Classifying Ecosystem Services for Economic Valuation: the case of forest water services

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Abstract

Since the release of the Millennium Ecosystem Approach (MEA), studies valuing ecosystem services have grown in the literature. As a consequence of this growing literature, different interpretations exist on the classification of services as derived from MEA, and several studies have argued that this may not be the most appropriate framework when the aim of the analysis is economic valuation. The present work contributes to this debate by reviewing and comparing these critical views in order to: firstly, to clarify the existing confusion in the terminology and interpretations; and secondly, shed some light into a desirable classification and conceptualization of ecosystem services for valuation. To illustrate this, we present an examination of existing primary valuation studies of water related services provided by tropical forests, that we analyze under the MEA classification framework and compare it with an output-based classification, in which the service is defined in terms of their benefits (outputs) to humans. Our results support the idea that an output-based classification should provide with more accurate values and could contribute avoid certain problems such as double counting and potential underestimation of services values.

Keywords: ecosystem services, Millennium Ecosystems Approach, water services, tropical forests.

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1. Introduction

Ecosystems are recognized around the world as natural capital assets supporting and supplying services highly valuable to human livelihoods (MEA, 2005; Daily and Matson, 2008). There is a growing appreciation of the important role that ecosystems play in providing goods and services that contribute to human welfare, as well as a growing recognition of the impact of human actions on ecosystems. This awareness has lead to the recent interest in integrating ecology and economics (Polasky, 2009). The estimation of the economic value of ecosystem services (ES now onwards) is expected to play an important role in conservation planning and ecosystem-based management (Plummer 2009; Stenger *et al.*, 2009), as well as for ensuring that human actions do not damage the ecological processes necessary to support the continued flow of ecosystem services on which welfare of present and future generations depends (MEA, 2005). This becomes even more relevant under the threat of climate change, where a 3°C warming is estimated to transform about one fifth the world's ecosystems (Fischlin *et al.* 2007). A lack of economic valuation could underestimate the importance of such resources and leave to a detriment on the ecosystem services supply. As a consequence, there is an increasing consensus about the importance of incorporating the "ecosystem services approach" (MEA, 2005) into resource management decisions. However, quantifying the levels and values of these services has proven difficult (Nelson *et al.*, 2009).

The traditional focus of economics has been on valuing single natural assets with commercial use (land, fisheries, forests, energy, etc.) and goods and services provided by nature in the absence of markets (clean air, aesthetics, or recreation). There have been some studies in the past that have addressed the valuation of all ecosystem good and services at the worldwide level (Costanza *et al.*, 1997; Turner *et al.*, 2006; Troy and Wilson, 2006). Costanza *et al.* (1997) conducted the first study attempting to value the benefits from ES for the entire range of ecosystems in a global basis. This approach was a pioneer work but has also been criticized for many limitations, the more severe concerning the assumed linearity of the marginal values of ecosystem services with land (Toman, 1998 and Bockstael *et al.*, 2000).

Since the release of the Millennium Ecosystems Assessment (MEA, 2005), it has increasingly being used as the conceptual framework both from the ecologic and the economic perspectives. It claims for the integration of ecology and economy by considering the flow of ecosystem services that determine human welfare. Efforts done to date on valuing ES have relied on the MEA framework, since the link between ecosystem functions, services and benefits was conceptualized. The MEA framework relates ecosystem functions and biodiversity with ecosystem services that have an effect on human welfare. At the same time, global change is impacting these ecosystem functions and having an effect on ecosystem services. Figure 1 represents how global change is having an effect on biodiversity and ecosystem functions, and this is translated into a change in the ecosystem services provided to humans, that will experiment changes in welfare associated with income.

Recent work is however shifting the stand of economic analyses to starting with land use and habitat functions to predict the provision of services and the value these services provide (Polasky *et al.*, 2005; 2008; Naidoo *et al.*, 2006; Naidoo and Iwamura, 2007). Therefore, complex ecological functions and processes have started to be put a value where traditionally no valuations were made at that ecological level. This development allows researchers to put the focus on ES at different stages of the ecological processes that derive in the final economic benefits. As a consequence, a mismatch between the interpretation of the general ecosystem services classification as proposed in the MEA and the service-specific valuations has arisen, as the MEA approach does not explicitly specify what services should be given a value in order to avoid double counting and other problems. Moreover, the literature on ES valuation is mixed as ecosystem services, functions and benefits are many times used with different meanings among studies (Fischer *et al.*, 2009). Therefore, when the objective of the ecosystem services assessment is economic valuation, some recent studies have claimed that the MEA framework is not the most adequate approach (Wallace, 2007; Boyd and Banzhaf, 2007; Fisher *et al.*, 2009, among others). The main argument to sustain this view has been the potential double-counting of benefits when putting a value on each of the MEA service categories. However, these critic studies are not unanimous in their interpretation of ES and further efforts are needed in order to understand what potential limitations can arise if directly employing the MEA approach for economic valuation, and how can these limitations be addressed.

The purpose of this research is double fold. First, we aim at shedding light into the current debate about the classification of ecosystem services by reviewing the existing disperse literature on this topic (mainly post- MEA but not only) and identifying which are the current points of conflict derived from these different types of classifications and their implications for economic valuation purposes. Secondly, we undertake a practical examination of the classification of water related services of tropical forest in order to illustrate the difficulties associated with the direct use of the MEA classification applied to existing primary valuation studies. For this purpose, we use an alternative output based classification.

