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Development of an integrated methodology for the sustainable environmental and socio-economic management of river ecosystems

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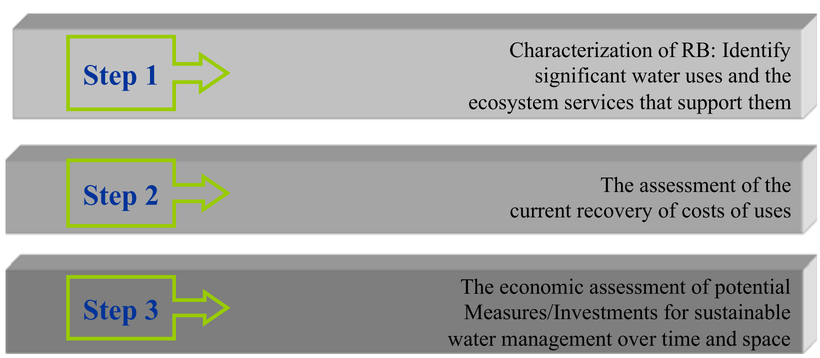
HIGHLIGHTS

- Total Economic Value integrating the Ecosystem Services Approach
- Economic valuation techniques
- Empirical results — value transfer technique

GRAPHICAL ABSTRACT



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ABSTRACT

The development of the Water Framework Directive aimed to establish an integrated framework of water management at European level. This framework revolves around inland surface waters, transitional waters, coastal waters and ground waters. In the process of achieving the environment and ecological objectives set from the Directive, the role of economics is put in the core of the water management. An important feature of the Directive is the recovery of total economic cost of water services by all users. The total cost of water services can be disaggregated into environmental, financial and resource costs. Another important aspect of the directive is the identification of major drivers and pressures in each River Basin District. We describe a methodology that is aiming to achieve sustainable and environmental and socioeconomic management of freshwater ecosystem services. The Ecosystem Services Approach is in the core of the suggested methodology for the implementation of a more sustainable and efficient water management. This approach consists of the following three steps: (i) socio-economic characterization of the River Basin area, (ii) assessment of the current recovery of water use cost, and (iii) identification and suggestion of appropriate programs of measures for sustainable water management over space and time. This methodology is consistent with a) the economic principles adopted explicitly by the Water Framework Directive (WFD), b) the three-step WFD implementation approach adopted in the WATECO document, c) the Ecosystem Services Approach to valuing freshwater goods and services to humans. Furthermore, we analyze how the effects of multiple stressors and socio-economic development can be quantified in the context of freshwater resources management. We also attempt to estimate the value of four ecosystem services using the benefit transfer approach for the Anglian River Basin, which showed the significance of such services.

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1. Introduction

Undoubtedly, water is one of the most valuable resources for the survival of species and the functioning of the natural environment. It is easy to understand that its qualitative and quantitative statuses play a crucial role in human health, but also in the socio-economic development in Europe. While water can contribute to economic development, the latter can pose a significant threat on water resources, if there is no control over effluents release and the extraction of the resource. Economists have long been fascinated by the complexity embedded in managing water resources (see for example, Booker et al., 2012; Easter and Renwick, 2004; Koundouri, 2004). This complexity dwells from the non-market characteristics of the water resources. Non-excludability, which means inability to deprive individuals from the enjoyment of yielded benefits and no jointness in consumption, reinforces individuals to conceal their preferences in relation to natural resources. For this reason, the market mechanism cannot yield the optimal allocation of costs and benefits accruing from the use of environmental resources. Benefits that stem from them, as will be described below, relate to the use and non-use values generated by environmental goods. Undoubtedly, such values can be directly linked to the ecosystem services provided by the natural resources. Therefore, recent advancements in the literature suggest the incorporation of the Ecosystem Services Approach (De Groot et al., 2002) into the management of water resources.

This paper describes a methodology that is being followed in order to achieve sustainable environmental and socioeconomic management of freshwater ecosystem services. This approach is consistent with a) the economic principles adopted explicitly by the Water Framework Directive (WFD), b) the three-step WFD implementation approach adopted in the WATECO document, c) the Ecosystem Service Approach to valuing freshwater goods and services to humans (Martin-Ortega et al., 2015). This paper starts with the economic aspects and implementation of WFD, continues with the description of Ecosystem Services Approach and ends with the description of the steps and sub-steps of the proposed methodology. Furthermore, in order to illustrate its implementation, the paper presents values of ecosystem services in Anglian river basin estimated with the use of the benefit transfer method. In this way, we describe how the arsenal of economic techniques can be used to monetize ecosystem benefits. Overall, the methodology attempts to connect the biological, economic and social aspects of water bodies for achieving sustainable management of water resources.

2. Economic aspects of the water framework directive

The development of the Water Framework Directive aimed to establish an integrated framework of water management at European level. This framework revolves around inland surface water, transitional water, coastal water and ground water. The integrated nature of the directive pursues a holistic approach of these various types of water resources. In this regard, the management engages in both qualitative and quantitative aspects of water in order to achieve good water status for EU waters by 2015 (EC, 2000).

In the process of achieving the environment and ecological objectives set from the Directive, the role of economics is put in the core of the water management. More specifically, the WFD requires the application of economic principles, approaches and instruments at River Basin District level. 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", discuss those economics elements. The management takes place at River Basin District level. In harmony with the WFD, each River Basin management plan has to undertake specific steps.

The first step is to conduct the economic characterization of water at River Basin District level. 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).

An important feature of the Directive is the recovery of total economic cost of water services by all users of water resources. According to Article 9, the 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 2000:12). The total cost of water services can be disaggregated into environmental, financial and resource costs (see Table 1).

The environmental cost is associated with social welfare losses that are caused by the deterioration of water quality. The financial cost includes the costs of providing and managing water services, which are related to the operations of water suppliers. The resource cost relates to the additional costs that have to be bore in order for the water demand to be covered due to overextraction of the available quantity of water resources, or the reduction in water supply due to weather conditions. For the purposes of the WF Directive, the cost recovery of water services should be linked to different water uses for different sectors, such as households, industry and agriculture.

Another important aspect of the WFD is the identification of major drivers and pressures in each River Basin District. Information on these should be included in the economic analyses as underlined by Annex III. Additionally, according to the polluters pay principle, the contribution of water uses in the recovery of cost should also be contained in the economic analyses, in order to assist in the identification of appropriate measures based on their cost-effectiveness (EC 2000:31).

