double counting problems with ecosystem services, tipping points and non-linearities also remain a challenge. The results obtained here however can help in understanding how values respond to different service and user characteristics, and evidences the need for including both users and providers in the design of economic instruments for sustainable management.

Finally, there is a need for recognition of the multiple and complex elements of value. Alongside valuation exercises such as the ones discussed here, the challenges of producing accurate value estimations for all services and all users should be acknowledged. Moreover, in a continent of important income inequalities and great cultural diversity, adequate attention to distributional concerns and the needs of poor people and indigenous communities (face to for instance, industrial agents) should be considered. There is also a need to think beyond the water values and recognize that there may be scope for stacking a range of ecosystem services. A forested watershed that protects soils, maintains regular river flows and houses a diversity of social groups, can deliver such services in a holistic manner.

**Acknowledgments**

The authors wish to thank the editor and anonymous reviewers for very helpful comments that improved the final version of this research piece. Dr. Ojea wishes to thank Bizkaia Xede Mobility Grant 2013, and Dr. Martin-Ortega acknowledges the Scottish Government Rural Affairs and the Environment Portfolio Strategic Research Programme 2011-2016, Theme 1 (WP1.2. Assessing the Value of Ecosystem Services). The database was partly built in the course of the CLIMBE project (Climate Change and Biodiversity Effects), financed with the grant program on Biodiversity Conservation of the BBVA Foundation (Spain). We are greatly grateful to Prof. Bill Slee for his valuable comments to an earlier version of this paper, and to Pablo Imbach, for his help in the buildup of the database.

**References**

Adger WN, Brown K, Cervigni R, Moran D: Total economic value of forest in Mexico. Ambio 1995, 24:286-296.

Agrawal A, Nepstad D, Chhatre A: Reducing Emissions from Deforestation and Forest Degradation. Annu Rev Environ Resour 2011, 36:373-396.

Asquith NM, Vargas MT, Wunder S. Selling two environmental services: in-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecol Econ 2008, 65: 675 -648

Barrantes G, Castro E: Disposición a pagar para la sostenibilidad del servicio hídrico en el sector doméstico costarricense. Documento preparado para el Ministerio de Medio Ambiente y Energía de Costa Rica. 3 Informe. San José, Costa Rica; 1998a.

Barrantes G, Castro E: Valoración económico ecológico del recurso hídrico en la cuenca del Arenal, Costa Rica: el agua un flujo permanente de ingresos. En: Proyecto Corredor Biológico Mesoamericano, 2002. Guía metodológica de valoración económica; 1998b.

Barrantes G, Castro E: Implementación de un esquema de cobro y pago por servicio ambiental hídrico: el caso de la Empresa de Servicios Públicos de Heredia, SA (ESPH, SA). In Proyecto Corredor Biológico Mesoamericano: Guía metodológica de valoración económica de bienes, servicios e impactos ambientales. Edited by Radoslav B. INBIO, Costa Rica; 1999.

Barrantes G, Castro E: Valoración económico ecológica del recurso hídrico en la cuenca del Arenal, Costa Rica: el agua un flujo permanente de ingresos. In Proyecto Corredor Biológico Mesoamericano: Guía metodológica de valoración económica de bienes, servicios e impactos ambientales. Edited by Radoslav B. INBIO, Costa Rica; 1998a.

Barrantes G, Vega M, Maldonado T: Desarrollo de una base metodológica para el cálculo de un canon ambientalmente ajustado por aprovechamiento de agua en la cuenca del río Grande de Tárcoles. Instituto de Políticas para la Sostenibilidad; 2003.

Barrantes G: Economic Valuation of water supply as a key environmental service provided by Montane Oak Forest watershed areas in Costa Rica. Ecology and Conservation of Neotropical Montane Oak Forests Ecological Studies 2006, 185(VI): 435–446.

