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The Use of Ecosystem Services Approach in Guiding Water Valuation and Management: Inland and Coastal Waters

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The Use of Ecosystem Services Approach in Guiding Water Valuation and Management: Inland and Coastal Waters

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Abstract In this chapter we develop an interdisciplinary methodology for identifying water-related ecosystem functions into ecosystem services for humans, which are then monetarily evaluated using market and non-market valuation methods. We then apply this methodology to selected case studies on inland and coastal waters and show how these results facilitate the implementation of the EU Water Framework Directive and the EU Marine Strategy Framework Directive.

Keywords: Total Economic Value, Ecosystem Services, Water Resources Management, EU Water Framework Directive, EU Marine Strategy Framework Directive.

1 Introduction

The purpose of this chapter is to present a methodology for the assessment of the total economic value of water services (i.e. the sum of financial, environmental and scarcity values), the cost recovery level for water services following an ecosystem services approach and the identification of cost-effective measures to enhance current levels of cost recovery. This methodology has been applied before in the implementation of the economic elements (articles 5, 9 and 11) of the European Water Framework Directive in Cyprus, Greece and Spain (for more details see Birol, Karousakis and Koundouri 2006a and 2006b, Koundouri 2010a and 2010b, Koundouri and Papandreou 2012 and Diaz *et al* 2013). The chapter is organized as follows: section 2 presents a brief overview of the European Water Framework Directive and the Marine Strategy Framework Directive, section 3 explains our proposed methodology for sustainable water resources management and section 4 presents examples of its application in Spain and Finland.

2. The EU's Water Framework Directive and the Marine Strategy Framework Directive

2.1 The European Union's Water Framework Directive

The European Union's Water Framework Directive (WFD) provides an integrated framework for water resources management and protection in Europe, both in terms of quality and quantity, to achieve the objective of good water status for all European Union (EU) waters by 2015 (EC 2000). This legally binding policy came into force in December 2000 and was voted in by the EU's Parliament in September 2000 (Kaika 2003). The WFD conveys the need to approach human activity and water resources in an integrated manner to achieve sustainable water resources management. It is important to highlight that the WFD explicitly recognizes the role of economics in reaching environmental and ecological objectives and demands the application of economic principles, approaches, tools and instruments at River Basin District (RBD) level.

The economic elements of the WFD are discussed in the following articles: Article 5 "Characteristics of the river basin district, review of environmental impact of human activity and economic analysis of water use," Article 9 "Recovery of costs for water services," Article 11 "Program of measures" and Annex III "Economic analysis." The implementation of the economic elements contained in the WFD is done following a RBD specific approach. The first step in this approach is to conduct an economic characterization of water at RBD. This involves the estimation of the socio-economic significance of water uses and the investigation of the dynamics of key economic drivers that may influence water pressures and its current status. The second step is an assessment of the recovery of the costs of water services, and the final step is an economic assessment of potential measures for balancing water demand and supply (WATECO 2002).

One of the most important concepts in the WFD refers to water resources management based on the recovery of the total economic cost of water services. Article 9 states that Member States "shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle" (EC 2000). The environmental cost reflects social welfare losses associated with water quality deterioration, caused by the water uses, while the resource cost represents additional costs required to cover water demand under water deficits due to the overexploitation of available water resources. Furthermore, the WFD also states that the cost recovery of water services should be analyzed for different water uses, which should be at least disaggregated into households, industry and agriculture. Table 1 shows the disaggregation of the total cost of water services.

Table 1 Total economic cost of water

Financial Cost	Costs of providing and administering water services: capital cost, operation cost, maintenance cost and administrative cost.
Environmental Cost	The environmental cost represent the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinization and degradation of productive soils).
Resources Cost	Resource cost represents the costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater).

Source: Koundouri, Kountouris and Remoundou (2010)

In Annex III of the Directive, it is explained that the economic analysis reports should contain adequate information on the major drivers and pressures in each RBD and on the contribution of water uses in the recovery of costs consistent with the polluter pays principle, to enable the selection of the program of measures on a cost-effectiveness basis (EC 2000). Nevertheless, the Commission’s Compliance Report (EC 2007) states that one of the main deficiencies in the WFD implementation is the economic assessment. Even though all EU Member States sent country reports in accordance to Article 5, half of them did not supply information at all on cost recovery. This reflects the informational and methodological difficulties that Member States face when implementing the economic elements of the WFD.

In order to achieve its goal of good environmental status for all water bodies by 2015, the WFD established a program and timetable for Member States to set up River Basin Management Plans (RBMPs) by 2009. However, there have been problems in their implementation. According to the Report from the Commission to the European Parliament on the implementation of the WFD, the assessment of the RMBPs “shows the poor quality of the assessment of costs and benefits. A strong improvement in this area and the definition of a shared methodology for the calculation of costs (including environmental and resource costs) and benefits (including ecosystem services) is necessary. Otherwise, it will be possible neither to ensure the implementation of effective pricing policies nor to avoid disproportionate and inadequate measures” (EC 2012). Finally, according to Article 9 of the

Directive, by 2010 Member States should have introduced pricing policies and economic instruments with the element of cost-recovery for the environment's benefit. Nonetheless, "there are very few Member States that have implemented a transparent recovery of environmental and resource costs. Cost recovery is implemented, to a greater or lesser extent, in households and industry. For agriculture, in many areas, water is charged only to a limited extent" (EC 2012). Therefore, the report suggests to the EU Member States to improve cost-benefit assessment to ensure cost-recovery and to ensure the transparency and fairness of water pricing policies.