Finally, Article 9 of the WFD calls for introduction of pricing policies and other economic instruments that incorporate an element of cost recovery related to environmental benefits.

3. Description of the Ecosystem Services Approach

As already mentioned, the Ecosystem Services Approach is in the core of the hereby-suggested methodology for the implementation of a more sustainable and efficient water management. Following this approach, emphasis is given on the functions of the ecosystem "as a whole" and on the variety of services that can be beneficial for human well-being, instead of just focusing on specific functions and relevant beneficiaries. This enables us not only to better understand the total value of an ecosystem and its benefits for human welfare, but also to identify the complex links among actions that affect the function and balance of the ecosystem (deciding for example whether to utilize the water of a river basin), and the effects on various economic sectors and stakeholders (using the water of a river may yield certain benefits, i.e. income for farmers and agricultural products for consumers, on the one hand, but might destroy a wide variety of ecological values that a river can offer on the other hand).

Table 1
Total economic cost of water.

Nature of cost	Description
Financial cost	Capital cost, operation cost, maintenance cost and administrative cost.
Environmental cost	The environmental cost represents the costs of damage that water users 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 that 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).

Adopted from Koundouri et al. (2009).

According to the Total Economic Value of Ecosystems and Biodiversity initiative (TEEB) ecosystem services can be provided into four main categories: (i) provisioning services, i.e. products obtained from ecosystems, (ii) regulating services, i.e. benefits arising from the regulation of ecosystem processes and functions, (iii) habitat services, i.e. services that are supportive for the production of all other ecosystem services, (iv) cultural services, i.e. benefits for humans such as spiritual enrichment, cognitive development, recreation and education, and Table 2 contains examples of ecosystem services across the four main categories as defined by TEEB.

Some of the above ecosystem services, such as food and timber, can be easily valued, since a market price is available for those products. On the other hand, it is rather difficult to quantify the value of non-marketed services, such as aesthetic values. Moreover, some of the benefits may be derived by the actual use, of the ecosystem, whereas other types of benefits can be derived only by the knowledge of its existence, even if there is no actual use of the ecosystem. The implementation of Ecosystem Services Approach requires the identification and quantification of all types of values, called Total Economic Value (TEV) that an ecosystem can provide.

The various types of economic value that have been briefly discussed in the previous paragraph are depicted in Fig. 1. To discuss into more detail its content, use values consist of three main categories: (i) direct use value, e.g. food consumption, (ii) indirect use value, e.g. carbon sequestration, and (iii) option value, e.g. paying for the conservation of a natural park, so it can be “used” in the future. Non-use values consists of three main categories: (i) bequest, i.e. valuing the fact that an ecosystem will be passed on to future generation, (ii) existence, i.e. the value of the existence of the ecosystem as it stands, and (iii) altruistic, i.e. valuing the fact that an ecosystem can be enjoyed by other people in the community. Table 3 contains examples of use and non-use values of water-related resources.

4. Quantification of the effects of multiple stressors on ecosystem services and economic development

A double approach is proposed to quantify the effects of multiple stressors on ecosystem services, one at a smaller spatial scale with mechanistic models integrating all cause-effect relationships between changes in the stressors and ecosystem structure and processes, and another at a larger spatial scale with statistical models integrating the knowledge grasped with the mechanistic models. Specifically, the cause-effect relationships between single or multiple stressors and ecosystem services is defined at the river segment scale (200–5000 m), whereas the integration of the information is performed at the sub-basin or basin scales (2000–10,000 km^2). Information at the river segment scale (diversity and ecosystem functioning) is integrated in mechanistic models based on the River Water Quality Model (RWQM).

Biologists and ecologists collect information at the basin scale using basin surveys, which is then fed into models. InVEST is a spatially explicit tool consisting of a suite of models that use land use and land cover patterns to estimate levels and economic values of ecosystem services. Overall, both models at both spatial scales, relate changes in stressors with changes in diversity and ecosystem functioning, and in turn with ecosystem services in biophysical terms. With regards to the quantification of services, the focus is on those that can be directly described with the deterministic models, and that are more likely to be influenced by multistressors. Specifically, water provisioning, sediment retention, water purification, storm peak mitigation – flood dissipation, habitat quality – diversity, opportunities for recreation. Among these services, special emphasis is placed on those ecosystem service directly tied with the freshwater ecosystems such as water purification, and habitat quality — diversity. It is particularly for these services that the mechanistic linkages in quantitative terms are developed using the RWQM. For example, the combined effect between a physical stressor such as flow regulation by dams and a chemical stressor such as pollution by a wastewater treatment plant on the stream ecosystem diversity and functioning will be assessed by scientists in the field of hydrology, biology, chemistry and ecology, then integrated in the RWQM, and expressed as relationships between the mentioned stressors and the services water purification and diversity.

Table 2
TEEB main service types.

Main service types	
Provisioning services	Food (e.g. fish)
	Water (e.gr for drinking, cooling)
	Raw material (e.g. Fiber, timber)
	Genetic resources (e.g. For crop-improvement and medical purposes)
	Medical resources (e.g. Biochemical products)
	Ornamental resources
Regulating services	Air quality regulation
	Climate regulation
	Moderation of extreme events
	Regulation of water flows
	Waste treatment
	Erosion prevention
	Maintenance of soil fertility
	Pollination
	Biological control
Habitat services	Maintenance of life cycles of migratory species
	Maintenance of genetic diversity
Cultural and amenity services	Aesthetic information
	Opportunities for recreation and tourism
	Inspiration for culture, art and design
	Spiritual experience
	Information for cognitive development

Adopted from De Groot et al. (2002).

5. A three-step approach for the sustainable management and socio-economic management of freshwater ecosystem services

In accordance with the requirements of economic analysis in WFD and the guidelines of WATECO document (2002), we propose a three-step approach (Fig. 2), for sustainable management of water-related resources. The Ecosystem Services Approach is incorporated into the proposed methodology. In a nutshell, this approach consists of the following three steps: (i) socio-economic characterization of the River Basin area, (ii) assessment of the current recovery of water use cost, and (iii) identification and suggestion of appropriate programs of measures for sustainable water management over space and time.