The main contribution of this paper is therefore to add to the debate on the definition of ecosystem services and discuss the implications for economic valuation purposes, with a specific focus on water forest services. The structure of this paper is as follows: section 2 reviews recent studies revisiting the MEA framework and identifies the main sources of disagreement, section 3 presents the case of water related services in tropical forests to illustrate the controversies of ES classification and valuation. Section 4 analyzes the main results while section 5 concludes with some recommendations for future analysis.

2. The MEA Approach and Economic Valuation

The field of ecosystem services is being given growing attention during the last years, but still many challenges remain unsolved. A recent review conducted by de Groot *et al.* (2009) identified the main research questions needed to be resolved in order to overcome research gaps in the valuation of ecosystem services, from which understanding and quantifying how ecosystems provide services is one of the greatest challenges. The MEA describes a framework to understand the sequence of links from ecosystem functions to services, but studies employing this framework for valuation purposes are valuing both ecosystem functions and services without paying much attention on the interactions (Boyd and Banzhaf, 2007; Wallace, 2007; Fisher *et al.*, 2009). Additionally, as a consequence of the increasing number of studies that have applied the MEA approach for economic valuation, differences exist on the classification and measurement of ES, and this has raised some critics (Fisher *et al.*, 2009). Critical studies have put in question what the best classification of ecosystem services is when the goal of the analysis is economic valuation (Boyd and Banzhaf, 2007; Wallace, 2007; Fisher and Turner, 2008). These critiques build up on the MEA classification but differ in their arguments. In order to shed some light on the discussion of the appropriate classification approach for the valuation of ES, main recent classifications of ES before and after MEA are reviewed here and their implications are discussed.

2.1 Classifications of ES for Valuation: alternative approaches

In Table 1 we summarize the main different alternative classifications that have being presented in the recent literature, with their definition of ecosystem service, classification categories and a few examples for specific services.

The MEA classifies ecosystem goods and services in: *provisioning services,* which consist of products obtained from ecosystems; *cultural services*, the nonmaterial benefits that people obtain from the ecosystem; *regulating services,* including benefits obtained from the regulation of ecosystem processes; and *supporting services,* those which are necessary for the production of all other ecosystem services (MEA, 2003). The nature of these services is not reduced to purely ecological processes, and the MEA understands cultural services as ecosystem services.

Boyd and Banzhaf (2007) define ecosystem services as the components of nature, directly enjoyed, consumed, or used to yield human well-being. This definition advocates for a pragmatic classification of nature contributions to human welfare from the perspective of environmental accounting. They consider services as the end products of nature, and distinguish them from intermediate components, and from benefits. They only value services and exclude benefits, in which anthropogenic inputs are involved. This restricted view to pure ecological processes has the advantage of being accurate for national accounting, however, if we are interested on the total economic benefits that can be obtained from an ecosystem, this methodology will underestimate these values.

Wallace (2007) heavily relies on the MEA classification but he argues that only end services should be considered in valuation. They have three levels of classification: processes, ecosystem services (what is valued) and benefits. One example would be water and erosion regulation. These are considered regulating services by the MEA approach, while according to Wallace, both are processes to achieve potable water, which would be the final service. At the same time, timber would not be an ecosystem service according to this classification, arguing that it is a good and not a service provided by ecosystems.

Fisher *et al.* (2009) define ecosystem services as the aspects of ecosystems utilized (actively or passively) to produce human well being. Based on this definition, they provide a classification with four levels: i) Abiotic inputs: such as sunlight, rainfall or nutrients; ii) Intermediate services: like soil formation, primary productivity, nutrient cycling, photosynthesis, pollination, etc.; iii) Final services: water regulation, primary productivity; and iv) Benefits: water for irrigation, drinking water, electricity from hydro-power, food, timber, non timber products. These final benefits are what they value in economic terms and are always derived from intermediate or final services.

2.2 Main points of disagreement in ES definitions

We have identified four key areas of disagreement in the interpretation and classification of ES for valuation purposes, based on the review of the recent literature. These are: a) the definition of ecosystem services, b) which ecosystem services should be valued, c) the types of economic values that should be considered and d) the nature of the services. These areas of conflict concerning ecosystem services are further analysed here.

a) The definition of ecosystem services

According to the MEA, ecosystem services can be broadly defined as “the benefits people obtain from ecosystems”. This is a broad definition that includes all ecosystem services affecting human wellbeing, including both intermediate and final services. Previous definitions are “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life” (Daily, 1997); or Costanza’s (1997) definition of ecosystem services as “the benefits human populations derive, directly or indirectly, from ecosystem functions”. How ecosystem services are defined is directly related to the number of different terminologies and classifications of ecosystem services existing in the literature.

Fischer *et al.* (2009) have reviewed these and other studies and have identified the different terminologies being used to refer to ecosystem services. As a result they found that concepts such as “functions”, “processes”, “services” or “benefits” are being employed without a clear definition and referring to different concepts depending on the study. To overcome this problem, some authors recommend to distinguish benefits from services, as they may not be considered the same (Boyd and Banzhaf, 2007; Fisher and Turner, 2008). For these authors, *services* are processes of the ecosystems that are related to well-being, while *benefits* are outcomes of the ecosystem services and have a straight relation to human welfare (and this way have an economic meaning). Based on this discussion, some authors defend the valuation of ecosystem services (Fisher *et al.*, 2009; Boyd and Banzhaf 2007), while others defend the valuation of both ecosystem services and benefits (Wallace, 2007). Under this latter view, recreation would be understood as a benefit of which ecosystems provide important inputs, but not a direct service from the ecosystems.

