Socio-Economics and Water Management: Revisiting the Contribution of Economics in the Implementation of the Water Framework Directive in Greece

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Abstract This chapter sets out the socio-economic principles that should govern water resources management for the achievement of a sustainable allocation of the resource over time and across space, in accordance with the EU Water Framework Directive. The resulting allocation should be economically efficient, socially equitable and acceptable and environmentally sustainable. The main background concept guiding the identification of such an allocation is the 'total economic value (TEV)' of water resources. This concept derives from the ecosystem goods and services that water resources provide the economy and society. In this chapter we present the state of the art with regard to estimating the TEV of water resources and explain how these estimations can facilitate the design and implementation of different European policies in relation to mitigation of different forms of water stress.

Keywords Nonmarket valuation, Total economic value, Water framework directive, Water valuation

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Abbreviations

CBA Cost-benefit analysis
CEM Choice experiment method
CV Contingent valuation
RBD River basin district
TEV Total economic value
WFD Water framework directive
WTP Willingness to pay

1 Introduction

In this chapter, we provide a state-of-the-art review of the basic economic valuation methods that can be used for the monetisation of the economic and societal benefits provided by water resources and discuss how the valuation outcomes can inform policymakers for a more efficient water management plan, in accordance with the European Union's Water Framework Directive (WFD) [1]. Contrary to previous pieces of legislation which focused on specific water-related environmental issues, the WFD aimed at creating an integrated policy framework for the sustainable management and protection of aquatic resources (inland surface waters, transitional waters, coastal waters and groundwater) both in terms of quantity and quality across European Union country members [2]. Therefore, as stated in Waternote 9,[1] the Directive has developed a 'combined approach for point and diffuse sources and refers to several related directives' (p. 1). The necessity for the development of such

[1] Waternote 9 can be accessed here (last accessed 12/02/2015): http://ec.europa.eu/environment/water/participation/pdf/waternotes/water_note9_other_water_legislation.pdf.

a policy framework became imperative by taking into account the increased demand for high-quality water quantities. For the implementation of the Directive, all member states are obliged within specific deadlines to identify all individual river basins within their national territories and assign them to specific river basin districts (RBDs).

2 Economic Aspects of Water Framework Directive

Given the increased water scarcity, the WFD has recognised the need of incorporating economic analysis in the water-related policy agenda through the use of appropriate economic instruments for assessing water value, thus meeting certain environmental objectives, in accordance with the various articles of the Directive. Economic issues are mainly discussed in articles 5 and 9 and in Annex III.

According to article 5, all member states need to undertake an analysis of each RBD characteristics, review the impact of human behaviour on the status of surface water and groundwater and proceed with an economic analysis of water use. Although each country shall proceed and implement its own techniques, the European Union's guidelines [3] suggest the following implementation steps: (1) characterise the river basin in terms of the economics of water uses, trends in water supply and demand levels and current recovery levels of water services' costs, (2) identify all waterbodies or groups of waterbodies that fail to meet the environmental objectives of the Directive, and (3) develop appropriate programmes of measures to be included in river basin management plans through a cost-effectiveness analysis and justify potential derogation from an economic perspective.

As highlighted in article 9 and Annex III, countries shall take into account the principle of cost recovery (including environmental and resource costs) of water services and consider the social, environmental and economic effects of the recovery and also the regional geographical and climatic conditions of each RBD. Table 1 provides a summary of the total cost of water services. The goal is to ensure an adequate contribution of the various water users (industry, households and agriculture) to the cost recovery of water services and to provide strong incentives for users to use resources efficiently. It is also crucial to evaluate the cost of the application of various measure programmes and choose the most cost-effective combination.

Overall, according to the relevant EU guidelines [3], the contribution of economic analysis is along the following topics: (1) understanding the importance of economic issues and trade-offs at each river basin; (2) identifying the most cost-effective way (e.g. through water prices, pollution charges or environmental taxes) for achieving certain environmental objectives for water resources, given the limited availability of financial resources; (3) evaluating the role of various measures for the improvement of water status and considering policies for the compensation of losers; and (iv) relaxing the environmental objectives on waterbodies, if this can help promote overall sustainability.

Table 1 Total economic cost of water services

Financial cost	Cost of providing and administering water services. Includes capital cost, operation cost, maintenance cost and administrative cost
Environmental cost	Environmental cost represents the costs of damage that water uses impose on the environment/ecosystems (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils)
Resource cost	Resource cost represents the costs of foregone opportunities which other uses suffer due to the depletion rate of recharge or recovery of water (e.g. linked to the over-abstraction of groundwater)

Source: Koundouri et al. [2], p. 10

The following sections discuss how economic analysis has developed a variety of appropriate tools for meeting the demands of the WFD. These tools allow us to quantify the total economic value of aquatic resources and inform policymakers about the effectiveness and sustainability of proposed management actions.