2.2 The European Union's Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD 2008/56/EC), was published in the Official Journal of the European Union the 17th of June 2008. It states that pressure on natural marine resources and the demand for marine ecological services are too high. Thus, its main goal is to achieve good environmental status of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. In the MSFD, a thematic strategy for the protection and conservation of the marine environment was developed with the objective of promoting sustainable use of the seas while protecting marine ecosystems. In a similar fashion to the WFD, it requests that Member States across a marine region or sub-region "should undertake an analysis of the features or characteristics of, and pressures and impacts on, their marine waters, identifying the predominant pressures and impacts on those waters, and an economic and social analysis of their use and of the cost of degradation of the marine environment" (MSFD 2008/56/EC). In order to analyze the progress in the achievement of good environmental status the MSFD suggests the development of criteria and methodological standards that ensure consistency and allow for comparison between marine regions or sub-regions. In relation to other economic elements contained in the Directive, Article 1 establishes that marine strategies should apply "an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations." Article 8 requires to Member States an initial assessment (due in 2012) comprising an economic and social analysis of the use of the waters and the cost of degradation of the marine environment. Article 13 states that member States should identify the measures which need to be taken in each marine region or sub-region in order to achieve or maintain good environmental status. Annex 6 explains that economic incentives should be included as “management measures which make it in the economic interest of those using the marine ecosystems to act in ways which help to achieve the good environmental status objective.” The directive highlights that Member States should “give due consideration to sustainable development and, in particular, to the social and economic impacts of the measures envisioned… Member States shall ensure that measures are cost-effective and technically feasible, and shall carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure.” Although monitoring programs are scheduled to be established and implemented by July 2014, it can be expected that similar problems as those encountered during the implementation of the WFD in terms of access to data and methodological difficulties will arise. In fact, the Commission decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters concluded that the methodological standards require further development and should be coordinated with the establishment of monitoring programs (EC 2010).

3. Methodology

In this section we propose a three step methodology for sustainable water and marine water resources management. In the first step we examine the pressures and impacts of the different sectors to water resources. We then assess the current recovery level for each use following an ecosystem services approach in order to account for environmental costs. In the third step we explore economic instruments (i.e. taxes, permits, subsidies, pollution fees, etc.) capable of providing adequate incentives for sustainable water resources management and we propose a cost-efficient package of measures. A summary of the three step methodology is presented in Table 2. Note that the economic analysis needs to be integrated with other fields of expertise (e.g. hydrology, geology, oceanography, engineering, sociology, etc.). This reflects the interdisciplinary nature of the methodology for identifying water-related ecosystem functions into ecosystem services for humans and should be considered all along the management and decision-making process. The ultimate objective of this assessment is to provide recommendations to help decision makers to develop policies and use economic instruments to provide incentives to allocate and use water more efficiently.

Table 2 Three step methodology for sustainable water resources management

1 Characterization of the River Basin, Marine Region or Sub-region

- Economic significance of water uses
- Trends in key indicators and drivers
- Dynamic path of demand and supply of water
- Gaps in water status and ‘water balance’

2 Assessment of current cost-recovery following an ecosystem services approach

- How much water services cost and who pays this cost?
- How much of this cost is recovered?
- Potential cost-recovery mechanisms

3 Identification of measures and economic impact

- Construction of a cost-effective programme of measures
- Assessment of cost-effectiveness of potential measures
- Financial and socio-economic implications of the programme of measures
- Are costs disproportionate? Derogations

Following Table 2 and based on existing secondary data sources we first should identify the main pressures for water resources in each river basin district (RBD) or Marine Region (MR)/ Marine Sub-region (MSR) and characterize them according to water availability, environmental status and pollution loads. In a second step, the financial, environmental and resource costs associated with the provision of water services for each of the water uses are calculated. Then, recommendations to improve the current recovery level or to improve its environmental status are discussed and presented. The results will help to establish pricing policies in the domestic, agricultural and industrial sectors in order to achieve full cost recovery. Furthermore, the methodology identifies the least costly measures to achieve this outcome.

The conceptual framework and methodology proposed is based on Sustainable Water Resources Management. Within this framework, the most important concept is Sustainable development (SD) defined as a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations. Sustainable development has a triple goal of SD over space and time:

1. Achieve environmental/ ecological sustainability (ecosystem resilience, resource-specific equilibrium)
2. Reach economic sustainability (economic efficiency by economic sector)
3. Attain social sustainability (affordability and equity by income group)

This framework is appropriate for both directives. Recall for example that the MSFD establishes in its Article 1 that marine strategies should apply "an ecosystem-based approach to the management of human activities ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status… enabling the sustainable use of marine goods and services by present and future generations." In order to manage water resources in a sustainable manner the application of economic principles, approaches, tools and instruments at RBD level or MR/MSR is necessary. As explained in section 1, an important economic concept is that of water resources management based on the recovery of the total economic cost of water services. The total economic cost of water includes the financial cost of water companies (including costs of investments, operation and maintenance costs and administrative costs), but also the environmental and resource costs. The environmental cost reflects social welfare losses associated with water quality deterioration, caused by the water uses, while the resource cost represents additional costs required to cover water demand under water deficits due to the overexploitation of available water resources. The cost recovery of water services should be analyzed for its different uses. In the following sections we elaborate on the three-step methodology.

Step 1 Economic characterization of the River Basin, Marine Region or Marine Sub-region and identification of significant issues

The first step involves the estimation of the socio-economic significance of water uses and the analysis of the dynamics of key economic drivers that influence pressures and thus water status. In this step is very important to coordinate the work with different scientists (e.g. hydrologists, biologists, oceanographers etc.) in order to obtain the categorization of different aquifers or marine waters in relation to their environmental status: good, moderate or bad.

Step 1 A. Evaluation of the economic significance of water in the region

This first step aims to identify the different types of water uses in the region and their economic significance. This allows conducting an assessment of the residential, industrial, agricultural and tourism water needs in the area or marine water needs for transport, tourism, fishing or energy production in the area. In this stage it is necessary to collect information about the following water uses and services in order to construct a baseline scenario: a) Water for residential use (e.g. population connected to public water supply system, population with self-supply, number of water supply companies, etc.), b) Water for industrial use (e.g. turnover for key sub-sectors, employment in sectors, etc.), c) Water for agricultural use (e.g. total cropped area, cropping pattern, livestock, gross production, income, farm population, etc.), d) Tourism (e.g. total number of tourist days, daily expense per tourist day, employment and turnover in the tourism sector, etc.), e) Health related water services and f) Environmental and ecosystem services. It should be highlighted that in this first phase of data collection it is essential to have a close collaboration with the local water agencies and stakeholders.

Step 1 B. Identification of key economic drivers influencing pressures and water uses.

The objective of this step is to identify the economic drivers that influence pressures and water uses in the region. Thus, information about general socio-economic indicators and variables is required (e.g. population growth, income, employment, etc.). Key sector policies that influence significant water uses should be also identified (e.g. agricultural and environmental policies) as well as the production or turnover of main economic sectors and significant water uses. Information about planned investments linked to existing regulation, likely to affect water availability should be collected as well as information about the implementation of future (environmental and other) policies likely to affect water uses.