b) The ecosystem services to be valued

One of the most frequently cited problems of the use of the MEA framework for valuation is the risk of double counting (Boyd and Banzhaf, 2007; Fisher *et al.*, 2009). The main argument for this is that the MEA classification can lead to double counting. Double counting may arise when a service is valued at two different stages of the same process providing human welfare, being an example a forest providing water flow (as a regulating service) and water supply for hydropower (as a provisioning service). The benefits from water supply for hydropower are directly dependent on the flow of water. If both services are given an economic value, the benefits obtained from that ecosystem can be overvalued. Many studies that have applied the MEA framework for valuation have addressed this problem by excluding supporting services from the valuation (Chiabai et al, 2009; Ojea *et al.* 2010), since supporting services are recognized by the MEA as being the support for the other services to exist (MEA, 2005). However, it can be the case where supporting services have associated economic values not addressed through provisioning or regulating services, and could therefore be considered in the benefit assessment of ES. In relation to this, there is a debate on the best way to distinguish ecosystem services from functions, and how to classify the services to make them quantifiable in a consistent manner (Godoy *et al.*, 2009). While some studies do not consider functions for valuation, some analysts have argued that the source of value of biological diversity is linked to the functioning of ecosystems, and that this value may be more important than values arising from individual species as in bioprospecting (Polasky, 2009). In this line of thinking, biological diversity is important for sustaining the functioning of ecosystems, which in turn provides valuable life support services (Polasky, 2002), and such value may differ from the benefits from individual species. Other studies have avoided the complexity of ecosystem functioning by focussing on the final benefit that connects to human well-being (Fisher and Turner, 2008). In this line, Boyd and Banzhaf (2007) go further by defending the valuation of ecosystem services through "components" of nature, where components are understood as final goods coming from ecosystems that are consumed by people.

c) The types of value considered

A debate also exists regarding the inclusion of non-market values in the ecosystem services valuation, and specially, non-use values. Sometimes it is argued that non-market values should not be included due to the difficulties of its estimations and the unreliability of the methods to do so. In this respects, some authors argue that stated preferences methodologies often do not measure marginal changes (Turner *et al.*, 1998), and what they measure is the total existence value of a resource. Other studies criticize the bias related to stated preference techniques (Fisher *et al.*, 2009), even when the literature on non-market valuation has evolve so far in the last decade with methodological refinements that have reduced the significance and increased the understanding of these bias. Another critic argument against existence values has been the insensitivity to scope (Boyle *et al.* 1994; Desvousges *et al.* 1993; Diamond and Hausman, 1994). However, recent studies defend the idea that non-use values are strictly related to the existence of a resource, and scope insensitivity cannot be a criteria for invalidating contingent valuation (Heberlein *et al.*, 2005; Ojea and Loureiro, 2009). As a consequence, existence values are attached to the minimum biological levels of a resource (eg. minimum viable population of a specie or minimum habitat area needed for a desired biodiversity level), and are difficult to relate to a environmental change that is not crossing this minimum boundaries. If we are valuing the benefits from ecosystem services we are thus interested on the total economic value (TEV) of that ecosystem. In order to derive the total economic value we cannot exclude existence values as we will be underestimating the overall benefits. However, if we are valuing flows, existence values will become relevant when the maintenance of the ecosystem service is threatened.

d) The nature of the services

Some authors claim that ES should be strictly defined as ecological phenomena, and thus cultural and scenic values should be excluded from the classification of ES (Fisher *et al.*, 2009; Boyd and Banzhaf, 2007). Other authors claim that services which are directly linked or interacting with human activity such as recreation (through the tourism business) or timber production (through forestry) should not be considered as a service from the ecosystem. The main reason for this argument is that other inputs than natural are included in the provision of the service (e.g. labour force, technology, etc.) (Boyd and Banzhaf, 2007). Boyd and Banzhaf (2007) justify this distinction as they are interested on the services of ecosystems that are purely contributing to national accounting, and thus increasing GDP. On contrast, if the aim of an approach is different from identifying and valuing purely the ecosystem services adding to GDP, we see no reason for excluding cultural services. There are three main reasons for including them: first, as stated before, if we exclude cultural values we will exclude non-use values related to the existence of the resource, that may fall in the category of cultural values; second is that indeed, non-use values contribute to the TEV of the ecosystem; and third is that cultural values such as recreation, scenic beauty or the existence value of a resource may be determined by ecological phenomena. As an example, people’s preferences for recreation may be conditional to the good ecological status of the ecosystem, the species composition, biodiversity richness and other ecological functions of the ecosystem.

To a large extent, the above mentioned problems (a, b, c and d) are derived from the fact that the MEA classification is not clearly focused on the final outcomes that ES’s provide to humans, which are what generates an impact (positive or negative) in human welfare, and therefore are susceptible to have an economic value. To explore to what extent these problems can be identified and addressed by means of an adequate classification for valuation, we confront the MEA classification with an output based classification for the case of forest water services.

3. Identifying forest water related services for valuation

Water related services provide a good example of the above mentioned difficulties regarding the classification of ecosystem services for economic valuation purposes and it is used here to illustrate the above discussed debate. Also, despite the literature on water quality impacts is fairly well spread out (Alyward, 2002) and valuation studies exist since at least 1970 (Wilson and Carpenter, 1999), economic analysis of watershed services as provided by tropical forests is still scarce (Lele, 2009). Existing studies have quantified the value of environmental amenities such as water quality, but the valuation of ecosystem services provided by forests producing these amenities is less clear. Therefore, understanding the role of forests as providers of water related services and the way economic valuation should measure these services still needs clarification and further development.