3 Methodology for Implementing the WFD

When a fully functioning market exists, as in the case of private goods, the value of the assessed asset is normally reflected in the market price (e.g. fish products are priced in a market). However, a market value does not exist for services such as recreation activities or biodiversity. In this section, we provide an overview of the most important economic techniques employed for identifying and estimating water's total economic value (or, at least, some components of it).

3.1 Total Economic Value

The total economic value (TEV) comprises two main types of values that can be derived from an environmental resource: use and non-use values. The former refer to benefits that people receive from the usage of the specific commodity, while the latter refer to benefits people attach to the commodity even if they do not make use of it. Use values can be further divided into three main categories: direct use values, arising from the consumptive use of a certain environmental good; indirect use values, arising when individuals indirectly interact with the resource; and option values, representing the potential benefits that can be derived from the environmental asset by future generations. Non-use values can be further classified into existence values, i.e. values individuals place on the existence of the environmental good as it stands; bequest values, i.e. values individuals place on the importance of preserving the environmental asset for future generations; and altruistic values, i.e. values individuals place on the need to maintain an environmental good in order

Table 2 TEV components for water resources

Use values	
Direct use values	Indirect use values
Irrigation for agriculture	Nutrient retention
Domestic and industrial water supply	Pollution abatement
Energy resources (hydroelectric, fuel wood, peat)	Flood control and protection
Transport and navigation	Storm protection
Recreation/amenity	External ecosystem support
	Micro-climatic stabilisation
Option values	Reduced global warming
Potential future uses of direct and indirect uses	Shoreline stabilisation
Future value of information of biodiversity	Soil erosion control
Non-use values	
Biodiversity	
Cultural heritage	
Bequest, existence and altruistic values	

Source: Birol et al. [4], p. 107

to be used by other individuals. Table 2 provides examples of these various components of the TEV in the context of water resources.[2]

3.2 Nonmarket Valuation Techniques

The development of nonmarket valuation techniques allows us to quantify various components of the TEV of water. Revealed preference techniques are employed to estimate use values, while stated preference techniques are appropriate for estimating both use and non-use values.

3.2.1 Revealed Preference Techniques

In this section, we introduce the two basic revealed preference techniques, widely used in environmental economics, for revealing the values individuals assign to an environmental asset: the hedonic pricing method and the travel cost method.

[2] Please see also National Research Council [5] book on groundwater valuation (Table 1.3, p. 20) for a taxonomy of groundwater values in particular. For example, according to this taxonomy, groundwater use values are divided into extractive (municipal, industrial and agricultural) values and in situ (ecological, buffer, subsidence avoidance, recreational and seawater intrusion values) use values.

Hedonic Pricing Method

This method uses the price variations of real estate market in order to estimate the value of a local environmental good or service. The main assumption behind this method is that people take into account local environmental characteristics when deciding to buy a property; therefore, the quality of the surrounding environment (such as air, water and noise pollution levels) will be reflected in the prices of real estate property. For example, Mahan et al. [6], based on a dataset of 14,000 home sales in Portland, found that proximity to wetlands had a positive effect on property values (a decrease in the distance to the nearest wetland by 1,000 feet caused property values to go up by $436). Likewise, in the context of groundwater, land rent and property prices can be used as shadow prices, i.e. as implicit values for estimating the value of water's quantity and quality. Torell et al. [7], for example, compared sales of irrigated and nonirrigated pieces of land in the southern High Plains (an area within various central US states such as Texas, Oklahoma and Kansas) and found that the value of groundwater was an important part of transaction prices for irrigated farmland (comprising from 30% to 60% of the farm sale price across the various states). King and Sinden [8] valued soil erosion and related effects on groundwater in New South Wales, Australia, and concluded that the market seemed to be working to conserve the soil in the examined region.

Travel Cost Method

This method is commonly used for estimating people's willingness to pay for visiting various ecosystem areas and natural landscapes for recreational activities. The basic assumption behind this method is that the value of the environmental amenity will be reflected on the time and travel cost that a person is willing to incur in order to access the site. The results of this method are used to determine changes in the access cost of a recreational site or to assess policy interventions with a view to improving environmental conditions. Bowker et al. [9], for example, employed the TCM in the Chattooga and Nantahala rivers in the USA and derived a value for guided white water rafting between $89 and $286 per visitor per trip. Wilson and Carpenter [10] estimated WTP for water quality changes in lakes, rivers, wetlands and streams in the USA (their estimates were $6 per trip to avoid further degradation in the considered 13 sites, $13 per trip to improve water quality boatable state to fishable state and $51 per trip to improve water quality from boatable to swimmable state).