Barrio, Melina and Maria L. Loureiro: A meta-analysis of contingent valuation forest studies Original Research Article. Ecological Economics 2010 69(5), 1023-1030.

Bateman IJ, Mace GM, Fezzi C, Atkinson G, Turner K: Economic analysis for ecosystem services assessment. Environ Resour Econ 2011, 48:177-218.

Bernard F, de Groot RS, Campos JJ: Valuation of tropical forest services and mechanisms to finance their conservation and sustainable use: A case study of Tapantí National Park, Costa Rica. Forest Policy and Economics 2009, 11: 174-18

Bienabe E, Hearne RR: Public preferences for biodiversity conservation and scenic beauty within a framework of environmental services payments. Forest Policy and Economics 2006, 9(4): 335-348.

Brauman KA, Daily GC, Duarte TK, Mooney H: The nature and value of ecosystem services: an overview highlighting hydrologic services. Annual Rev Environ Resour 2007, 32:67-98.

Brouwer R, Tesfaye A, Pauw P: Meta-analysis of institutional-economic factors explaining the environmental performance of payments for watershed services. Environ Conserv 2011, 38:380-392.

Camhi A, Pagiola S: Payment for Environmental Services mechanisms in Latin America and the Caribbean: A compendium. Washington: World Bank; 2008.

Chiabai A, Travisis C, Markandya A, Ding H, Nunes PALD: Economic assessment of forest ecosystem services losses: costs of policy inaction. Environ Resour Econ 2011, 50:405-445.

Chomitz KM, Brenes E, Constantino L: Financing environmental services: the Costa Rican experience and its implications. Scie Total Environ 1999, 240:157-169.

Corbera E, Kosoy N, Martínez Tuna M: Equity implications of marketing ecosystem services in protected areas and rural communities: Case studies from Meso-America. Global Environ Change 2007,17:365-380.

Engel S, Pagiola S, Wunder S: Designing payment for environmental services in theory and practice: an overview of the issues. Ecol Econ 2008, 65(4): 663-674.

FAO, Food and Agriculture Organization: State of the World’s Forests. FAO, Rome 2012.

Fisher B, Kulindwa K, Mwanyoka I, Turner K: Common pool resource management and PES: Lessons and constraints for water PES in Tanzania. Ecol Econ 2010, 69(6): 1253-1261.

Fisher B, Turner KR, Morling P: Defining and classifying ecosystem services for decision making. Ecol Econ 2009, 68(3): 643–653.

Fisher B, Turner RK: Ecosystem services: classification for valuation. Biolo Conserv 2008, 141:1167–1169

Florax RJGM, Nijkamp P, Willis KG: Comparative environmental assessment 2002, Elgar, Cheltenham.

Fu BJ, Su CH, Wei YP, Willett IR, Lu YH, Liu GH: Double counting in ecosystem services valuation: causes and countermeasures. Ecol Res 2011, 26(1):1–14.

Gómez-Baggethun E, de Groot R, Lomas PL and Montes C: The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. Ecol Econ 2010, 69:1209-1218.

Johnson NL, Baltodano ME: The economics of community watershed management: some evidence from Nicaragua. Ecol Eco 2004, 49:57-71.

Johnston RJ, Besedin EY, Wardwell RF: Modeling relationships between use and non-use values for surface water quality: a meta-analysis. Water Resour Res 2003, 39(12):1363.

Koellner T, Sell J, Navarro G: Why and who much are firms willing to invest in ecosystem services from tropical forest? A comparison of international and Costa Rican firms. Ecol Econ 2010, 69:2127–2139.

Kosoy N, Martinez-Tuna M, Muradian R, Martinez-Alier J: Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America. Ecological Economics 2007, 61, 446-455.

Lele S: Watershed services of tropical forest: from hydrology to economic valuation of integrated analysis. Curr Opi Environ Sustain 2009, 12(1):148-155.

List JA, CA Gallet, What experimental protocol influence disparities between actual and hypothetical stated values? Environmental and Resource Economics 2001, 241-254.