For improving this understanding, a practical examination of existing water valuation studies has been undertaken. We examine these studies under the MEA classification framework and compare them with an existing alternative output-based classification, in which the service is defined in terms of their benefits (output) to humans. The result of this examination is used to illustrate the points of conflict or disagreement already mentioned in the general review of this paper, and this will be used to highlight the main implications that should be considered in future research. We focus on water services from tropical forests as these services are particularly important for communities in the tropics, both because rainfall is highly seasonal or locally limited and because, generally, intensively cultivated and densely populated agrarian landscapes downstream are affected by soil-hydrological process in the upstream forest (Bonell and Bruijnzeel, 2004).

3.1 Classification of water related services

The water cycle plays many roles in the climate, chemistry, and biology of Earth, making difficult to define it as a distinctly supporting, regulating, or provisioning service (MEA, 2005). This is due to the fact that while ecosystems are strongly dependent on the water cycle for their very existence, at the same time these systems represent domains over which precipitation is processed and transferred back to the atmosphere or passed to other system –both aquatic or humans such as farmers who irrigate. This intimate interlinkage make the classification of water related services particularly complex.

Following the MEA framework, it is common to list flood control, water regulation, soil erosion control and water purification under the notion of 'regulating services'; water supply as 'provisioning services' and habitat function as a 'supporting service' (Lele 2009). Other approaches to classify water services have been used in the past. Alyward (2002) group together erosion, sedimentation and nutrient outflow under the category of 'water quality' impacts; while changes in water yield, seasonal flow, storm flow response, groundwater recharge and precipitation are considered as 'water quantity' issues. Also prior to the MEA, De Groot *et al.* (2002) included water regulation and water supply as part of ecosystems regulation functions. According to this distinction, water supply refers to the filtering, retention and storage of water in streams, lakes and aquifers performed by the vegetation cover (soil biota) and focuses primarily on the storage capacity of forest rather than the flow of water through the system. The ecosystem services associated with water supply in this category relate to the consumptive use of water by households, agriculture and industry. Water regulation in this context deals with the influence of natural systems on the regulation of hydrological flows at the earth surface. According to De Groot *et al.* (2002) ecosystem services derived from the water regulation function are, for example, maintenance of natural irrigation and drainage, buffering of extremes in discharge of rivers (thus flood protection), regulation of channel flow, provision of a medium for transportation, groundwater recharge, water purification and erosion control. It is worth noticing how De Groot *et al.*'s definition of water regulation functions is to some extent divergent from the more recent MEA classification. In the MEA approach water supply corresponds to a provisioning service, and water filtering falls into the regulating services (where it is called 'purification'). Both de De Groot *et al.*'s and MEA approach coincide in splitting habitat functions as a separate supporting category, as it provides with living space for wild plants and animal species.

The problem with these classifications is that there is not always a clear distinction between the structure of the ecosystem, the ecosystem processes and the impacts they produce (ie. outcomes or benefits). In this line, Lele (2009) highlighs that structural changes in ecosystems (e.g. timber plantations) can influence several watershed processes (e.g. erosion rates, increase/decrease in water flow, increase/decrease in groundwater recharge). These changes can result in different kinds of human impacts (that can be negative, eg. decreased reservoir capacity due to salinitation, or positive, increased fertilization of floodplain lands)[1]. These impacts can affect different stakeholders (farmers, drinking water users, livestock owners, floodplain residents, hydropower companies) and can be positive or negative (eg. increase in groundwater recharge can imply more water availability; while increase in sediment load represents a negative impact in terms of for example, water use for hydropower) . According to this approach, the 'process' should not be the focus of valuation, but it is the outcome of the process what has an economic meaning, as it represents an impact on human welfare (benefit or cost).

Following this approach, a practical classification for economic valuation purposes could be therefore based on the output of the ecosystem processes. Failing to do so can have important consequences for valuation. On the one hand, there is the risk of estimating values of different stages of the same process that added up represent an over estimation. For example, we cannot value at the same time the capacity of a forest to provide regulation control over base and peak flow, and the value of hydropower generation, as the later is the outcome of the stream flow stability process. On the other hand, focusing only on certain processes we might be ignoring different types of outcomes derived from that same process. It is therefore necessary for economic valuation purposes to categorize all these services in a manner that, on the one hand, avoids double counting but that in the other hand allows for the inclusion of all elements affecting human welfare. The purpose of this study is to illustrate these difficulties through a practical examination of existing primary valuation studies of water related services provided by tropical forest and to highlight some of the implications that this might have for economic valuation.

[1] Aylward (2002) can be consulted for a pretty exhaustive relation of the nature of the impacts of tropical forest loss in water services.

3.2 Examining water related services classifications: methodological approach

In order to illustrate the problems arising from the classification of ES for economic valuation purposes, we have undertaken a review of existing primary valuation studies of hydrological services in tropical forest, that we have examined according to the MEA classification and an alternative output based categorization. For this purpose, we use Brauman *et al.* (2007) classification of water services. We have chosen this classification as a purely is specifically for water services and it is strictly output-based. Brauman *et al.* (2007) classify the water services in : i) improvement of extractive water supply, ii) improvement of in-stream water supply, iii) water damage mitigation, iv) provision of water-related cultural services, v) and water-associated supporting services. Under this classification, extractive water supply is a provisioning service describing ecosystems modification of water used for extraction purposes, which include municipal, agricultural, commercial, industrial and thermoelectric power use. In-stream water supply includes hydropower generation, water recreation and transportation, and freshwater fish production. Water damage mitigation is a regulating service; it includes ecosystem mitigation of flood damage and of sedimentation of water bodies, saltwater intrusion into groundwater and of dry-land salinization. Cultural hydrologic services include spiritual uses, aesthetic appreciation and tourism. The water-related supporting services of terrestrial ecosystems are wide-ranging and include the provision of water for plant growth and to create habitat for aquatic organisms such as estuaries.