3.2.2 Stated Preference Techniques

In contrast to revealed preference methods, capturing only use values, stated preference techniques are appropriate for measuring both use and non-use values from ecosystem services. Capturing and monetising the value of ecosystem services

Table 3 Scenario design criteria and contingent valuation measurement outcomes

Is the scenario...	If not, respondent will...	Measurement consequence
Theoretically accurate?	Value wrong things (theoretical misspecification)	Measure wrong thing
Policy relevant?	Value wrong things (policy misspecification)	Measure wrong thing
Understandable by respondent as intended?	Value wrong things (conceptual misspecification)	Measure wrong thing
Plausible to the respondent?	Substitute another condition, or not take seriously	Measure wrong thing. Unreliable, bias susceptible don't know or protest zero
Meaningful to the respondent?	Not take seriously	Unreliable, bias susceptible don't know or protest zero

Source: Mitchell and Carson [12], p. 190

may increase the efficiency of policy interventions, leading to an increase in environmental sustainability and net benefits for society [11]. This section reviews the two most popular methods of this type: the contingent valuation method and choice experiments.

Contingent Valuation Method

This method aims at eliciting people's willingness to pay (WTP) for *positive* changes in the quantity or quality of an environmental resource or their willingness to accept (WTA) compensation for *negative* changes in the status of the resource. It is a survey-based approach in which participants are asked to state their preference on a *hypothetical* scenario explained in the study. Therefore, the construction and implementation of the survey is a major challenge: particular care is required for the wording of the questionnaire and the administration of the survey so as to minimise bias. Table 3 summarises the basic criteria for a good scenario. Pate and Loomis [13] have provided a water-related application of CVM, in which households were willing to pay for the adoption of an improvement programme in a wetland in California. Hite et al. [14] also employed a CVM to assess public willingness to pay for reductions in agricultural nonpoint pollution and concluded that significant public support existed towards a policy providing farmers with precision application equipment to reduce nutrient runoff.

Choice Experiment Method

The choice experiment method (CEM) is a relatively new addition to the pool of stated preference techniques, having its theoretical foundations in Lancaster's [15] theory of value. The latter suggests that individuals derive satisfaction not by the consumption of a certain good itself but from its various attributes. Therefore, in choice experiments, a bundle of environmental goods is presented to respondents with various attributes or characteristics (price is usually one of the main attributes). Due to its experimental nature, the CEM enables researchers to evaluate attributes at various levels (e.g. high, medium or low status of water quality) and identify trade-offs that respondents have among the attributes. Each set of choices is then associated with a certain level of utility. Willis et al. [16] examined consumers' trade-offs between water supply security and river flows/biodiversity in local wetlands in Sussex, UK. Their findings suggest that though consumers assigned an insignificant value on increasing water supply, they had a positive value for a unit increase in the conservation of wetland habitats and river flows.

As a summary of this section, Table 4 presents the advantages and disadvantages of the main economic valuation methods. Also, it is worth noting that herein we have mentioned briefly only a couple of applications of revealed and stated preference techniques; nevertheless, the literature is vast (e.g. regarding the estimation of groundwater benefits, we refer the interested reader to Work Package 6-Genesis Project[3] for a thorough discussion of a large number of valuation studies, undertaken worldwide).

3.2.3 Laboratory Experiments

Laboratory experiments investigate preferences under a 'real setting' situation, fully controlled in a laboratory [19]. Real economic incentives are provided to the participants in order to reveal their WTP for a certain public or private good. Table 5 contains a brief description of some basic incentive-compatible mechanisms. For example, in the second-price sealed-bid Vickrey auction [21], participants submit sealed bids and the good is acquired by the participant who provides the highest bid, but at a price equal to the value of the second-highest bid. Several conditions may affect the quality of the performed experiments, such as the participants' unfamiliarity with the elicitation mechanisms, their tendency to use numbers (presented to them) as anchor values for their WTP, the presence of researchers scrutinising participants' behaviour and the use of a non-representative sample [20].

[3] Work Package 6 'Application of valuation techniques to assess the benefits of groundwater quantity-quality improvements' of the Genesis Project (Groundwater and Dependent Ecosystems: New Scientific and Technological Basis for Assessing Climate Change and Land-use Impacts on Groundwater). Genesis Project is available at: www.thegenesisproject.eu.