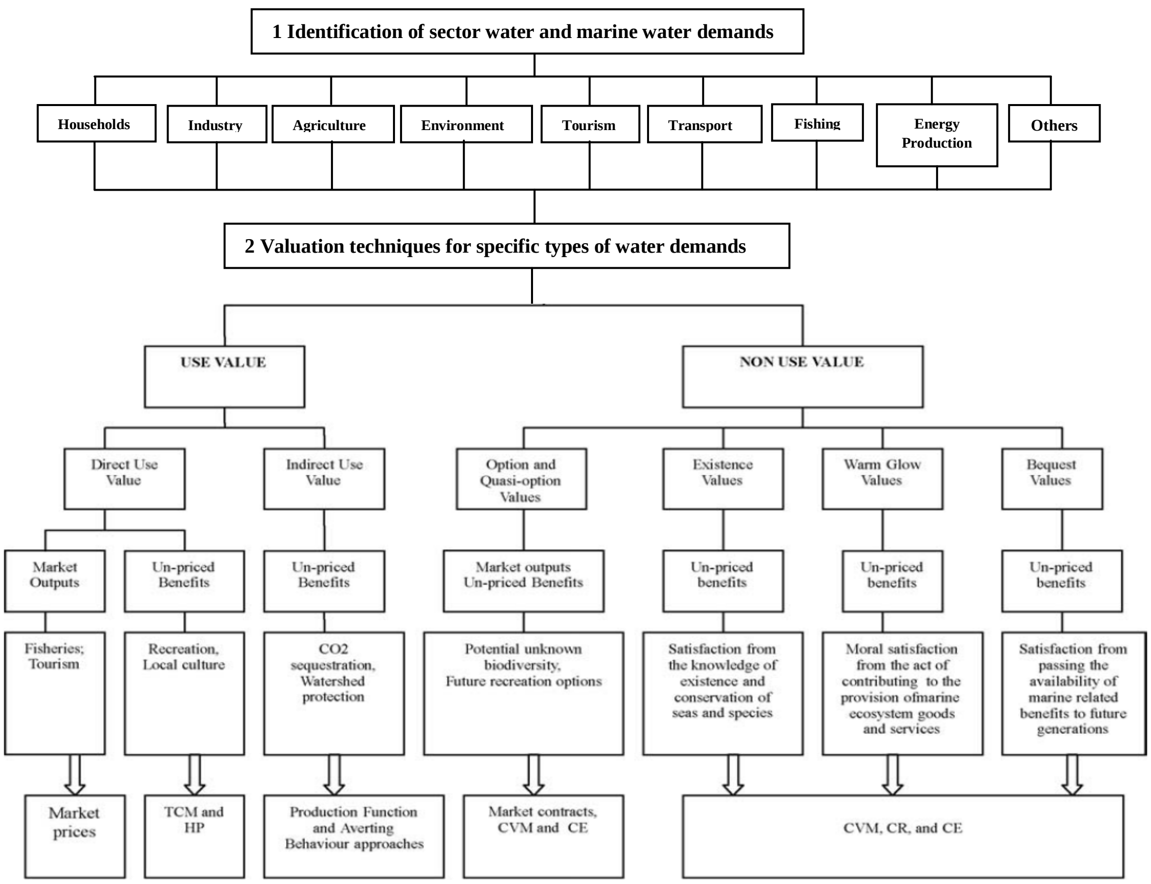
Step 1 C. How will these economic drivers evolve over time and how will they influence pressures?

It is important to examine how the economic drivers will evolve over time and how they will influence pressures. It is also important to understand the behavior of relevant trend variables such as: a) changes in demographic factors (e.g. population growth in specific urban areas), b) the economic growth and changes in economic activity composition (e.g. changes in the relative importance of services/sectors) and c) changes in land planning, (e.g. new areas dedicated to specific economic activities, etc.). It is also important to understand critical uncertainties like changes in social values and policy drivers, (e.g. globalization), changes in natural conditions, (e.g. climate change) and changes in non-water sector policies (e.g. changes in agricultural policy or industrial policy that will affect production and consumption in economic sectors).

Step 1 D. Evolution of Demand and Supply

The evaluation of the spatial and dynamic availability of significant water bodies is further needed. Then appropriate methodologies should be applied in order to assess sector-specific water demand. Figure 1 explains how we can estimate water demand.

Figure 1Estimating water demand



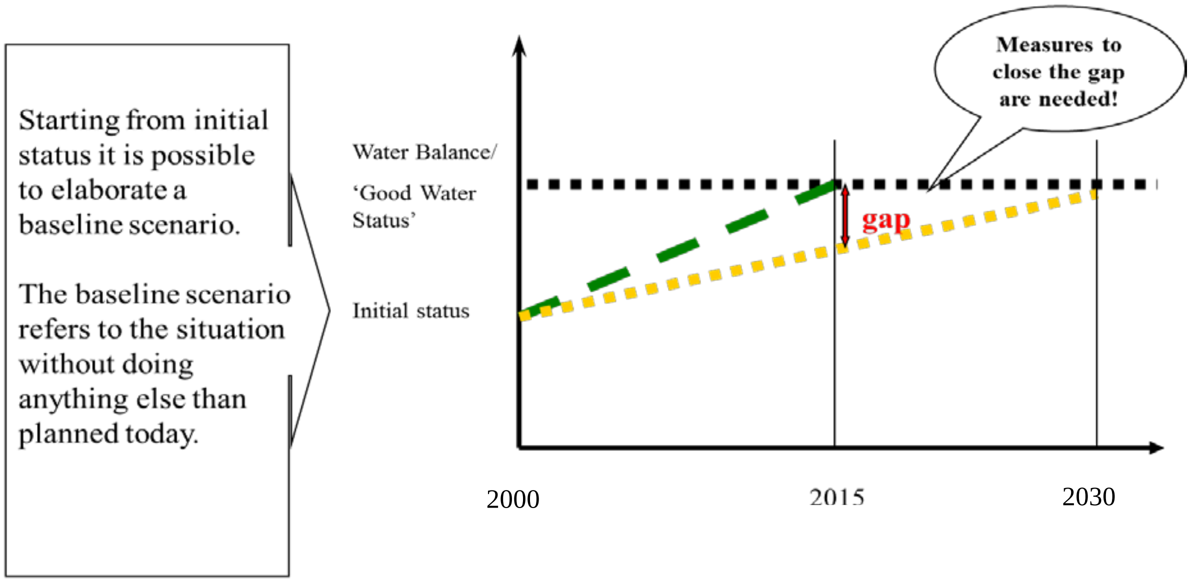
Applicable Economic Valuation Methods

Source: Adapted from Pearce and Moran (1994) and Remoundou et al (2009)