We have focused in Central and South America, as one of the main source together with south-east Asia water services valuation studies (Lele, 2009). We indentified 25 valuation studies that were published from 1985 to 2009, providing over 100 value observations. Most of them (60%) are published in peer review journals but we have chosen to also include 'grey literature' – not published in peer reviewed journals- which in this case concerns mostly technical reports made for public administrations[2]. This choice was made because it allowed us to a significant increase of the number of observations, but also because we are aiming at assessing the problems of ES in practice, and therefore, we are interested at the way in which services are *actually* being defined in economic assessment for policy purposes.

[2] This is the case of important number of studies prepared by the Tropical Agronomic Research Institute (CATIE) in Costa Rica, made to inform the Ministry of Environment of the country).

The studies include a range of valuation techniques from cost-based methods (including avoided costs, reforestation costs and opportunity costs); to non-market stated preferences techniques (mostly contingent valuation) and market data (eg. hydropower and agricultural production). We also have included in our dataset a number of Payments for Ecosystem Services (PES) studies as approximation of market data[3]. Once the valuation studies were identified, a four-step methodological approach was followed. Figure 2 graphically illustrates this examination process, which consists in:

1. Identification of the water services valued. We identify the water services valued in the valuation study as reported in the original paper.

2. Identification of the MEA corresponding categories. We associate the services under valuation from step 1 to the main MEA categories, following the MEA framework of classification (MEA, 2005)[4].

3. Re-classification of the valued services on the basis of an output-based classification. We classify original services from step 1 into an output-based category (Brauman *et al.*, 2007).

4. Identification of the potential problems derived from ES classifications. We then compare the results of steps 2 and 3 and identify the main sources of conflict.

[3] By means of creating market transactions between downstream and upstream economic agents, PES schemes are supposed to induce upstream stakeholders to take downstream effects into account when making decisions about their own land use and they are expected to contribute forest conservation (Pagiola, 2005). The fact that entering on the PES scheme is in most cases voluntary, indicates that if the service buyers (for example, hydroelectric companies or irrigators) are willing to participate is because their WTP for the service is at least the price of the payment scheme. However, taking the payments as a value of the service requires some considerations as they do not correspond necessarily to the maximum WTP of the beneficiaries, and therefore do not produce a strictly correct measure of economic value. The actual price of the service is not necessarily established by a previously identified market study on buyers' WTP. Take for example the case of Jesus de Otoro watershed in Hondura reported by Kosoy *et al.* (2005). The actual PES fee was determined by a series of technical studies, which were supposed to include an economic valuation and was only 3.6% of the water users' WTP estimated in a survey. However, we consider that the PES payments can be taken as an indicator of the value, albeit very likely a lower bound, and that is why we include it in our study.

[4] It should be noticed that this does not mean that in the analyzed studies, authors make explicit the correlation between the service they value and a MEA corresponding category (at least not in all cases). This correlation is made as part of our analysis.

4. Results and Discussion

Table 2 presents the results of the examination analysis. It includes a column corresponding to each of the steps of the process: valued service as defined in the study, corresponding MEA categories and output-based defined according to Brauman *et al.*'s (2007) classification. The country of study and the range of the values reported in the studies (in 2005 USD value per hectare of forest) is also included. From this examination exercise, the potential problems that can arise from the classification of ES have been identified. These potential problems are presented in Table 2 and are summarized here:

- ***Double counting.*** When the valued service corresponds to a process and not an output, there is a risk of double counting. For example, the study by Postle *et al.* (2005) reports the value for water flow. The outcome of that process (water flow) could be for instance hydropower generation. If an additional value is given to hydropower, we would be double counting. This is also the case of Barrantes and Castro (1998a) who value permanence and continuity of stream-flow for hydropower generation. Another source of risk of double counting comes when the valued service corresponds to two different MEA categories but actually respond to outputs of the same nature. This is the case for example of the several studies valuing water quality and water quantity. Under the MEA framework this could be interpreted as two different categories of service: provisioning in the case of water quantity and regulating in the case of water quality ('purification'), while by analyzing the studies, one realizes that in most cases the value is given to one same output: water consumption, and therefore the value refers to the improvement of extractive water supply. This is the case of the studies by Johnson *et al.* (2004) who value potable water availability in the Calico watershed in Nicaragua; and the case of Valera's (1998) study in Costa Rica; and Whittington *et al.* (1990) in Haiti.

- ***Potential value underestimation.*** In some cases, two services of a different output nature are valued together corresponding to one only MEA category. This is the case, for example, of the study by Corbera *et al.* (2007), who report on a PES in Guatemala for the maintenance of the water flow and the reduction of sediment load in the La Escoba River. Under the MEA framework, these two services correspond to one only category: regulating, but they are actually of a different nature as one corresponds to a regulating service related to the in-stream use of water, while the second relates to damage mitigation. Producing an only value for these two types of services results in underestimation of the total value. Other studies report the compounded value of outcomes of an essentially different nature. This is the case for example of the study by Asquith *et al.* (2007) and Vargas (2004) which includes the in-kind payment for two environmental services in Bolivia: the protection of habitat of migratory bird species and upland vegetation for protecting *dry-season water supplies.* As the service buyers are jointly compensating individual upstream landowners the value can only be considered as the compounded value of the water flow and supply and the non-use value of the preservation of habitat, so provisioning, regulating and supporting services all together. In the study by Reyes *et al.* (2001) only one value is given for domestic water supply and for hydropower. Additionally, some studies report the value of forest for 'water capture function' (eg. Barrantes and Castro 1998b) or generically the value for 'hydrological services' (eg. Reyes *et al.* (2004). This does not allow for knowing which is the actual benefit that is been valued and it is unclear if it is the total value of all water services provided by the forest and can lead to underestimation of the total forest value.