The above diagram is used to portray the way a variety of forces can prevent future generations from meeting their needs (environmental economic and societal). More specifically, pressures impact water resources by a variety of causes, such as political decisions, economic development, use of water by agricultural, industrial and residential sector, population growth. This increases the stress that is put on the water, influencing the current state of the resource. The impacts of such incidents can be for instance, the damage of ecosystems, depleting quantity of available resources, decrease in economic development and conflict (local and/or international). As a response to these phenomena, action concerning the supply or/and the demand side of water needs to be designed and implemented, in order to secure the sustainable use of water resources.

The methodology is in line with the DPSIR (Drivers, Pressures, State, Impact, Response) framework (Kristensen, 2004; Ker Rault et al, 2004) (Fig. 3). More specifically, both the socio-economic benefits/costs yielded from the ecosystem services, but also the impact of economic development will be valued. It is apparent, that for such a task to be successful an abundance of information is required. This concerns information on the chemical, ecological and biological characteristics of the water system. Therefore, the cooperation between disciplines is of

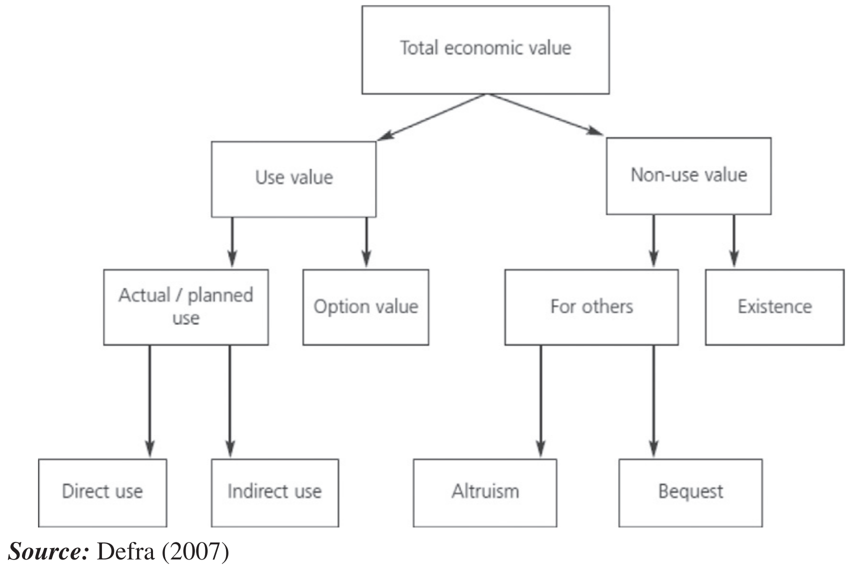

Fig. 1. Total Economic Value of ecosystem services according to DEFRA. Defra, 2007.

utmost importance in order to assess the current ecological status, the effects of human action and the effects on human wellbeing.

5.1. Step 1: socio-economic characterization of the river basin area

The main objective of "step 1" is to examine the socio-economic significance of water uses and services across the various economic sectors, and to identify the most important socio-economic drivers and pressures that affect the water status, both quantitatively and qualitatively. More specifically, this step is decomposed into four basic sub-steps. Initially, it is needed to identify the different economic sectors of the river basin area and, then, examine the usage of water supply for each of those sectors. In general, the analysis is focused on the importance of water uses for the following sectors: residential (i.e. drinking water for households), industrial, agricultural, tourism, health, and environment. Collecting socio-economic data for each of the aforementioned categories (such as turnover for key industrial sub-sectors, total cropped areas in agricultural sector and total number of tourists per year) is necessary for the adequate assessment of the importance of water uses and services and the construction of a baseline scenario.

Next, the main focus is on the identification of the main socio-economic drivers that have an impact on water stressors and uses in the river basin region. At this stage, it is necessary to collect data on general socio-economic indicators such as GDP per capita, employment statistics, population growth and education, and information on key water-related policies at each sector and planned investments which are likely to affect current regulation and, in turn, water status in terms of quality and quantity.

Following, it is examined how the evolving economic drivers will affect pressures. At this stage, it is crucial to fully understand the path of evolution on three main categories: (a) trend variables (such as changes in economic and population growth, changes in the relative importance of economic sectors and changes in land use percentages), (b) critical uncertainties (such as changes in social values and policy drivers, changes in national or international economic sector policies, and changes in natural environment and conditions), and (c) policy variables (i.e. planned investments on key economic sectors that attempt to restore the natural environment or mitigate damage, technological advancements that are likely to affect water uses on industrial sector for example and have a positive impact on water stressors). Finally, it is assessed how the water supply and demand evolves over time and space. At this phase, it is necessary to gather detailed information on water supply and demand statistics per economic sector over a period of at least five years. The information required for the described tasks, is closely related to the information the Member States report in the context of the WFD. Therefore, the information included in the River Basin Management Plans can directly be fed into the analysis.

The successful completion of the four sub-steps should enable the construction a baseline scenario in four stages. The first stage involves consideration of possibilities of evolution of the population in urban and rural areas.

The second stage involves the development of scenarios using key assumptions and quantification of the water balance. Next, using the scenarios it is examined how key variables are developed across time. Finally, in Stage 4, a storyline provides a potential evolution of the water system over 50 years (starting at present time). Fig. 4 depicts the implementation of the baseline scenario.

Table 3
Examples of use and non-use values for water resources as parts of the Total Economic Value.

Use values	
Direct use values	*Indirect use values*
Irrigation for agriculture	Water purification
Domestic and industrial water supply	Waste treatment
Energy resources (hydro-electric, fuel wood, peat)	Flood control and protection
Transport and navigation	Natural hazard mitigation
Recreation/amenity	External eco-system support
	Micro-climatic stabilization
Option values	Reduced global warming
Potential future uses of direct and indirect uses	Shoreline stabilization
Future value of information of biodiversity	Soil erosion control
Non-use values	
Biodiversity	
Cultural heritage	
Bequest, existence and altruistic values	

Adopted from (Birol et al., 2006).