Methodology for Constructing Baseline Scenario Using Parameters from in Step 1

The following four stages methodology permit the construction of a baseline scenario using the parameters described in Step 1. In stage 1 we consider three possibilities of evolution of population. Then, we consider two possibilities of evolution of demography of other cities in the region. Finally we consider the possible evolution of rural population. In stage 2, we build scenarios using basic assumptions and quantify the water balance with these assumptions. In stage 3, we apply stage two over time. Finally, in stage 4, based on stages 1, 2 and 3, we describe a plot that tells the story of the system from now until at least 2030, giving consistency to the assumptions and water balance curves. It should be noted that in practice time and money constraints will define the detail of Step 1. Figure 2 explains how to apply the baseline scenario developed in Step 1:

Figure 2 How to implement the baseline scenario?



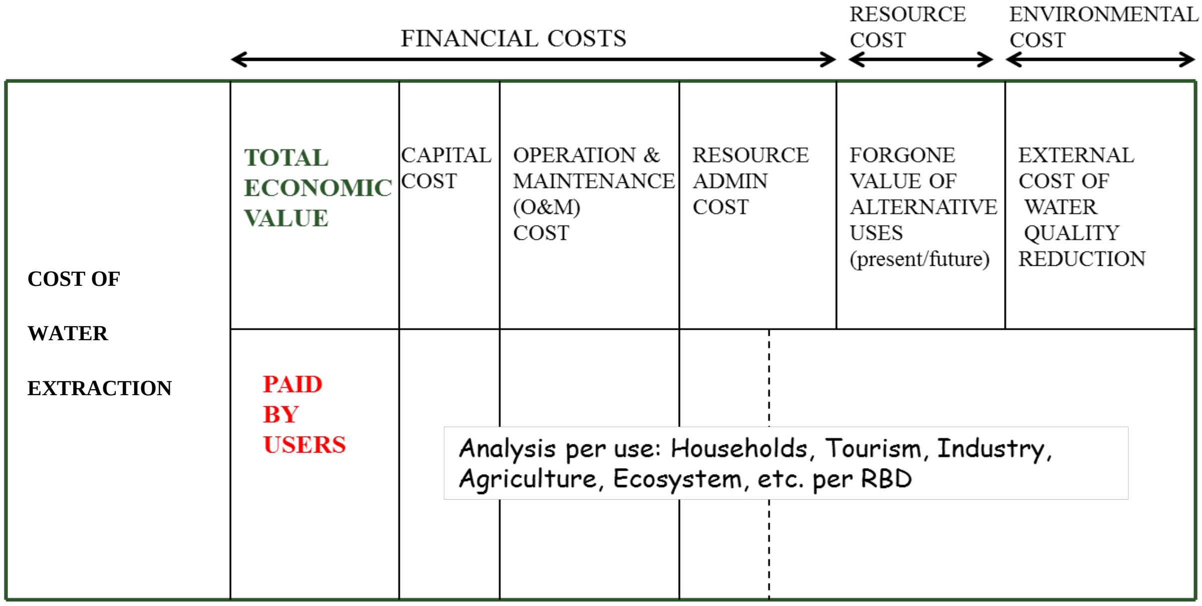
Step 2 Assess cost-recovery of water services following an ecosystem services approach

The current level of recovery of costs of water services should then be assessed in a second stage. The following stages will help us to understand the status quo of the recovery of water services and to propose cost-recovery mechanisms.

Step 2 A. How much do current water services cost? And Step 2 B. Who pays these costs?

These sections are concerned with the estimation of costs of water services by sector. Do users and/or institutional mechanisms recover these costs? Figure 3 presents the costs related to water extraction (financial, resource and environmental costs).

Figure 3 Costs related to water extraction



Financial Cost

The financial cost of water services includes operational, administrative, maintenance costs of existing infrastructure and investment cost for the enterprises of drinking water supply and sewerage and the irrigation water companies. The relevant data, for the calculations under the study, can be collected from the enterprises' annual published financial reports.

Resource Cost

The resource cost is a cost associated with current or future scarcity arising due to overexploitation of water resources beyond their rate of replenishment implying that resource cost is present when water demand for all uses is not covered adequately and is zero otherwise. In the literature (Koundouri 2004) resource cost is approximated by the cost of backstop technology to cover excess demand. The price of this desalination plants can be used for the resource cost approximation in the relevant water district.

Ecosystem Services and Environmental Cost

Constanza *et al* (1997) explain that ecosystem functions "refer to the habitat, biological or system properties or processes of ecosystems." On the other hand, ecosystem goods (e.g. water and food) and services (e.g. flood and disease control) are the benefits that people derive, directly or indirectly, from ecosystem functions. For instance, water regulation is an ecosystem service. Its ecosystem function is the regulation of hydrological flows. Examples of this ecosystem service include the provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation. For simplicity, ecosystem goods and services are often referred together as ecosystem services.

The environmental cost refers to the cost associated with water quality depletion and thus the subsequent limitation of water resources' capacity to provide goods and services, which can be translated to value for people. Values from water resources include both values associated with the direct use of water for drinking, irrigation for agriculture and recreation, but also non-use values relating to nutrient retention, flood control and protection, biodiversity and bequest and aesthetic purposes among others. Increasing degradation of water bodies has led to increased recognition of the services they provide, in the different ways that they support livelihoods and general wellbeing, as well as to a greater willingness to pay (WTP) for them and to cooperate in initiatives to protect them (Tognetti *et al* 2005). The estimation of the benefits from water conservation will follow the ecosystem approach. This is the state-of the art approach adopted, among others, by the Millennium Ecosystem Assessment Program (MEA) (2005) and the UK national ecosystem assessment for the evaluation of the climate change effects on ecosystems. The MEA analyzed and assessed for the first time the links between ecosystems and human wellbeing at global level. Ecosystem goods and services are grouped into four categories: provisioning (physical goods obtained from ecosystems), regulating (benefits obtained from the regulation of ecosystem processes), cultural (services obtained through aesthetic experience, reflection, recreation) and supporting services (those that are necessary for the production of all other ecosystem services) (Remoundou *et al* 2009). A classification of ecosystem goods and services is presented in Table 3.