Table 4 Advantages and disadvantages of economic valuation methods[a]

Hedonic pricing method	*Advantages*
	Based on observable and readily available data from actual behaviour and choices
	Disadvantages
	Difficulty in detecting small effects of environmental quality factors on property prices Connection between implicit prices and value measures is technically complex and sometimes empirically unobtainable Ex post valuation (i.e. conducted after the change in environmental quality or quantity has occurred) Does not measure non-use values
Travel cost method	*Advantages*
	Based on observable data from actual behaviour and choices Relatively inexpensive
	Disadvantages
	Need for easily observable behaviour Limited to in situ resource use situations including travel Limited to assessment of the current situation Possible sample selection problems Ex post valuation Does not measure non-use values
Production function approach	*Advantages*
	Based on observable data from firms using water as an input Firmly grounded in microeconomic theory Relatively inexpensive
	Disadvantages
	Understates WTP Ex post valuation Does not measure non-use values Omits the disutility associated with illness
Contingent valuation	*Advantages*
	It can be used to measure the value of anything without need for observable behaviour (data) It can measure non-use values Technique is not generally difficult to understand Enables ex ante and ex post valuation
	Disadvantages
	Subject to various biases (e.g. interviewing bias, starting point bias, nonresponse bias, strategic bias, yea-saying bias, insensitivity to scope or embedding bias, payment vehicle bias, information bias, hypothetical bias) Expensive due to the need for thorough survey development and pre-testing Controversial for non-use value applications
Choice experiment method	*Advantages*
	It can be used to measure the value of any environmental resource without the need for observable behaviour (data), as well as the values of their multiple attributes It can measure non-use values

(continued)

Table 4 (continued)

	Eliminates several biases of CVM Enables ex ante and ex post valuation
	Disadvantages
	Technique can be difficult to understand Expensive due to the need for thorough survey development and pre-testing Controversial for non-use value applications

Source: Commission on Geosciences and Environment and Resources (CGER) [17], cited in Birol et al. [4], p. 114

[a]When time and budget constraints do not allow for the employment of an original valuation study, the benefit transfer method can be applied, i.e. economic estimations can be transferred from one study site to another with similar location characteristics. More details about this method can be found in Koundouri et al. [18]

Table 5 Incentive-compatible mechanisms

Elicitation mechanism	Participant procedure	Market price	Rule	# of winners
English auction	Sequentially offer ascending bids	Last offered bid	Highest bidder pays market price	1
2nd price auction	Simultaneously submit sealed bids	Second highest bid	Highest bidder pays market price	1
*N*th- price auction	Simultaneously submit sealed bids	*N*th highest bid	*n*-1 highest bidders pay market price	*n*-1
Random *N*th- price auction	Simultaneously submit sealed bids	Randomly drawn *N*th highest bid	*n*-1 highest bidders pay market price	*n*-1
Becker-DeGroot-Marschak	Simultaneously submit sealed bids	Randomly drawn price	Participant pays market price if bid exceeds market price	Individually determined
Real choice	Choose alternatives in multiple scenarios	Randomly drawn binding scenario	Everybody pays market price	All participants
Incentive-compatible conjoint ranking mechanism	Rank alternatives in multiple scenarios	Randomly drawn binding scenario	Everybody pays market price	All participants
Open-ended choice experiment	Simultaneously submit quantities	Randomly drawn price	Everybody pays market price for submitted quantities	All participants
Multiple price list	Accept/reject stated prices	Randomly drawn price	Participants pay market price if it is accepted	Individually determined
Real dichotomous choice experiment	Accept/reject	Given price	Participants pay market price if it is accepted	Individually determined
Quantity trade-off experiment	Accept/reject	No price	Participants complete trade if it is accepted	Individually determined

Source: Alfnes and Rickertsen [20], p. 219

3.3 *Integrated Hydro-Economic Models for Optimal Water Management*

In the previous section, we provided an overview of some common valuation techniques with regard to the calculation of various components of water's TEV. Now, we turn to hydro-economic models as tools for estimating water's economic value and suggesting strategies leading to an optimal water allocation.[4]

Integrated hydro-economic models are mathematical models combining hydrologic, engineering, environmental and economic aspects of water resource systems at a regional level [22]. They are used in order to suggest ways for more efficient and transparent use of water, given the existence of scarcity. The main assumption behind hydro-economic models is that demand for water may change subject to dynamic changes in water quantity and the type of use. Due to the various conditions that affect water availability (such as location and hydrologic conditions), more than one demand curves may be used [22].

Although hydro-economic models are driven by various institutional and socio-economic factors, the key focus is on the water system and its effect on one or more economic sectors [23]. Figure 1 depicts the disciplinary dimensions behind integrated hydro-economic models, and Table 6 provides a brief description of various types of hydro-economic models with their associated advantages and disadvantages.