5.2. Step 2: assessment of the current recovery water use cost

The main objective of the second step is to assess the current level of cost recovery of water services. Similar to Step 1, it is divided into four basic sub-steps. In the beginning, the extraction cost of water is estimated. This consists of three categories: financial cost, resource cost, and

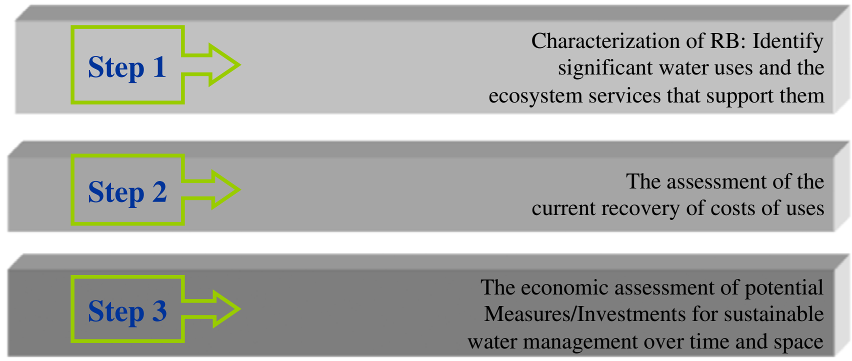

Fig. 2. The three-step methodology.

environmental cost. Financial costs are rather straightforward, referring to operational, administrative and maintenance costs of the existing infrastructure, and investment costs for water supply and sewerage and irrigation companies. Resource costs refer to the cost that occurs because of the overexploitation of water-related resources beyond the rate of natural replenishment. Those costs reflect the current and future scarcity of water. Following Koundouri (2004), the cost of the development of a backstop technology as a means to cover water demand and mitigate scarcity issues can be used as an approximation for the resources cost.

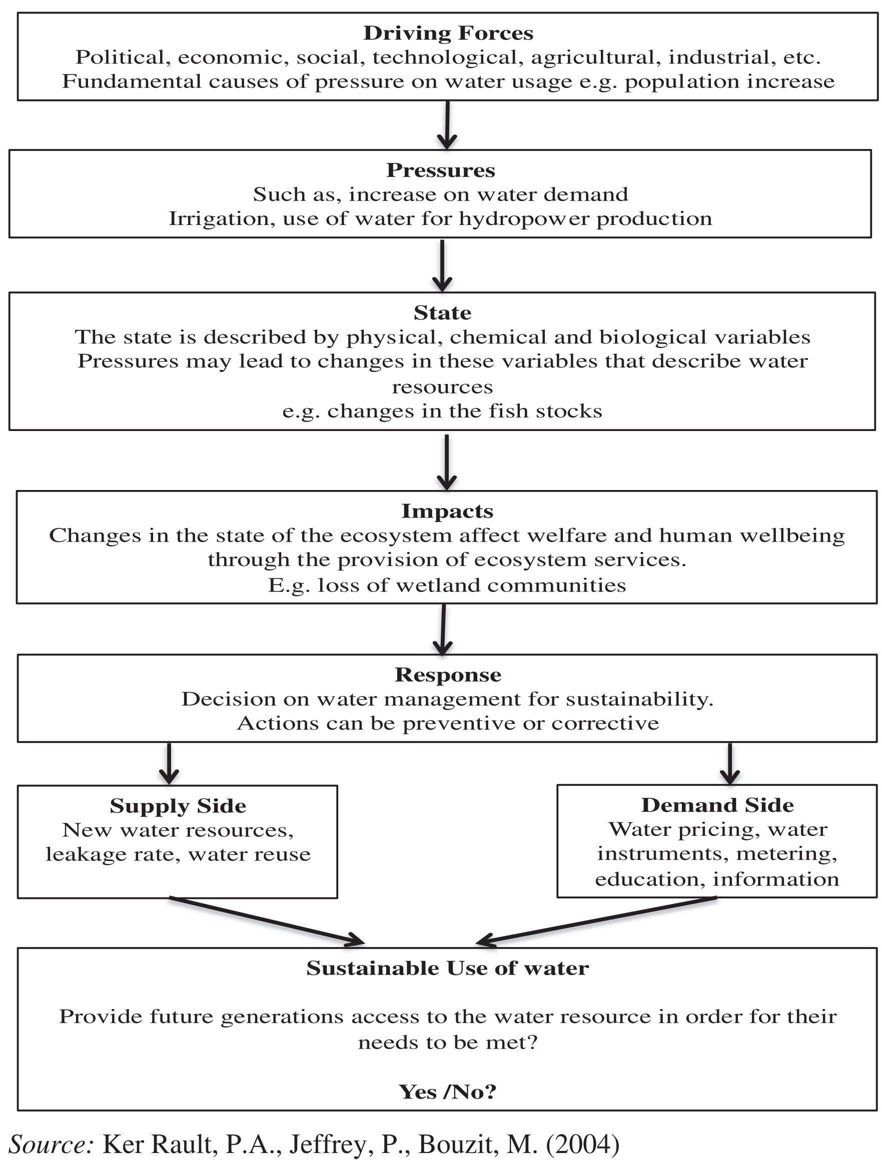

Fig. 3. Water management for sustainability: DPSIR model.
Ker Rault, P.A., Jeffrey, P., Bouzit, M. (2004).