Table 3 Classification of ecosystem goods and services

Types of ecosystem services	**Examples**

Provisioning services	Food provision, raw materials, fisheries, etc.
Regulating services	Gas and climate regulation, water regulation, flood and storm protection, bioremediation of waste, etc.
Cultural services	Recreation and ecotourism, aesthetic values, spiritual and religious values, cultural heritage values, etc.
Over-arching support services	Resilience and resistance, biologically mediated habitat, nutrient cycling

Source: Remoundou et al (2009)

Many variables are involved in the degradation of ecosystem services. For example, the excessive demand for ecosystem services provoked by economic growth, demographic changes, and individual choices. The conservation of ecosystem services may not be ensured by market mechanisms. This could result when markets do not exist for regulatory services or when policies and institutions do not allow people living within the ecosystem to benefit from services it may provide to others who are far away (MEA 2005).

From an economic perspective, resources provide a diverse array of goods and services that translate into economic services and values to the human population. The total economic value, that is, the sum of all economic values that result from an environmental resource can be defined in terms of the use value and non-use value of the resource under evaluation. The use value component refers to the set of benefits individuals derive from using the resources while non-use values reflect the values individuals attach to an environmental resource even if they themselves do not use it. The economic values generated from water resources are summarized in Table 4.

Table 4 Total Economic Value of Water Resources

Total Economic Value Component
Direct use values
Irrigation for agriculture Domestic and industrial water supply Energy resources (hydro-electric, fuel wood, peat) Transport and navigation Recreation/amenity Wildlife harvesting
Indirect use values

Nutrient retention
Pollution abatement Flood control and protection
Storm protection
External eco-system support Micro-climatic stabilisation Reduced global warming Shoreline stabilisation Soil erosion control
Option values
Potential future uses of direct and indirect uses Future value of information of biodiversity
Non-use values
Biodiversity **Cultural heritage** Bequest, existence and altruistic values

Source: Adapted from Birol, Karousakis and Koundouri 2006b

Various techniques have been developed by economists in order to valuate environmental costs and benefits (see figure 1). They are classified into revealed and stated preference methodologies. Revealed methods take into account observable market information, which can be adjusted and used for revealing the individual's preference and thus quantifying the associated welfare benefits. The hedonic pricing and the travel cost methods are prevalent in the environmental economics literature. The basic premise of the travel cost method is that the time and the cost expenses that people incur to visit a site represent the price travellers assign to the site and its attributes. Thus, the number of trips realized at different travel cost can provide a robust index of individual's WTP for access to the site. The hedonic pricing method has a more restricted range of applications. Hedonic pricing is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. Thus, property prices will reflect the value of a set of characteristics, including environmental characteristics that people consider important when purchasing a property (Birol *et al* 2006a).

In stated preference approaches the market for the good is elicited using questionnaires. Thus, stated preference techniques present consumers with hypothetical markets in which they have the opportunity to pay or accept compensation for the environmental good or service in question (Bateman et al 2003). In environmental valuation research, the Contingent Valuation Method (CVM) and the Choice Experiment Method (CEM) are widely used. In a contingent valuation application respondents are asked to state their maximum WTP (or minimum willingness to accept compensation) for changes in the quantity or quality of non-market environmental resources. The method intends to uncover individuals' estimates of how much having or avoiding the change in question is worth to them. This method has been criticized for its lack of validity and reliability despite the strengths of CVM regarding its ability to estimate non-use values and evaluate irreversible changes (Diamond and Hausman 1994). This is on account of potential problems including information bias, design bias (starting point bias and vehicle bias), hypothetical bias, yea-saying bias, strategic bias (free-riding), substitute sites and embedding effects. In a choice experiment framework, the environmental resource is defined in terms of its attributes and levels these attributes would take with and without sustainable management of the resource. Accordingly respondents are asked to choose from those alternative bundles of attributes. This has a clear benefit over other valuation methods as it leads respondents to explicitly make trade-offs between the various attributes of the situation, where one attribute is price. Based on a random utility framework and welfare theory it allows for welfare estimates to be derived providing resource managers and policy makers with valuable information about public preferences for many states of the environment (Bennett and Adamowicz, 2001, Birol and Koundouri, 2008).

How can these methods be made operational in the context of the development of water management strategies at the policy level? Recently there has been a growing interest in the potential for producing generally applicable models for the valuation of non-market environmental goods and services, which do not rely upon expensive and time-consuming original survey work, but rather extrapolate results from previous studies of similar assets. This approach is called meta-analysis for the use and non-use values generated by environmental resources. Meta-analysis is the statistical analysis of the summary of findings of empirical studies: i.e. the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings (e.g.: freshwater fishing meta-analysis of valuation studies). Meta-analytical research seems to have been principally triggered by increases in the available number of environmental valuation studies and seemingly large differences in valuation outcomes as a result of use of different research designs. The fact that gathering primary site-specific data is costly has made Environmental Benefits Transfer (BT) a popular alternative for the valuation of ecosystem goods and services. BT is about applying existing economic value estimates from one location where data are collected to another similar site in another location with little or no data. Values then must be adjusted to reflect site-specific features.

Step 2 C. What is the current cost-recovery level?

Once the total cost of water services is determined and the revenues of water companies are calculated an assessment of the cost- recovery level is possible. The cost recovery level will provide an indication of how much of how much of the total cost of different water uses is charged to users.

$$Cost\ re\mathrm{cov}ery\ Level = \frac{\mathrm{Re}\,\mathrm{cov}ery}{Total\ Economic\ Cost}$$

Step 2 D. Propose cost-recovery mechanisms.

A selection of potential cost-recovery mechanisms that could be employed by the water management agencies are explained below (for a more detailed explanation see Panayotou 1994).