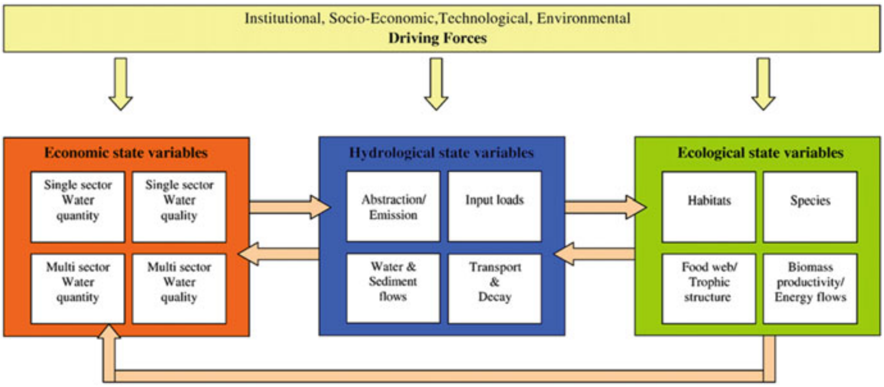

Fig. 1 Disciplinary dimensions underlying integrated hydro-economic modelling. *Source*: Brouwer and Hofkes [23], p. 17

[4] Apart from nonmarket valuation techniques and hydrological models, linear programming and various other econometric modelling approaches can be used for estimating the economic value of water. For example, programming models can be used for estimating the water quantity which maximises farmers' private profits through computer simulations (in cases where there is no data on a wide range of prices). These techniques are, nevertheless, beyond the scope of this review chapter.

Table 6 Some design choices, options and implications for building hydro-economic models

Simulation/ optimisation	
Simulation	
Summary	Time-marching, rule-based algorithms; answers question: 'what if?'
Advantages	Conceptually simple; existing simulation models can be used, reproduces complexity and rules of real systems
Disadvantages	Model only investigates simulated scenarios, requires trial and error to search for the best solution over wide feasibility region
Optimisation	
Summary	Maximises/minimises an objective subject to constraints[a]; answers question: 'what is best?'
Advantages	Optimal solutions can recommend system improvements; reveals what areas of decision space promising for detailed simulation
Disadvantages	Economic objectives require economic valuation of water uses; ideal solutions often assume perfect knowledge, central planning or complete institutional flexibility
Representing time	
Deterministic time series	Model inputs and decision variables are time series, historical or synthetically generated
Summary	Conceptually simple: easy to compare with time series of historical data or simulated results
Advantages	Inputs may not represent future conditions; limited representation of hydrologic uncertainty (system performance obtained just for a single sequence of events)
Disadvantages	
Stochastic and multistage stochastic	
Summary	Probability distributions of model parameters or inputs; use of multiple input sequences ('Monte Carlo' when equiprobable sequences or 'ensemble approach' if weighted)
Advantages	Accounts for stochasticity inherent in real systems
Disadvantages	Probability distributions must be estimated and synthetic time series generated; presentation of results more difficult; difficulties reproducing persistence (Hurst phenomenon) and non-stationarity of time series
Dynamic optimisation	
Summary	Inter-temporal substitution represented
Advantages	Considers the time-varying aspect of value; helps address sustainability issues
Disadvantages	Requires optimal control or dynamic programming
Submodel integration	
Modular	
Summary	Components of final model developed and run separately
Advantages	Easier to develop, calibrate and solve individual models
Disadvantages	Each model must be updated and run separately; difficult to connect models with different scales
Holistic	
Summary	All components housed in a single model

(continued)

Table 6 (continued)

Simulation/ optimisation	
Advantages	Easier to represent causal relationships and interdependencies and perform scenario analyses
Disadvantages	Must solve all models at once; increased complexity of holistic model; requires simpler model components

Source: Harou et al. [22], p. 632
[a]If optimised time horizon is a single time period, the model can be considered a simulation model that uses an optimisation computational engine

4 Rapid Assessment of the River Basin Districts in Greece

In this section, we provide a brief description of the socio-economic and water status of Greece's river basin districts.

Greece occupies a total area of 131,957 km^2 and consists of 14 river basin districts. Table 7 summarises information about the population, area and water uses in each RBD. Greek authorities have undertaken management plans in each RBD to characterise the ecological and chemical status of all water bodies (e.g. rivers, lakes, coastal areas, etc.). In some districts, authorities have aggregated across waterbodies to determine the overall quality status for each basin, while in others a characterisation is made separately for each type of waterbody (readers may want to consult each district's management plan for more information on the chemical and ecological parameters).[5]

5 Review of Representative Valuation Case Studies from Greece

In this section, we provide some representative examples of water-related valuation studies in Greece. All these studies have been developed, during the last decade, by the RESEES/ICRE8 team.[6] We would like to point out that in no sense is this current section meant to provide an exhaustive list of economic valuation methods in the entire country; our goal is to present a representative sample.