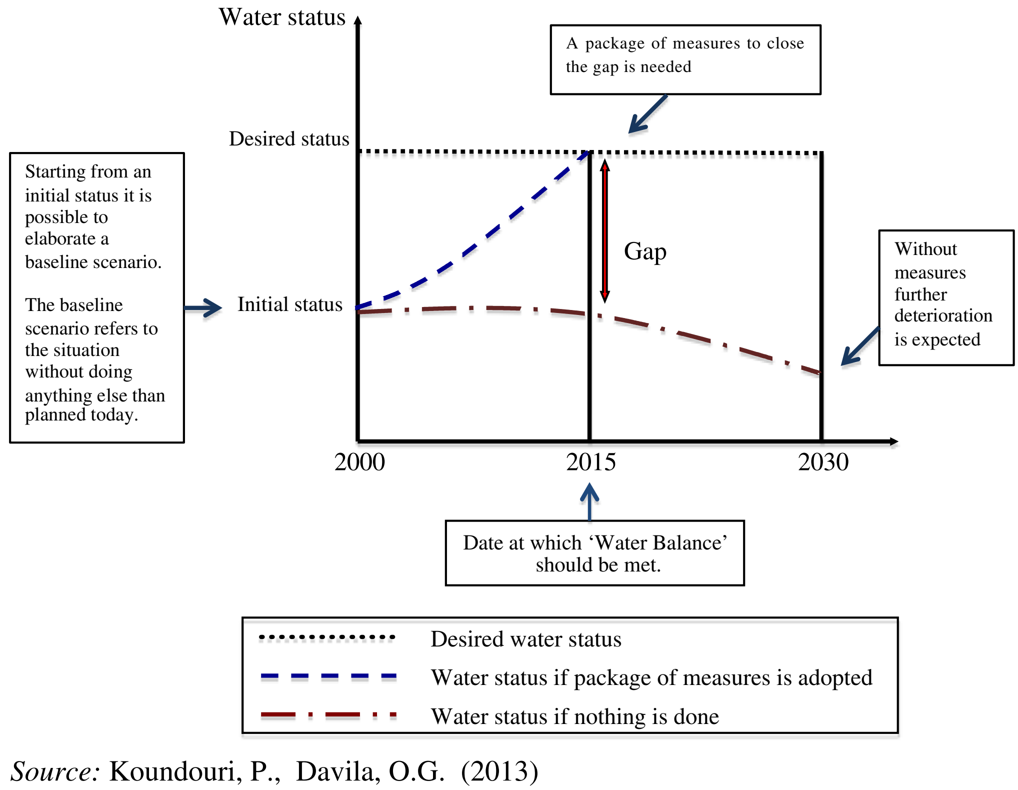

Fig. 4. Construction of baseline scenario.
Koundouri and Davila (2013).

Additionally, the environmental costs refer to those associated with the depletion of water ecosystem quality, which in turn leads to a decrease in the capacity of water-related resources to provide goods and services that are beneficial for human well-being. To estimate the environmental damage, it is necessary to apply appropriate valuation techniques that allow the estimation of the total economic value of water resources across the various economic sectors, and willingness to pay for the conservation of water resources of all affected individuals. These techniques will be discussed in detail in the following section. It is worth highlighting that, consistently with the Ecosystem Services Approach and as indicated by the Total Economic Value of Ecosystems and Biodiversity framework, the applied valuation techniques should take into account all four types of services that ecosystems can provide: supporting services, provisioning services, regulating services and cultural services.

In the second sub-step, and after having a complete picture of the total cost of water services from the previous sub-step, it should be identified who pays for the total cost of water services across the various economic sectors. This can be approximated by the revenues of water companies from each sector. Since information on water supply companies' revenues and total cost of water services is available, we are able proceed into the third sub-step and calculate the current level of cost recovery:

$$Cost\ \ Recovery\ \ Level = \frac{Recovery}{Total\ \ Economic\ \ Cost}.$$

Step two ends with the identification of potential mechanisms that can be implemented in order to achieve recovery of cost. Examples include: (i) pricing, where a market is created and the right to "use" the environment is priced,[1] (ii) tradable permits, where a certain level of permitted emissions is defined for each watershed and it is allocated to polluters with reference to their current output or level of emissions, (iii) quotas, (iv) taxes/subsidies, (v) direct controls for specific pollutants, (vi) educational and awareness campaigns, (vii) voluntary agreements between polluters and regulators/policymakers, and (viii) effective legal instruments. The selection of the appropriate mechanism (or mechanisms) should be determined with reference to the specific political and institutional conditions that characterize water supply and pricing at each river basin area. Moreover, the suitability of the selected measures should be determined in terms of their ability to achieve efficiency. To elucidate that, the mechanisms should equate the marginal TEV to its marginal cost.

5.3. Step 3: identification and suggestion of appropriate programs of measures for sustainable water management over time and space

Step 2, concluded with the identification of various mechanisms that would be potentially used to enhance the current management practices and achieve sustainability. Building on this output, Step 3 addresses the need to identify the least costly package of measures, as mentioned in the WFD. This includes a combination of economic instruments (such as taxes and tradable permits), educational and "awareness" measures on water uses and scarcity issues, investments on green technology, and agri-environmental programs providing technical and financial support (Jaeger et al., 2013).

In the second sub-step, we proceed with an assessment of the cost of measures by estimating a range of costs with reference to various key parameters that affect costs over time. The "proper" assessment will allow a fair cost allocation among the various water users and the identification of relevant losers and winners. In the next sub-step, the impact of the measures on key economic sectors/uses is examined. More specifically, we examine the net impact on public expenditures and revenues (expenditures on agri-environmental programs and revenues from economic instruments for example), impact on wider

[1] As recognized both by the WFD and the Water Blueprint (more information on: http://ec.europa.eu/environment/water/blueprint/index_en.htm) the current pricing is not realistic in some of the member states.

socio-economic conditions such as significant changes in the pattern of employment and significant changes in industries operation caused by changes in the price of watery supply.

Finally, after the identification of the most cost effective measures, it is necessary to employ a long-run[2] cost-benefit analysis (CBA) in order to make sure that there are not disproportionality issues in the selected packages. With regards to water management, a package of measures can be characterized as disproportionate if two criteria are met: (i) the achievement of good water status has a severe negative effect on the status of the wider environment and the human activities, (ii) the beneficial outcome of good water status cannot be achieved by other means. Under the existence of disproportionality, two strategies can be suggested: (i) less stringent objectives and (ii) time derogations from the original plan.

The outcome of selected package of measures will be characterized as sustainable due the course of time, if its net present value is positive:

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

with NPV denoting the net present value, K_t being the construction cost, B_t being the stream of benefits, C_t being the stream of costs and r being the discount rate.

One of the most challenging issues in the employment of long-term CBA is the selection of the appropriate discount rate. Following relevant literature (Gollier et al., 2008; Koundouri, 2009), we suggest the use of declining discount rate rather than the selection of a constant rate. One of the benefits of the declining discount rate is that emphasis will be given on the long-term (vs. short-term) improvement of social welfare.

6. Economic valuation of ecosystems in line with the TEEB initiative

The valuation of ecosystem services can be based on a wide range of economic techniques. Broadly speaking, economic valuation consists of three approaches to gauge the total economic value of a good or service, which are analyzed below. It is important to mention that, economic valuation is an anthropocentric approach. For this reason, economic valuation techniques seek to obtain affected stakeholders' value for each benefits they enjoy directly or indirectly, which are generated by the natural processes of the ecosystems.