1. Pricing: this mechanism creates a market in which the right to use the environment (like a use right) is priced. The scarcity provoked by the issuance of less environmental-use rights than demanded would ensure a more rational use of the environment, because the more it is used the more it costs.
2. Tradable permits: an aggregate level of emissions permitted is set for each watershed and allocated among polluters according to the level of output or current level of emissions.
3. Quotas: this instrument sets a maximum allowable construction quota measured in for example number of rooms for each year, in each zone, consistent with objectives to limit development and improve water quality.
4. Taxes/subsidies: a polluter can be taxed to reduce pollution. A Pegouvian tax should be set exactly equal to the marginal environmental damage corresponding to the socially optimal level of pollution. On the other hand Instead of taxing the polluters to reduce pollution to the optimal level, polluters can be subsidized to do exactly that
5. Direct controls can be established for specific pollutants.
6. Educational and awareness campaigns could be developed.
7. Voluntary agreements between polluters and regulators could be established.
8. More effective legal instruments could be devised.

Another alternative is the promotion of green investments for pollution control and remediation, resource conservation and management, land use and infrastructure and renewable energy sources. The feasibility of each measure should be examined within the political and institutional environment framing for water provision and pricing, and then provide recommendations as to the effectiveness of each measure or combination of measures.

Step 3: The economic assessment of potential measures for reaching good water status

Following the identification of potential measures in the previous step the final aim of the methodology is to define the least-costly measures to achieve sustainable water resources management. It is important to assess the cost and benefits associated with the implementation of each measure. To achieve step 3 the following sub-steps are thus needed:

Step 3 A. Identify least-cost set of measures.

This step aims to identify the cost effectiveness of package measures like economic instruments (e.g. abstraction/pollution taxes, tradable permits, subsidies), measures to increase awareness regarding water scarcity, aiming at reducing abstraction/pollution, direct controls on pollution dischargers, agro-environment programs providing financial and technical assistance for, e.g. reallocation of crop production mix over agricultural land, adoption of water-saving technologies coupled with land-allocation restrictions, etc. or green investments.

Step 3 B. Assessment of cost of measures.

This step estimates a range of costs along with key parameters influencing costs over time (cost change with developments in sectors). This will allow us to explain how to allocate the costs of measures to water users and identify winners and losers, in order to feed into the analysis of disproportionate costs to justify derogation (discussed in the Step 3 D). It is important to convey this information to decision makers to drive policy and planning to properly allocate water among various competing uses (agricultural, forest, industrial and others), and to allocate resources to improve the quantity and quality of water reserves.

Step 3 C. Assessment of the impact of measures on economic sectors/uses.

The aim of this step is the assessment of the net impacts on public expenditures and revenues. This includes the impacts on expenditures for agro-environment schemes, revenues of economic instruments and impacts of changes in the prices charged for publicly owned water services. Wider economic and social impacts are also considered. For example, significant changes in patterns of employment, economic impacts on industries and local economic development from changes in the price of water supply, level of discharges and water quality and effects on the retail price index and inflation.

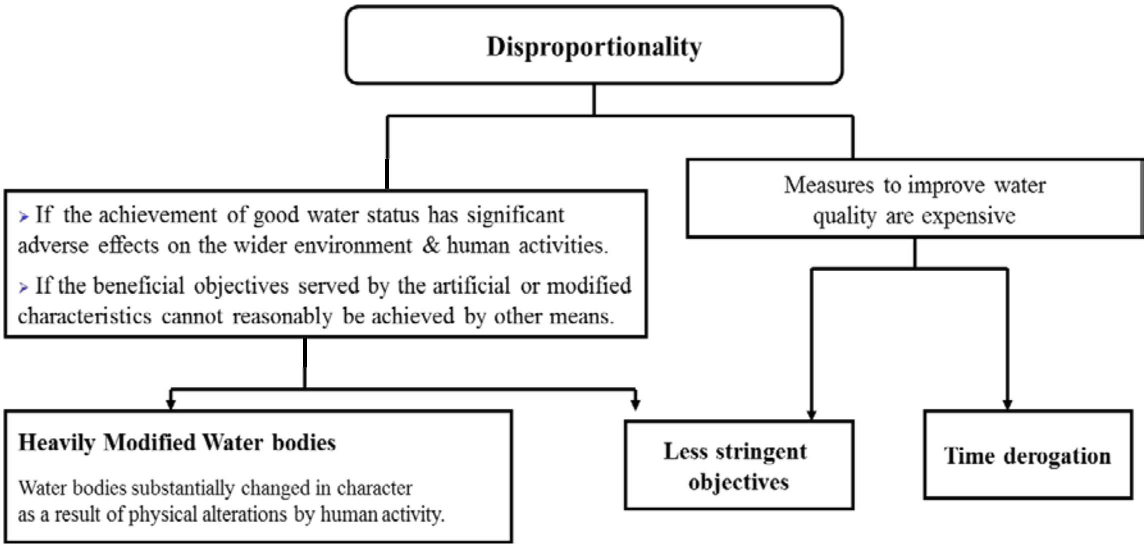
Step 3 D. Are costs of measures disproportionate?

After considering the different measures and defining the cost-efficient package of measures it is important to assess whether the final package of measures is disproportionate. Disproportionality arises when the achievement of good water status has significant adverse effects on the wider environment and human activities but the beneficial outcome cannot be achieved by other means. In such cases less strict aims may be justified or derogations from the initial time schedule. It is thus evident that disproportionality is a political judgment. To decide on the disproportionality of the measures, a Cost-Benefit Analysis (CBA) is needed. In a CBA framework, the estimated economic values accrued by the involved stakeholder groups are aggregated over their relevant populations and added to capture the total economic value generated by the investment project or policy. A project or policy is deemed to be profitable if total benefits exceed total costs. Due to the expected long-run impacts on the local economy and ecology, the sustainability of any project related to water is to be tested using a long-run cost CBA, and the net present value (NPV) of the project is to be estimated using different discount rate schemes (Birol, Koundouri and Kountouris 2010). The NPV results reveal whether the net benefit generated by the policy or investment project is positive and significant well into the future. A general calculation of the NPV is the following:

$$NPV = -\sum_{t=0}^{N} \frac{K_t}{(1+r)^t} + \sum_{t=0}^{N} \frac{B_t - C_t}{(1+r)^t}$$

Where K_t is the construction cost, B_t is the stream of benefits, C_t is the stream of maintenance costs and r is the discount rate. The internal rate of return is another important aspect of a CBA. It is the discount rate for which the NPV is zero. Since a CBA of long-term investments is enormously sensitive to the discount rate the use of the classical NPV in the long term is problematic. Recent economic literature (Koundouri, 2009; Gollier, Koundouri and Pantelides 2008) proposes the use of a Declining Discount Rate (DDR). The use of DDR in long–run cost–benefit analysis can replace traditionally employed constant discount rates. This implies that the policy-maker will put more effort into improving social welfare in the far distant future than in the short term.