[5] Management Plans (in Greek) are available at http://wfd.ypeka.gr (last accessed 12/02/2015).

[6] The *International Centre for Research on the Environment and the Economy* (ICRE8) is the outcome of the evolution of the *Research Team on Socio-Economic and Environmental Sustainability* (ReSEES). More details about the team's research can be found at: http://www.icre8.eu/.

Table 7 Economic analysis of the most important water uses in each RBD

RBD	Population (2001)	Area (km^2)	Demand for supply (hm^3/year)	Demand for irrigation (hm^3/year)	Demand for industry (hm^3/year)	Demand for livestock (hm^3/year)
West Peloponnesus	331,180	7,235	35	180	16.4	2.8
North Peloponnesus	615,288	7,397	69.7	416	8.3	6.5
East Peloponnesus	288,285	8,442	31.7	330	7.1	4.6
West Sterea	312,516	10,199	44	340	0.39	7.84
Epirus	464,093	9,980	54	303	4	10
Attica	3,737,959	3,186	414.7	68.5	20.8	1.6
East Sterea	577,955	12,291	49.6	796	29.2	7.5
Thessaly	750,445	13,142	83	1 211	17	13
West Macedonia	596,891	13,624	140	938	83	95
Central Macedonia	1,362,190	10,146	7.77	463	0.26	Trivial
East Macedonia	412,732	7,320	47.7	816.3	16.2	5.8
Thrace	404,182	11,243	47.6	792.1	14.7	7.1
Crete	601,131	8,335	42.33	320	4.1	
Aegean Islands	508,807	9,103	37.19	80.20	1.24	

Source: Data in this table (except the last two rows) were collected by different studies in Greek ('Ολοκληρωμένα Σχέδια Διαχείρισης των Λεκάνων Απορροής της Χώρας, 2013') available at http://wfd.ypeka.gr (last accessed 12/02/2015). For the last two rows, studies were not yet available on-line, and data were taken by Koundouri et al. [24], p.13

5.1 Production Function Approach (Duration Analysis): Crete

Genius et al. [25] developed a model to investigate the potential effect of information transmission on the adoption and diffusion of modern irrigation technology in agriculture. Information transmission was considered through two main sources: extension agents and social learning (i.e. interaction with peer farmers and learning by doing). The model was tested empirically through a dataset of 265 olive growers located in the island of Crete. The dataset included information about the year in which farmers adopted a new irrigation technology (such as drip or sprinklers) and about key farming-operation variables, such as production patterns, gross revenues, input use, water cost and the farmers' socio-demographic characteristics. According to the available data, none of the farmers had adopted a new technology before 1994, whereas 64.9% (172) of farmers had adopted a drip technology between 1994 and 2004. The mean adoption time for the sample was 4.68 years.

Using duration analysis, the authors found that both extension services and social interaction with peer farmers had been essential for the adoption and diffusion of new technology. Moreover, the two aforementioned channels were found to be complementary. Other variables affecting the decision to adopt the new technology were water and crop prices (water prices being positively while crop prices negatively associated with the adoption time), risk attitudes (risk-avert farmers being more likely to adopt the new irrigation technology), climatic conditions (adverse conditions, as in the case of Crete, which is characterised by a semiarid climate, were positively associated the adoption time) and some socio-demographic characteristics (e.g. the adoption time decreased with farmers' age up to 60 years but thereafter increased, thus highlighting the combined effect of planning horizon and farming experience).

5.2 Choice Experiment, Lab Experiment, Contingent Valuation: The Asopos River Basin

The Asopos river basin runs in the Eastern RBD of Greece, approximately 60 km north of Athens, and serves a population of approximately 70,575 citizens. The Asopos area constitutes the largest industrial region in Greece. The river and groundwater of the basin have been subject to long-term (since the 1970s) industrial and agricultural pollution. Agriculture plays an important role on water quality due to nitrate runoff from the excessive use of fertilisers, while industries create major environmental problems due to the lack of a holistic plan for the treatment of the produced industrial (liquid, solid and air) wastes. As a result, Asopos has been characterised as one of the most polluted rivers in Greece, having an impact not only on the areas that it runs through but also on the coastal area which it flows into. Asopos's serious environmental degradation, coupled with two different sub-population groups with regard to socio-economic characteristics (rural local residents vs. vacation urban residents from Athens), makes this case study particularly interesting.