6.1. Revealed preference methods (RP)

This type of methods, is used to elicit the value that the public places on impacts (good and/or bad) stemming from changes in the circumstances. This is achieved by observing the actual behavior of the public in an actual market. The term “actual” is used intentionally, as opposed to the use of hypothetical situations by the stated preference methods. Therefore, with the use of actual markets the researcher is able to trace the non-market good and quantify it using its market “footprint” (Russell, 2001). Although, a number of revealed preference approaches exist, for the purpose of this paper, the following three will be presented: i) hedonic pricing method; ii) travel cost method; iii) averting behavior and preventive expenditure. A final comment before the methods are introduced, is that the name of the methods is justified by the fact that the behavior of the public is deemed to reveal the price related to the non-market good (Pearce et al., 2006).

6.1.1. Hedonic pricing method (HPM)

The principle behind the HPM is that the price of a good captures the value of a bundle of characteristics of this good. For instance, the price of a computer might depend on its memory capacity, the resolution of its screen and its energy efficiency. HPM endeavors to isolate the incorporated values of each of the characteristics of the good. In an attempt to extract the value of a non-market good, the researcher makes use of a market good through which the non-market good is traded. Therefore, it is the market related to non-traded good that is of interest for HPM.

This method is often performed in the context of housing markets. Based on what mentioned earlier, a residence can be decomposed into its characteristics. For example, number of rooms, location, nearby amenities, year of construction etc. The market price of the house is a function of the characteristics it displays. Therefore, better characteristics will yield higher prices.

6.1.2. Travel cost method (TCM)

This technique is associated with estimating the value of the use of non-market goods for recreational purposes. The focus of this method is the number and frequency of recreational trips made by the individuals to and from some natural area and the cost of realizing these trips. The cost of performing a trip captures the cost of direct monetary cost of traveling, such as petrol expenses, depreciation of vehicle, fares and so on. Additionally, another element of this cost is the time spent traveling. Time can be allocating among several activities, therefore the household experiences an opportunity cost in allotting time to traveling. Furthermore, the shadow price of time is considered to be the individual's wage rate. This information is usually obtained through asking individuals at a recreational site.

This information can be used to estimate the price the individuals pay for environmental non-market resources. For example, we can estimate the effect of improved water quality on the demand for recreational activities in a specific site. For this purpose, the travel cost function would be enriched with an additional variable for water quality. The demand for recreational trips would move to the right, leading to higher consumer surplus that would mean that individuals would be willing to undertake higher costs or travel more frequent to the area, due to the environmental improvement.

As for HPM, there are also some issues in using TCM. For instance, sample selection bias (the non-travelers are not taken into account). The use of the wage rate as the price of time of traveling has also faced strong criticism. The negative utility affiliated with the time of traveling definable, while individuals might gain some utility by traveling through nice sceneries.

6.1.3. Averting behavior and preventing expenditure

Those methods are based on the notion that when individuals face risks or utility loss that stem from a negative externality (non-market bad), will be willing to pay for goods and services traded in the markets to mitigate this utility loss.

A useful example that will provide an illustration of these methods is offered by Garrod and Willis (1999). According to this, households install double-glazed windows to mitigate their exposure to noise caused by road traffic. Double-glazed windows are market goods. Households use double-glazing as a substitute good of absence of noise pollution due to traffic. The more noise pollution, the higher the expenditure of the households to purchase substitute goods to avoid, or mitigate it. The changes in the household expenditure on these substitutes due to the public bad can be used to provide a measure of the value that the households assign to the traffic reduction and the increase of quiet. Additionally, individuals may increase the time spent indoors, due to the increase of noise pollution.

Nevertheless, implications arise in the application of such methods. For instance, the averting behavior of the individuals may create additional value from engaging themselves in other activities or from the use of the substitute products. Therefore, this value should be deducted from the value of the expenditures to accurately measure the value associated with the elimination of the public bad. Moreover, in some cases, these methods do not provide estimates for the total value of

[2] Long-run CBA is an appropriate way to proceed, since the application of a package of measures will be having a long-term impact on the socio-economic and environmental conditions of the examined geographical area.

the impacts on welfare. More precisely, even though the individuals purchase other goods to avoid the lower utility that the non-market bad imposes, in some cases they are unable to avoid it completely.

6.2. Stated preference methods (SP)

In contrast with Revealed Preference techniques, Stated Preference methods are survey-based methods, which seek to elicit individuals' preferences. This family of methods is based on the Random Utility Theory, according to which the researcher does not know individuals' utility, but instead the researcher can observe the choices made by the individuals and conclude on their *representative utility*. In this context individuals' utility is described as:

$$U_{jn} = V_{jn} + e_{jn}, \quad j = 1, \ldots, J, \quad n = 1, \ldots, N$$

where U_{jn} is individual's n utility, V_{jn} is what the researcher observes based on individual's n choices and e_{jn} is the error term.

It is due to this framework that these methods have been used so extensively. More precisely, these methods are of relevance in the following instances:

- When the good of interest embodies both *use* and *non-use values*. As it is mentioned above, RP fail to capture values related to intangible characteristics of the good.
- In cases where the researcher is interested in evaluating a change in a policy/good ex ante.

RP methods require the existence of a demand curve for the good of interest. However this is not always available. Public policies or the development of new goods might entail that a market does not exist. "Constructed" markets used in SP can overcome this obstacle. Consequently, SP methods can be used for both real and hypothetical goods. The second point might be confusing as to what a constructed market is. This is nothing but a scenario that is introduced to the respondents of the survey. The script defines the good, the institutional setting, the way and timing of providing the good, and the way the good would be financed. Respondents then are asked to implicitly state their WTP for changes in the level of the provision of the good. The questionnaires intend to describe the scheme and make the respondents behave as if they were in an actual market. The underline assumption of these methods is that the respondents do behave in the same way no matter if the market is real or not.

6.2.1. Contingent Valuation Method (CVM)

CVM is one of the methods that fall under the SP methods classification. CVM uses questionnaires to elicit the willingness to pay (WTP) of the individuals. The literature is rich of valuation exercises using the CVM approach, therefore it could be claimed that this is the most used of the SP methods (examples can be found in Venkatachalam, 2004). The fact that people are asked "what they would do" as opposed to "what they are observed doing" is one of its biggest strengths, because it enables the researcher to elicit both use and non-use values.