Figure 4 Disproportionality



4 Selected case studies on inland and coastal waters

This section presents two case studies of groundwater and marine water resource management using an ecosystem services approach: Spain (marine water) and Finland (groundwater). Both studies use non-market valuation methodologies as discussed in section three. In the literature there are other examples on how the ecosystem services approach is used on inland and coastal water resource management. For a review of case studies in the Mediterranean and Black sea see Remoundou *et al* (2009). For a more detailed application of the methodology discussed in section three see Koundouri and Papandreu (2012).

4.1 Marine water resource management using an ecosystem services approach in Santander, Spain

According to the IPCC (2007), climate change will have a huge impact on coastal areas, for example on sea level rise, changes in maritime storms, and may increase water salinity. Flooding, land loss, and their impact on water resources are important sources of concern. In this context, Díaz-Simal *et al* (2010) used a choice experiment to elicit the WTP for avoiding climate change challenges (i.e. environmental and health risks in marine environments) via the payment for mitigation measures. The experiment was implemented in Santander, Spain, a coastal region with vulnerability to marine dynamics and the effects on its beaches (and their role as crucial locations for social and touristic activities), loss of marine biodiversity and a surge in exposure to medusas and other dangerous species present on the beaches that have motivated restrictions of bathing activities due to health risks.

They followed a split-sample approach in order to elicit the value people place on improvements in biodiversity and recreational opportunities and reductions in the health risks associated with the presence of jellyfish species in the short, medium and long run. In a choice experiment, the good under valuation is described in terms of its characteristics, attributes, and the levels these attributes take (Bennett and Blamey, 2001). Price is usually included as an attribute because this allows the evaluation in monetary terms of the marginal value of the other attributes. Then, the respondents are requested to choose their most preferred option among different combinations of levels of attributes that are shown to them. In a random utility theory framework, each alternative *j* in a choice set has an associated utility level for each individual *i* represented by:

$$U_{ijt} = \beta X_{jt} + e_{ijt}$$

The utility of a choice contains a deterministic component (βX_{jt}) and an error component (e_{ijt}). An alternative choice *j* will be chosen over some other option *k* if $Uj > Uk$. They used a random parameters logit model to allow for heterogeneity in preferences between respondents in the sample. In this class of models the coefficient vector for each individual is the sum of population mean and an individual variation. This model does not exhibit the independence of irrelevant alternatives (IIA) property of the simple multinomial logit model because the stochastic part of the utility is correlated among alternatives. Therefore, the probability of an individual *i* of choosing alternative *j* in a choice situation *t* is given by:

$$\Pr_{ijt} = \int \left(\frac{\exp \beta_i X_{jt}}{\sum_k \exp \beta_i X_{kt}} \right) f(\beta|\theta) d\beta$$

where X is a vector of attributes and β_i a vector of associated coefficients. Three different questionnaires were developed because three different time frames were considered. A short introductory text explained the situation in Santander and the expected changes under a management policy. The payment was a year tax lasting for five, thirty and sixty years respectively depending on the version. The individuals who showed reluctance to support any protection policy were invited to elaborate on their answers. The final section in the questionnaire focused on the socioeconomic condition of the respondents. Table 5 presents an example of a choice card whereas Table 6 presents the attributes and their levels used in the analysis.

Table 5 Choice card example

	Alternative 1	**Alternative 2**	**Alternative 3 (no policy action)**
Biodiversity	Medium	High	Low
Number of days beaches are closed because of Medusa Portuguesa outbreaks	5	15	15
Beach Size	High	Low	Low
Additional annual cost to your household for the next five years	125	50	0
I prefer			

Source: Díaz-Simal et al (2010)

Table 6 Attributes and their levels.

Attribute	Levels
Biodiversity	• Low: The area for shell fishery is altered by climate change and is not suitable for this type of fisheries anymore. The Bay of Santander is no longer a stop for migrating birds and invertebrates • Medium: The shell fishery area is preserved but reduced and the Bay is no longer a stop for migrating birds and invertebrates • High: Current level of biodiversity is preserved
Number of days beaches are closed because of Medusa Portugessa outbreaks	• 5 days per year • 10 days per year • 15 days per year
Beach Size (recreation)	• Low: The four main beaches in Santander will reduce from 3kn long that are now to pocket ones. Pocket beaches and beaches located at the flood prone Somo split will disappear due to erosion. • High: Renurishment of the main beaches in Santander and pocket beaches will preserve their size throughout the year
Additional annual cost to your household	• 0 euros per year • 50 euros per year • 75 euros per year • 100 euros per year • 125 euros per year • 150 euros per year

Source: Díaz-Simal et al (2010)

Table 7 presents the present value of WTP estimates assuming a 3% discount rate.

Table 7 Present value of WTP estimates (r = 3%)

Attribute	60 years version	30 years version	5 years version
Biodiversity medium	1245.4	408.7	97.2
Biodiversity high	2214	730.5	80.1
Health risk	0	0	-8.84
Recreation high	1107	514.3	47.9

Source: Díaz-Simal et al (2010)

Their results show that people place a positive value on increased biodiversity and recreation opportunities in all the considered time frames. Their results also imply that the present value of future biodiversity and recreation related benefits increases with the time frame. It is interesting to note that they found evidence of the presence of a strong non-use component in the total economic value of biodiversity and recreation. Zero WTP values to hedge against long-run health risks associated with jellyfish outbreaks may be an indication that people do not perceive the health risk as realistic. In fact, the negative sign shows that people are willing to accept health risks from the presence of jellyfish. Their results also provide useful insights for the design of optimal risk insurance schemes to hedge against extreme natural hazards in the Bay of Santander. They suggest that people can understand the long-run nature of climate change related hazards and are willing to pay to prevent those risks for their benefit but also the benefit of the future generations. The results also imply that any insurance scheme should take into account the great heterogeneity of preferences with respect to the attributes of a mitigation strategy if socially equitable and acceptable schemes are to be adopted. The monetary estimations under their exercise could inform the assessment of a long-run cost-benefit analysis to investigate whether different planned mitigation measures are economically efficient. It is evident that these results are all relevant for the implementation of the MSFD in the Marine Region as discussed in section 2.2.