Henrik Lindhjem, 20 years of stated preference valuation of non-timber benefits from Fennoscandian forests: A meta-analysis. Journal of Forest Economics 2007, 12(4), 251–277.

Loomis J B: Environmental Valuation Techniques in Water Resources Decision Making. J Water Resour Plann Manage 2000, 126:339-344.

MA, Millennium Ecosystem Assessment: Ecosystems and Human Well-Being: Current State and Trends. Island Press; 2005

Maltby E, Ormerod SJ: Freshwaters–openwaters, wetlands and floodplains. In: The UK National Ecosystem Assessment Technical Report, pp. 295–360. UNEP-WCMC, Cambridge; 2011.

Marozzi: La disposición a pagar a pagar en agua potable: El caso de Huacas, Guanacaste, Costa Rica. Tesis de Maestria. CINPE-UNA, 1998.

Martin-Ortega J, Jorda-Capdevilla D, Glenk K, Holstead K: What defines ecosystem services-based approaches?. In: Martin-Ortega J, Ferrier R, Gordon I, Kahn S (eds): Water Ecosystem Services: A Global Perspective. Cambridge University Press, Cambridge.

Martin-Ortega J, Ojea E, Roux C: Payments for water ecosystem services in Latin America: a review and conceptual model. Ecosystem Services 2013, 6: 122-132.

Martinez LM, Pérez-Maqueo O, Vázquez G, Castillo-Campos G, García-Franco J, Mehltreter K, Equihua M, Landgrave R: Effects of land use change on biodiversity and ecoysstems services in tropical montane cloud forest of Mexico. Forest Ecol Manag 2009, 258:1856–1863.

Meadows D, Randers J, Meadows D: Limits to Growth: Limits to Growth. Chelsea Green; 2004.

Mejías R, Alpizar E, Waterson V: Análisis beneficio-costo del programa de servicios ambientales en Costa Rica: tres estudios de caso. Proyecto Ecomercados. Centro Científico Tropical, CCT; 2000.

Menkhaus S, Lober DJ: International ecotourism and the valuation of tropical rainforest in Costa Rica. J Enviorn Manag 1996, 47:1-10.

Merayo O: Valoración económica del agua potable en la cuenca del río En Medio, Santa Cruz. Guanacaste. Tesis de Maestría. CATIE 1999.

Munoz-Pina C, Gevara A, Torres JM, Brana J: Paying for the hydrological services of Mexico's forest: analysis, negotiations and results. Ecol Econ 2008, 65:725–736.

Nelson JP, Kennedy PE: The use (and abuse) of meta-analysis in environmental and natural resource economics: an assessment. Environ Resour Econ 2009, 42: 345-377.

Nogaard RB. Ecosystem services: from eye-opening metaphor to complexity blinder. Ecol Econ 2010, 69:1219-1227.

Ojea E, Loureiro ML: Identifying the scope effect on a meta-analysis of biodiversity valuation studies. Res Energy Econ 2011, 33:706-724.

Ojea E, Martin-Ortega J, Chiabai A: Defining and classifying ecosystem services for economic valuation: the case of forest water services. Environ Sci Policy 2012, 19(20): 1-15.

Ojea E, Nunes PALD, Loureiro M: Mapping biodiversity indicators and assessing bioidviersty values in global forest. Environ Resour Econ, 2010, 47(3):329-347.

Pagiola S: Payments for environmental services in Costa Rica. Ecol Econ 2008, 65:712-724

Pascual U, Corbera E, Muradian R, Kosoy N: Special Section Payments for Environmental Services: Reconciling Theory and Practice. Ecol Econ 2010, 69(6):1193-1364.

Pascual U, Corbera E: Pago por servicios ambientales: perspectivas y experiencias innovadoras para la conservación de la naturaleza y el desarrollo rural. Revista Española de Estudios Agrosociales y Pesqueros 2011, 288:11-29.