Despite of that, the survey nature of the method is one of its main weaknesses. The CV survey questionnaires consist of three parts. The first part includes questions about the attitude of the respondents towards the good or policy to be valued. The second part follows with the presentation of the scenario that gives respondents information about the good, the market that it belongs to, its provision and method of payments. During this stage, the respondents are asked to value the good based on their preferences and the conditions in the market. The final stage concludes with questions on the demographic and socio-economic characteristics of the participants. Using statistical methods and the information from the survey, economists are able to conduct their analysis.

Nevertheless, a fundamental problem of the CVM is that although it provides a rigorous description of the market and the good, respondents' experience with the hypothetical market cannot be compared to the experience they have with real markets (Bateman et al., 2002).

6.2.2. Choice Modeling (CM)

Similar to CVM, CM is also a survey-based technique. In CM surveys, goods are described in terms of their attributes, as it will be explained below, and of the levels that these attributes take. Accordingly, the respondents are asked to choose among various alternatives, where different attributes and their levels are assigned to the good. The task is then to rank these alternatives, to rate them, or to choose the most preferred according to the used CM methods. These methods are:

- ☐ *Contingent ranking*, where the respondent ranks several alternatives;
- ☐ *Contingent rating*, where the respondent rates different scenarios on a 1–10 scale;
- ☐ *Paired comparisons*, where the respondents choose their preferred alternatives out of a set of two choices and then they are asked to manifest how strong their preferences are for this alternative using a scale.

The fourth method is *Choice Experiments* (CE), where the respondents are asked to choose their favorite alternative of sets of various alternatives. One of the alternatives usually represents the current status (status quo alternative). The inclusion of such an alternative is needed in order to produce welfare-consistent estimates. That is because, individuals are induced to make decisions on changes based on the costs and benefits corresponding to these changes. Additionally, the introduction of the opt-out alternative allows respondents to avoid choosing a change in the good or policy. Also, given the fact that the value of the change is evaluated based on a baseline, which is in fact the current status, the relevant estimates of compensating and equivalent surplus can be derived.

Although CV and CM belong to the same family, the choice between them is determined by the objective of the commissioned study. Despite the common features of the methods, following the presentation of the topic by Bateman et al. (2002), several issues should be considered before choosing one method or the other.

Firstly, CVM is more effective when the total value of a good, service, or policy is investigated. Choice Modeling on the other hand, can effectively provide information about specific attributes. Additionally, the questionnaires of choice modeling (CM) are easier for people to understand. That is due to the fact that CM surveys do not explicitly ask respondents about their WTP. Furthermore, CV surveys might include questions such as "What amount of money would you be willing to pay for…?", which are often criticized due to complicating the task for the individuals.

6.3. Benefit transfer (BT)

Benefit transfer relies on estimates from primary studies undertaken in locations (study sites) similar to the study site under consideration (policy site). This method has been extensively used for local, national and global ecosystem assessments (e.g. the UK NEA, 2011; EEA, 2010; TEEB QA, 2010). The low cost in terms of money and time has resulted in the widespread use of the method. The method is based on the rationale that the value attained from primary studies for similar sites can be used for the valuation of a good related to the study site. Although its implementation is simple, careful application is required.

7. Estimating the value of ecosystem services using the benefit transfer approach

To elucidate the use of economic techniques for water management, we present the use of the BT method to estimate benefits from ecosystem services in the Anglian river basin (UK). The Anglian river basin

(RB) covers an area of 27.890 km^2 mainly within the administrative regions of East of England and East Midlands (Fig. 5). It is predominantly a rural area without big urban centers. Anglian RB contains various protected areas, including water-depended protected areas (23 Special Areas of Conservation and 22 Special Protection Areas) with economically significant species, drinking and recreational waters.

Several pressures are being imposed on the river basin, with water abstractions, organic pollution, pesticides, phosphate, physical modification, non-native species being among the most significant.

From the above we conclude that use and non-use values are attached to the water ecosystem, which are subject to change due to the existence of pressure on water. More specifically, apart from the provision of water for consumption or production input, local stakeholders, enjoy passive values such as those described above. In order to elicit these values, it is essential to implement both market and non-market techniques. In cases, where these values can be traced in the literature, benefit transfers can be used. The value is then adjusted to capture the differences between the study sites, from where the values are obtained and the policy site for which the values are estimated.

Initially, a review of the literature is performed in order to put together a list of values from sites with similar characteristics to the policy site. In case this is not possible, less similar sites may be used. After that, the necessary adjustments for i) currency, ii) purchasing power and iii) income difference should be undertaken. Additionally, the changes in prices that are caused due to inflation should also be considered. Therefore, the willingness to pay that is obtained in a site is adjusted in a way that represents the socioeconomic characteristics of another site.

The initial step, included the review of relevant literature. More specifically, one of the tools we used was Google Scholar. Using relevant keywords, we collected a high number of articles. Additionally, we used the TEEB valuation database, from which we subtracted the studies

Fig. 5. Map of the Anglian river basin.
Anglian River Basin Management Plan (2009).

that referred to river ecosystems. The values were taken from primary studies that had made use of techniques like those mentioned in previous section. During the next step we decided on the studies that were of high relevance, namely those that estimated the value of the four ecosystem services in which we were interested (Table 4). After the values were identified, we made the aforementioned adjustments and we calculated the average value for each category of services.

Based on 28 studies (see Appendix A) we estimated the following values for four categories of ecosystem services.

From the above table, we can conclude that erosion protection attracts the lowest value compared to the other three types of services. On the contrary, the provisioning services are valued the highest. Additionally, the cultural and regulated services seem to be perceived as fairly important compared to erosion protection. This means that the river is associated with high passive values such as recreational, existence and bequest values. Associating future changes in the water ecosystem with the result of the value transfer method, it would become clear which changes generate high avoided benefits due to changes in the provision of ecosystem services.