4.2 Groundwater resource management using an ecosystem services approach in Rokua, Finland.

In their paper Koundouri *et al* (2012), concentrate on Rokua in Northern Finland. This is a groundwater dependent ecosystem that is very sensitive to climate change and natural variability. Their study analyzes the uncertainty about the system dynamics and the effect of future climate change and delivers implicit prices for improvements in water quantity, recreation and scientific knowledge in the case of Rokua esker. They analyzed what values people place on improvements to scientific research that reduces uncertainty about the effects of future climate changes on its groundwater dependent ecosystem using a nested multinomial logit and an error component model. Their model is also set in a random utility theory framework. As explained in the previous section, each alternative *j* in a choice set has an associated utility level for each individual *i*. The utility of a choice contains a deterministic component (*V*) and an error component (ε): $U_{ij}= V(z_{ij,} s_i)+ \varepsilon(z_{ij,} s_i)$

We can observe some attributes of the alternatives as faced by the individual, labelled z_{ij} j, and some attributes of the individual, labelled s_i. McFadden (1974), explained that under the assumption that utility and attributes have a linear relationship in the parameters and variables function and that the error terms follow a Weibull distribution and are identically and independently distributed, the probability of any alternative *j* being chosen can be expressed in terms of a logistic distribution. This specification is known as the multinomial logit model. In this model, the choice probabilities have a closed form:

$$P_{ij} = \frac{\exp\left(V(z_{ij}, s_i)\right)}{\sum_{h \in A} \exp\left(V(z_{ih}, s_i)\right)}$$

The aim of their CE is to contribute to the revision of management practices in order to achieve and maintain ‘‘good water status’’ which ensures sufficient water of good quality for humans and the environment for today and the future. The package of measures includes the following: (i) restrict peat land drainage in the groundwater area, (ii) expand the conservation area and compensation when legally required and (iii) restore (technical solutions) of peat lands, groundwater and lakes level. The policy under consideration is characterized by five different management-related attributes. Table 8 shows the attributes and their possible levels, in a mid-term horizon (5–10 years from now) depending on whether a policy is implemented or not. Table 9 shows an example of a choice card.

Table 8 Water management attributes and levels used in the CE

Attribute	Definition	Management Level
Water quantity	This attribute refers to the total quantity of water available in groundwater aquifer, lakes and spring	**Increased:** most of the lakes have restored their water level **Same as now:** some lakes have water quantity problems. Current state of water is sustained. **Limited:** water quantity has been considerably declined. The last alternative reflects what is expected to happen in the absence of revised management in the future (Status quo level).
Recreation	This attribute refers to the sum of all values (direct and indirect) derived from recreational activities	**Increased:** environmental improvements result in an increase in recreational values. **Same as now:** current levels of recreational values are sustained. **Low:** This is the case where no measures are taken. As a result of environmental degradation in the absence of the revised management, recreational values are going to decline (Status quo level).

Total Land Income	This attribute refers to the total income opportunities for the local people emerging from economic activities of logging, peat harvesting and tourism industry based in Rokua area	**Same as now:** Total income will remain unchanged. **Restricted:** Total income opportunities will get restricted (Status quo level).
Investment on Research	This attribute refers to the scientific research to better understand long-term environmental changes in Rokua	**High:** More Resources **Medium:** Current Resources (Status quo level). **Low:** Stop current research
Price	One-off payment	0e,10e, 20e, 50e, 100e

Source: Koundouri et al (2012)

Table 9 Choice card example

Assuming that the following three water management scenarios were the only choices you had, which one would you prefer?

Attributes	Scenario A	Scenario B	Scenario C:
			Status quo
Water Quantity	Increased	Same as now	Limited
Recreation	Same as now	Increased	Low
Total Land Income	Restricted	Restricted	Restricted
Investment on Research	High	Low	Medium
One-off Payment	100	50	None
I prefer (Please tick as appropriate)	Option A	Option B	Option C

It should be noted that they included a relevant attribute amongst the chosen attributes that describe alternative water management practices. The benefit estimates reported in their study show that scientific research followed by water quantity status and recreation is not only a significant factor in the choice of a water management scenario but is also valued higher compared to other improvements. On average, a household would be willing to pay €33 to €37 to ensure that the scientific research on environmental changes in Rokua will not stop. Thus, high levels of these attributes increase the probability that a management scenario other than the status quo is selected. It should be noted that people's WTP for research exists regardless of the certainty of the outcome. Respondents did not differentiate between moderate and high levels of research but were willing to pay to avoid less research. Besides, male respondents, respondents with children and with a higher than secondary education were more likely to prefer a move from the status quo, while those who have visited Rokua in the past and older people were more likely to choose the status quo option. Introducing monetary valuation into public decision-making contributes to public debate and awareness concerning environmental problems, while supporting decisions taken by policy agencies. Future policies should consider investing in scientific research to understand long-term environmental changes given that the research shows that people are willing to pay for it. Finally, their results provide an insight into the return value of the foreseen investment programs in water quantity improvements and help to prioritize limited budgets for the WFD implementation and could be used to outline future land use and ecosystem protection policies.

Conclusions

Following an ecosystem services approach, in this chapter we presented an interdisciplinary methodology for the assessment of the total economic value of water services (i.e. the sum of financial, environmental and scarcity values), the cost recovery level for water services and the identification of cost-effective measures to enhance current levels of cost recovery using market and non-market valuation methods. This methodology was applied to selected case studies on inland and coastal waters. As it was shown in the relevant sections, this methodology facilitates the implementation of the EU Water Framework Directive and the EU Marine Strategy Framework Directive.

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