Moreover, it should be mentioned that in the reviewed literature there is hardly any non-use value reported as such. It is unclear from the reviewed studies whether a value is given to water flow or water continuity (eg. Corbera *et al.* 2007; Postle *et al.* 2005) also include non-use related values.

Finally, there is a set of studies for which we have found no conflict between the definition of the service as reported in the original study and its corresponding MEA category with the output-based classification. This concerns basically water supply provisioning services for its extractive use or consumption. This is the case of the studies by Barrantes and Castro (1998a and 1999), who value water as an input for agricultural production in Rio Grande de Tárcoles watershed (Costa Rica); Marozzi (1998), who puts a value in potable water in Las Huacas de Guanacaste, also in Costa Rica and Pagiola's (2008) payments for ecosystem services for water supply to hydropower, bottling and irrigation in Costa Rican forests.

The above analysis illustrates, for the case of water services, the main issues discussed in the literature and help us to flag up the existing potential problems of applying directly the MEA classification of ecosystem services. From the analysis we can conclude that more efforts should be made when valuing ecosystem services in order to avoid the potential problems identified here. Additionally, we have observed other issues such as the variety of definitions of ecosystem services, even within the water services literature. Additionally, there is a lack of attention ton non-use values and the nature of the services is often mixed up.

The identification of these potential problems should allow us to feedback on the design of primary valuation studies which accurately assess service value, and not process of functions, focusing on the actual outputs of the service provided by forest. Particular care should be taken in the definition of the service to be valued, identifying first which is the nature of the service in terms of its outputs (benefits) for humans. For example, if we are talking about regulation of water quality, it needs to be clearly defined whether it is for human supply (extractive supply) or for habitat conservation (supporting) or both. This is particularly the case for non provisioning services, which seem to be more difficultly defined for valuation purposes and are more susceptible of double counting or value underestimation.

The exercise presented here should be understood as a first attempt to illustrate the conflicts between the MEA framework classification of ES with the actual outputs that the services provide to humans, and that have an impact in welfare. A larger sample of studies could be analyzed, for example by including the abundant literature on tropical forest ecosystem valuations in south-east Asia or expanding the analysis to another type of ecosystems, such as wetlands. The output classification (Brauman *et al.* 2007) used here as an alternative to MEA, has been selected from the existing classifications for water services as it is the most clearly output focused, but it is not exempt of limitations. For example, the role of non-use related services is not clearly reflected in this classification and gets diluted under the category of water related supporting services.

5. Concluding Remarks

Having accurate information on the welfare changes associated with ecosystem services is of crucial importance for the design of effective conservation strategies. The definition of the MEA framework has represented a very significant progress in the recognition of ecosystem services and has served as an important basis for their valuation. However, recent studies have started to question the capability of employing the MEA framework for the definition and classification of services for the purpose of valuation in an accurate manner. This literature is however not unanimous. In this paper we have identified the main different interpretations between classifications of ES and their valuation, according to: the definition of services, the ES that are valued, the types of economic values that are considered in the services and the nature of these services. From this review, we conclude that there is an important need for research on the definition, interpretation and classification of ecosystem services to successfully go beyond the MEA framework for valuation purposes.

The case of water related services has proven to be a good example for illustrating the potential problems of classifying ecosystem services given the current discussion in the literature. The review of the literature of existing studies shows clearly how the valuation studies up to date have focused on different aspects of water services, which is sometimes valued at different stages of the same process providing human welfare (eg. stream flow and hydropower supply) and sometimes put one only value in two services of a different nature (eg. in-stream use of water and damage mitigation). When analysing in detail the case of water related services in tropical forests, we obtain that a straightforward application of the MEA categories can potentially generate problems, not only double counting, but also the potential underestimation of the services value. Our results support the idea that an output-based classification should provide with more accurate values. Valuation should therefore focus on the outcomes of these ecosystem services and pay attention on the interactions among services on a given ecosystem, putting an additional effort to develop output-based classifications that help in a more accurate valuation. Future research should explore what classifications of ecosystem services are more suitable for economic valuation at the case study level.

There is a need to apply a classification of ES that avoids biasing the estimation of the benefits from ecosystem services. This becomes relevant both for synthesizing the work done on ES valuation but also for conducting new primary studies valuing ES. Future research should explore what classifications of ES are more suitable for economic valuation at the case study levels. We believe that the framework developed here may contribute to avoid potential problems in the valuation of ecosystem services, such as avoiding double-counting and identifying at what process ecosystem services are providing economic benefits. However, we conclude that classifying ecosystem services may be case and context specific, depending both on the interactions among services and how these services affect human welfare.