For this purpose, Koundouri et al. [26] conducted a choice experiment in order to calculate the WTP of the two sub-population groups (Asopos and Athens residents) for improvements in environmental conditions. Following common practice, the CE survey included the following steps: (1) selection of attributes, (2) definition of attribute levels, (3) choice of experimental design in order to allocate alternative scenarios to choice tasks and (4) elicitation of preferences, based on respondents' ranking of available scenarios in each choice task. Table 8 presents the main attributes and the corresponding levels in various policy plans presented to the respondents. The results (Table 9) show that respondents from both sub-populations had significant marginal WTP for alternative policy scenarios improving local environmental conditions.

Moreover, a lab experiment [27] was conducted to examine the impact of environmental degradation on health and the cost from consuming products produced in an area with poor water conditions. A sample of 61 consumers were

Table 8 Attributes and levels

Attribute	Status quo (option A)	Some policy action
Environmental conditions	Bad	Moderate or good
Impact on local economy	Negative today	Improved by 2015 or positive by 2027
Human health	Water not suitable for drinking, cooking and irrigation	Water suitable for all uses (drinking, cooking and irrigation) or water suitable for some uses (drinking and cooking)
Cost in Euro (tri-monthly water bill per household for the next 15 years)	0	2, 4, 6, 8 or 12

Source: Koundouri et al. [26], p. 105

Table 9 Marginal WTP for the two sub-populations (all respondents)

Attribute level	Marginal WTP (Athens)	Marginal WTP (Asopos)
Status quo policy option	7.28***	8.31***
Environmental conditions: moderate	10.07***	9.59***
Environmental conditions: good	2.41***	0.47
Local economy improved by 2015	4.03***	1.70***
Local economy positive by 2027	−1.78***	−1.13***
Water for some uses	5.68***	7.29***
Water for all uses	6.27***	5.16***

Source: Koundouri et al. [26]
Note: Marginal WTP for status quo becomes insignificant when serial non-participants are excluded, i.e. those that are not satisfied by none of the alternative policy scenarios
*** is 99% significance level

recruited in Athens to participate in a 4th price Vickrey auction performed in the lab: after a brief training on the lab experiment process, participants were asked to bid in order to exchange a kilo of potatoes produced in the Asopos area with a kilo of potatoes produced in a region with good ecological status. Bids were modelled as a function of respondents' socio-economic characteristics, initial monetary endowment, risk perceptions and potato consumption habits. Estimates were obtained through a random effects regression model. The results suggest that participants were willing to pay a price premium in order to exchange the Asopos potatoes with potatoes from a less polluted region (the mean upgrade bid from lower to upper quality potatoes was found to be €0.60 euro per kilo). Moreover, participants were willing to pay in order to reduce their potential health risk even when they were informed that there would be no available data for assessing risks of consumption to human health.

Also, Tentes and Damigos [28] and Tentes et al. [29] have conducted two economic valuation studies, a contingent valuation and a choice experiment, respectively, in the Asopos area with a view to estimating environmental damage to groundwater. WTP estimates from both studies fall into the same range of values. Different household profiles showed different willingness to pay, depending on attitudes against the environmental damage, population age and place of residence

[28]. Households were willing to pay almost 160 €/month for in situ remediation measures at certain areas which suffer most, in order to serve all groundwater uses [29].

5.3 Choice Experiment: Cheimaditida Wetland

The wetland of Cheimaditida, located 40 kilometres southeast of Florina in the northwest part of Greece, covers an area of 168 km^2 and contains one of the last remaining freshwater lakes in Greece. Rich fauna, flora and habitat diversity can be met in the wetland. However, the economic activity in the area (mainly agriculture, forestry and fishing) has caused negative effects on the water quantity and quality and in turn on the wetland's rich biodiversity.

Birol et al. [30] conducted a choice experiment in order to estimate the value of the benefits derived by the wetland. Face-to-face interviews were employed in eight towns and two cities (Athens and Thessaloniki) representing a continuum of distances from the wetland, as well as urban and rural populations. Table 10 summarises the main attributes and their various levels presented to the study participants: two ecological (biodiversity and open-water surface area), two socio-economic (research/education and retraining of farmers) and one monetary attribute were selected. Different combinations of these attributes yielded the following management scenarios: (1) current scenario ('status quo'), i.e. low biodiversity, low water surface area, low research and educational opportunities and no farmers' retraining; (2) scenario 1 (low impact), i.e. low biodiversity, higher levels of open-water surface area, low research and educational opportunities and retraining of 30 farmers; (3) scenario 2 (medium impact), i.e. high level of biodiversity, low open-water surface area, high research and educational opportunities and retraining of 75 farmers; and (4) scenario 3 (high impact), high level of biodiversity, high open-water surface area, high research and educational opportunities and retraining of 150 local farmers. The payment vehicle was a one-off tax payment for the year 2006–2007 deposited to the 'Cheimaditida Wetland Management Fund', controlled by a credible and independent body. The collected dataset, besides responses on the various management plan scenarios, included socio-economic characteristics and the participants' attitudes towards the environment.