Pearce D, Turner RK: Economics of Natural Resources and the Environment. Pearson Education Ltd; 1990.

Plummer ML: Assessing benefit transfer for the valuation of ecosystem services. Front Ecol Environ 2009, 7(1): 38–45.

Postle SL, Barton H and Thompson Jr: Watershed protection: Capturing the benefits of nature's water supply services. Nat Resour Forum 2005, 29: 98 – 108.

Reyes V, Cordoba C: Valoracion económic del bosque y su relación con el recurso hídrico para uso hidroeléctrico en la microcuenca del Río Volcan. Tesis de Maestría. CINPE-UNA 2000.

Reyes V, Miranda M, Monge C, Salar F: Valoración económica de los recursos hídricos en las cuencas de los ríos Banano y Banaito. The Nature Conservancy; 2004.

Reyes V, Segura O, Verweij P: Valuation of hydrological services provided by forest in Costa Rica. European Tropical Forest Research Network 2001, 35.

Solórzano R, Segura O, Tosi J, Burgos J, Castro E, Marozzi: Valoración económico ecológica del agua: primera aproximación para la interiorización de costes. CCT-CINPE. San José, Costa Rica; 1995.

Spangenbergh JH, Settele J: Precisely incorrect? Monetising the value of ecosystem services. Ecol Complex 2010, 7:327-337.

Stenger A, Harou P, Navrud S: Valuing environmental goods and services derived from the forests. J Forest Econ 2009, 1(1):1–14.

Sunderlin WD, Angelsen A, Belcher B, Burgess P, Nasi R, Santoso L, Wunder S: Livelihoods, forests, and conservation in developing countries: An Overview. World Dev 2005, 33(9), 1383-1402.

TEEB, 2010: The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

The UK National Ecosystem Assessment Technical Report, UNEP-WCMN, Cambridge, 105-159; 2010.

Turner RK, Morse-Jones S, Fisher B: Ecosystem valuation, a sequential decision support system and quality assessment issues. Ann N Y Acad Sci 2010, 1185: 79–101.

Turner WR, Bradley BA, Estes LD, Hole DG, Oppenheimer M, Wilcove, DS: Climate change: helping nature survive the human response. Conserv Letters 2010, 3(5): 304-312.

Valera V: Valoración económica de los recursos hídricos de la cuenca del río Grande de Tárcoles. Tesis de maestría. CATIE 1998.

Van der Ploeg S, Y Wang, T Gebre Weldmichael and RS de Groot: The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, 2010. Wageningen, The Netherlands.

Van Hecken G, Bastianensen J: Payments for ecosystem services: justified or not? A political view. Environ Sci Policy 2010, 13:785-792.

Vargas MT: Evaluating the economic basis for payments for watershed services around Amboró National Park, Bolivia. Master thesis, School of Forestry and Environmental Studies. Yale University, New Haven, CT 2004.

Veloz A, Southgate D, Hitzhusen J, Macgregor R: The economics of erosion control in a subtropical watershed: A Dominican case. Land Econ 1985, 61(2):145-155.

WEO, World Economic Outlook 2014, World Economic Outlook Database. From: https://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx

Wittington D, Briscoe J, Mu X, Barron W: Estimating the willingness to pay for water services in developing countries: a case study of the use of contingent valuation surveys in southern Haiti. Econ Dev Cult Change 1990, 38(2): 293–311.

Wunder S, Engel S, Pagiola S: Taking Stock: A Comparative Analysis of Payments for Environmental Services Programs in Developed and Developing Countries. Ecol Econ 2008, 65:834-852.Author 1, A.; Author 2, B. Title of the chapter. In Book Title, 2nd ed.; Editor 1, Editor 2, Eds.

Zandersen, Marianne and Richard S.J. Tol. 2009. A meta-analysis of forest recreation values in Europe. Journal of Forest Economics 15(1–2), 109–130.