8. Conclusions and discussion

Overall, this methodology represents an interdisciplinary approach to implement sustainable management of water resources, while satisfying the requirements of water related directives. the first conclusion is that the approach requires the exchange of information between different disciples in order to produce robust results. Biologists need to obtain information on how freshwater ecosystem function in different contexts of pressures and stressors. Additionally, the effects of these factors also need to be examined in relation to the chemical status of the resource. The link of anthropogenic factors, such as irrigation, pollution, and the ecological, chemical status of the water must also be considered. It is apparent that the environmental cost as part of the total cost of water can be accurately estimated, only if a fruitful pairing between social and natural sciences is achieved.

The 3 step approach is a holistic tool to assess the total economic value of water services, the extent to which related costs are recovered and a way to identify cost-effective measures to achieve higher cost recovery making use of the economic valuation techniques. The importance of that lies in the fact that economic valuation of ecosystem services enables to compare public policy scenarios and could contribute to make optimal decisions.

Additionally, its main advantage is the integration of the ecosystem services framework, which when combined with traditional economic frameworks can produce results that are meaningful to policy makers, stakeholders and the wider public. Furthermore, this approach embeds a cause-result relationship that having the interaction between different natural and artificial elements (e.g. pollution, economic development) in its very core. For this reason it should be noted that the presented approach is a concrete tool that can be used not only to fulfill the requirements of relevant EU Directives, but also to achieve sustainable use of water resources regardless of the existence of legal any legal framework.

Table 4
Economic value of four ecosystem services.

Category of ecosystem service	Type of service	Average value per person per year (UK, 2013)
Provisioning services	Provisioning services (drinking water)	€ 28.98
Regulating services	Water treatment	€ 24.99
Supporting services	Erosion protection	€ 2.82
Cultural and amenity services	Habitat for species	€ 16.65

Finally, it is recognized that further research could investigate how changes in any parameter of the system can impact not only human welfare, but also the environment as a function of the human welfare.

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Appendix A

Ecosystem service	Title	Country
Provisioning services	Hardner, J. J. (1996). Measuring The Value Of Potable Water In Partially Monetized Rural Economies.	Ecuador
	Abrahams, N. A., Hubbell, B. J., & Jordan, J. L. (2000). Joint Production And Averting Expenditure Measures Of Willingness To Pay: Do Water Expenditures Really Measure Avoidance Costs?. American Journal Of Agricultural Economics, 82(2), 427–437.	Georgia
	Bilgic, A., Eren, G., & Florkowski, W. J. (2008). Willingness To Pay For Potable Water In The Southeastern Turkey: An Application Of Both Stated And Revealed Preferences Valuation Method. In 2008 Annual Meeting, February 2–6, 2008, Dallas, Texas (No. 6755). Southern Agricultural Economics Association.	Turkey
	Um, M. J., Kwak, S. J., & Kim, T. Y. (2002). Estimating Willingness To Pay For Improved Drinking Water Quality Using Averting Behavior Method With Perception Measure. Environmental And Resource Economics, 21(3), 285–300.	South Korea
	Kwak, S. Y., Yoo, S. H., & Kim, C. S. (2013). Measuring The Willingness To Pay For Tap Water Quality Improvements: Results Of A Contingent Valuation Survey In Pusan. Water, 5(4), 1638–1652.	Pusan, Korea
Water treatment	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Lee, C. K., & Han, S. Y. (2002). Estimating The Use And Preservation Values Of National Parks' Tourism Resources Using A Contingent Valuation Method. Tourism Management, 23(5), 531–540.	Korea
	Hite, D., Hudson, D., & Intarapapong, W. (2002). Willingness To Pay For Water Quality Improvements: The Case Of Precision Application Technology. Journal Of Agricultural And Resource Economics, 433–449.	Mississippi, USA
	Bhat, G., Bergstrom, J., Teasley, R. J., Bowker, J. M., & Cordell, H. K. (1998). An Ecoregional Approach To The Economic Valuation Of Land-And Water-Based Recreation In The United States. Environmental Management, 22(1), 69–77.	USA
	Loomis, J., Kent, P., Strange, L., Fausch, K., & Covich, A. (2000). Measuring The Total Economic Value Of Restoring Ecosystem Services In An Impaired River Basin: Results From A Contingent Valuation Survey.	USA

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(*continued*)

Ecosystem service	Title	Country
	Ecological Economics, 33(1), 103–117.	
	Gürlük, S. (2006). The Estimation Of Ecosystem Services' Value In The Region Of Misi Rural Development Project: Results From A Contingent Valuation Survey. Forest Policy And Economics, 9(3), 209–218.	Turkey
	Crutch-Field, S. R., Cooper, J. C., & Hellerstein, D. (1997). Benefits Of Safer Drinking Water: The Value Of Nitrate Reduction (Agricultural Economic Report No. 752). Us Department Of Agriculture, Economic Research Service, Food And Consumer Economics Division.	USA
Habitat for species	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	UK
	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	UK
	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	UK
	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	Norway
	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	Sweden
	Nijkamp, P., Vindigni, G., & Nunes, P. A. (2008). Economic Valuation Of Biodiversity: A Comparative Study. Ecological Economics, 67(2), 217–231.	UK
	Halstead, J. M., Luloff, A. E., & Stevens, T. H. (1992). Protest Bidders In Contingent Valuation. Northeastern Journal Of Agricultural And Resource Economics, 21(2), 160–169.	New England, US
Erosion protection	Colombo, S., Calatrava-Requena, J., & Hanley, N. (2003). The Economic Benefits Of Soil Erosion Control: An Application Of The Contingent Valuation Method In The Alto Genil Basin Of Southern Spain. Journal Of Soil And Water Conservation, 58(6), 367–371.	South Spain
	Magrath, W., & Arens, P. (1989). The Costs Of Soil Erosion On Java: A Natural Resource Accounting Approach. World Bank Policy Planning And Research Staff, Environment Department.	Java, Indonesia
	Bishop, J., & Allen, J. (1989). The On-Site Costs Of Soil Erosion In Mali. World Bank, Policy Planning And Research Staff, Environment Department.	Mali
	Moore, W. B., & Mccarl, B. A. (1987). Off-Site Costs Of Soil Erosion: A Case Study In The Willamette Valley. Western Journal Of Agricultural Economics, 42–49.	US
	Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., Mcnair, M., … & Blair, R. (1995). Environmental And Economic Costs Of Soil Erosion And Conservation Benefits. Science-Aaas-Weekly Paper Edition, 267(5201), 1117–1122.	US

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