The econometric analysis (four basic conditional logit models) revealed that respondents were willing to pay in order to promote all attributes of the choice experiment: WTP varied between €15.10 and €17.8 for improvements in biodiversity, €7.25 and €11.02 for improvements in open-water surface area, €8.69 and €10.79 for education and research opportunities and €0.075 and €0.195 for farmers' retraining. Taking into account the existence of potential heterogeneity among respondents' preferences, people with higher levels of education, income and environmental consciousness appear to prefer management scenarios with higher levels of ecological and socio-economic attributes. Also, the compensating surplus increased when moving from the status quo to one of the alternative scenarios for

Table 10 Wetland management attributes and levels used in the CE

Attribute	Definition	Management level
Biodiversity	The number of different species of plants, animals, their population levels, the number of different habitats and their size	Low: deterioration from current levels High: a 10% increase in population and size of habitats
Open-water surface area	The surface area of the lake that remains uncovered by reed beds	Low: decrease from the current open-water surface area of 20% High: increase open-water surface area to 60%
Research and education	The educational, research and cultural information that may be derived from the existence of the wetland, including visits by scientists, students and school children to learn about ecology and nature	Low: deterioration from the current levels of opportunities High: improve the level of educational and research opportunities by providing better facilities
Retraining of farmers	Retraining of local farmers in environmentally friendly employment such as eco-tourism and arid-crop production	Number of farmers retrained in environmentally friendly employment: 30, 50, 75, 150
Payment	A one-off payment to go to the 'Cheimaditida Wetland Management Fund'	4 payment levels from the pilot CV: 3, 10, 40, 80

Source: Birol et al. [30], p. 147

the management of the wetland. Subject to various model specifications, the WTP ranged between €58.2 and €107.59 for the low-impact scenario, €80.11 and €116.49 for the medium-impact scenario and €102.69 and €134.46 for the high-impact scenario. Finally, a cost-benefit analysis was employed to calculate the net benefits generated by each of the three aforementioned scenarios. The estimated aggregate net benefits were €335.351.463, €357.421.769 and €412.825.286 for the low-, medium- and high-impact management scenarios respectively, indicating that social welfare maximises with the high-impact scenario.

6 Conclusion and Policy Implications

Economic analysis needs to be integrated with other field expertise (climate change, hydrology, geology, engineering, sociology, etc.) and be considered along the management and decision-making process. The main purpose of this chapter was to discuss how economic analysis can assist in achieving the targets of the EC WFD in terms of designing efficient, socially equitable and environmentally sustainable water management policies. In summary, integrating economic analysis in an interdisciplinary management effort towards implementing the WFD entails identifying the uses of the RB services for different sectors of the local economy and estimating their monetary value. Estimating such values is an important prerequisite for the design of appropriate policies, leading to sustainable management over time and space.

A variety of valuation methods, primarily revealed and stated preferences methods, is available to economists in order to identify and quantify economic values, use and non-use, arising from the various aquatic resources and ecosystems.

A brief description of water-related empirical studies conducted in Greece, during the last decade, reveals that various socio-demographic characteristics and different stakeholders' interests affect perceptions and willingness to pay for a certain environmental good or policy intervention. Comparing the benefits, for all water users, yielded by the implementation of various water-related management scenarios, to the associated costs, allows us to identify a socially efficient wetland management strategy. In other words, CBA may be helpful in the avoidance of policy interventions with disproportionate costs to member states.

In order to achieve a socially efficient policy and WFD compliance 'good status', it is essential to employ economic instruments that allow us to impose the payment of the total economic values of RB on the users of these services. For instance, financial penalties could be imposed on pollution dischargers; alternatively, subsidies could be paid directly by the central or local government to the provider of water services in the form of investment subsidies (capital subsidies, lowering fixed costs). In this way, users would internalise (in their individual decisions) the social value of the resource and would thus be incentivised to use it in a sustainable manner. The effects of such policy interventions on different social groups could vary but could also be smoothed out with a redistributional instrument subject to explicit government priorities, approved by democratic processes.

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