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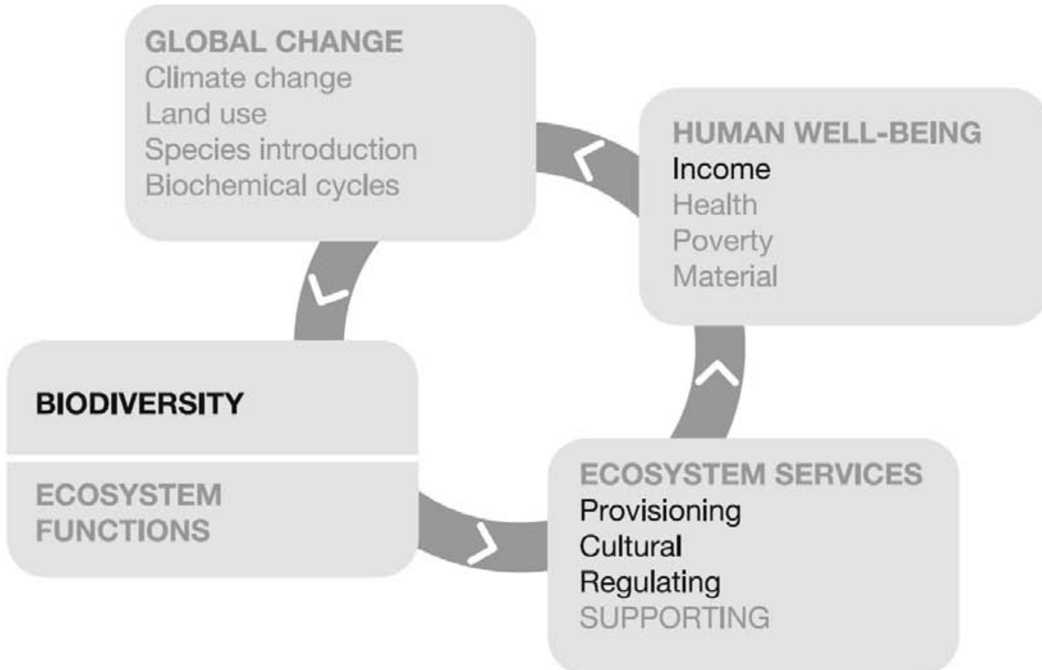
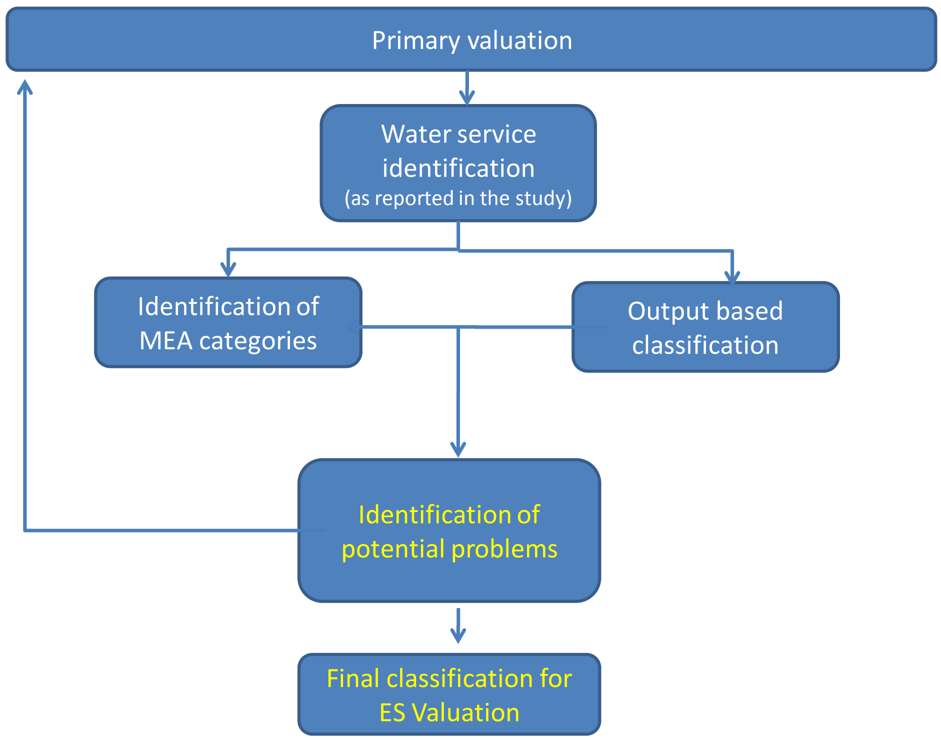
Figures

Figure 1. MEA Conceptual Framework



Source: Adapted from MEA (2005), Simboloxico.

Figure 2: Methodology for the classification of water related ES from a sample or primary valuation studies.



Tables

Table 1: Different classifications for ecosystem services

Source		Daily (1997)	MEA (2005)	Boyd and Banzhaf (2007)	Wallace (2007)	Fisher and Turner (2008)
ES definition		The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life	Benefits people obtain from ecosystems	Components of nature directly enjoyed, consumed, or used to yield human well-being	Benefits people obtain from ecosystems	Aspects of ecosystems utilized (actively or passively) to produce human well-being
Classifications and ES Value*			**Cultural** **Provisioning** **Regulating** **Supporting**	Intermediate components **Services** Benefits	Processes **Ecosystem services** Benefits	Abiotic inputs Intermediate services **Final Services**
Types of economic value		Use and non-use values	Use and non-use values	Use values	Use and non-use values	Use values
Nature of the ES		Ecological and Anthropogenic	Ecological and Anthropogenic	Ecological functions	Ecological and Anthropogenic	Ecological functions
examples	Flood regulation	YES	YES	NO	NO	YES
	recreation	YES	YES	NO	YES	NO
	aesthetic	YES	YES	NO	YES	NO

*the category under economic valuation according to each original study is indicated in bold.

Table 2: Classification Services from Water Related Services

Reference	Country	Ecosystem service as referred to in the site	Value 2005 USD /ha*	MEA classification	Output-based classification[1]	Examination output
Adger *et al.* (1995)	Mexico	avoided sedimentation	0.40 – 1.76	regulating	water damage mitigation	No conflict detected
Asquith *et al.* (2008)	Bolivia	water flow and supply and non-use value for bird habitat	0.08 – 3.16	regulating, provisioning and supporting	improvement of extractive water supply; in stream water supply and supporting	Potential value underestimation
Barrantes and Castro (1998a)	Costa Rica	permanence and continuity of stream flow	3.03	regulating	in stream water supply	Potential double counting
Barrantes and Castro (1998b)	Costa Rica	water capture function	na	all water services	all water services	Potential value underestimation
Barrantes and Castro (1998b)	Costa Rica	watershed protection	na	all water services	all water services	Potential value underestimation
Barrantes and Castro (1998a)	Costa Rica	water as an input for production	na	provisioning	improvement of extractive water supply	No conflict detected
Barrantes *et al.* (2003)	Costa Rica	water productivity of the forest	na	all water services	all water services	Potential value underestimation
Barrantes and Castro (1999)	Costa Rica	water supply	1.96 – 144.74	provisioning	improvement of extractive water supply	No conflict detected
Chomitz et a.l (1999)	Costa Rica	water flow for hydropower generation	18.85	regulating and provisioning	in stream water supply	Potential double counting
Corbera *et al.* (2007)	Guatemala	continuous waterflow and reduction in sediment loads	22.14	regulating	in stream water supply and water damage mitigation	Potential value underestimation
De Sena (1997)	Costa Rica	recreation	na	cultural and amenity	water related cultural services	Potential double counting
Johnson *et al.* (2004)	Nicaragua	potable water availability (quantity and quality)	1.18	provisioning and regulating	improvement of extractive water supply	Potential double counting

Table 2 (cont.): Classification Services from Water Related Services

Reference	Country	Ecosystem service as referred to in the site	Value 2005 USD /ha*	MEA classification	Output-based classification[1]	Examination output
Kosoy *et al.* (2007)	Honduras Costa Rica Nicaragua	water quality	3.05 – 51.58 76.24 – 530.30 29.51 – 366.06	provisioning and regulating	improvement of extractive water supply	Potential double counting
Marozzi (1998)	Costa Rica	potable water	4.94	provisioning	improvement of extractive water supply	No conflict detected
Martínez *et al.* (2009)	Mexico	water regulation and recreation (mixed together)	147.75	regulating and cultural services	in stream water supply	Potential double counting
Mejías *et al.* (2000)	Costa Rica	household water consumption	na	provisioning	improvement of extractive water supply	No conflict detected
Mejías *et al.* (2000)	Costa Rica	water quality and quantity	na	provisioning and regulating	improvement of extractive water supply; in stream water supply	Potential value underestimation
Mejías *et al.* (2000)	Costa Rica	hydropower	na	provisioning	in stream water supply	Potential double counting
Merayo (1999)	Costa Rica	potable water for household supply	2.81	provisioning	improvement of extractive water supply	No conflict detected
Moreno (2006)	Costa Rica	water capture function	59.77 – 75.23	all water services	all water services	Potential value underestimation
Pagiola (2008)	Costa Rica	water supply for hydropower	15 – 67.96	provisioning	in stream water supply	Potential double counting
Pagiola (2008)	Costa Rica	water supply for bottler	41.24	provisioning	improvement of extractive water supply	No conflict detected
Pagiola (2008)	Costa Rica	water supply for irrigation	30 – 51.21	provisioning	improvement of extractive water supply	No conflict detected

Table 2 (cont.): Classification Services from Water Related Services

Reference	Country	Ecosystem service as referred to in the site	Value 2005 USD /ha*	MEA classification	Output-based classification[1]	Examination output
Pagiola (2008)	Costa Rica	water supply for tourist companies	45	provisioning	improvement of extractive water supply	No conflict detected
Postle *et al.* (2005)	Ecuador	water supply	0.32	provisioning	improvement of extractive water supply	No conflict detected
Postle *et al.* (2005)	Costa Rica	water flow	0.09	regulating	in stream water supply	Potential double counting
Reyes *et al.* (2001)	Costa Rica	hydropower and water consumption	152.71 – 268.77	provisioning	improvement of extractive water supply and in stream water supply	Potential value underestimation
Reyes *et al.* (2004)	Costa Rica	hydrological services	na	all water services	all water services	Potential value underestimation
Reyes and Cordoba (2000)	Costa rica	hydropower	193.69	provisioning	in stream water supply	Potential double counting
Solórzano *et al.* (1995)	Cosa Rica	water consumption	na	provisioning	improvement of extractive water supply	No conflict detected
Valera V (1998)	Costa Rica	water supply (quantity and quality)	167.73	provisioning and regulating	improvement of extractive water supply	Potential double counting
Vargas M T (2004)	Bolivia	water flow and supply and non-use value for bird habitat	0.63	regulating, provisioning and supporting	improvement of extractive water supply; in stream water supply and supporting	Potential value underestimation
Veloz *et al.* (1985)	Dominican Republic	avoided erosion	6016.55	regulating	water damage mitigation	No conflict detected
Whittington *et al.* (1990)	Haiti	water supply (quantity and quality)	238.40	provisioning and regulating	improvement of extractive water supply	Potential double counting

[1]As proposed by Brauman *et al.* (2007)
na: not available, missing values correspond to studies for which it was not possible to identify related forest area and therefore value per hectare is not possible to calculate. An analysis of the factors determining services values can be consulted in Chiabai *et al.* (2010).