An assessment of wetland management scenarios: the case of Zazari–Cheimaditida (Greece)

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Abstract This study suggests an integrated framework for the assessment of wetland management scenarios, based on a holistic approach of wetland ecosystems. All costs and benefits of management scenarios are estimated in terms of the value of wetland functions, which are indirectly valuated with a Contingent Valuation of goods and services they provide. The social impact of introducing the scenarios is also investigated with a stakeholder analysis, based on a survey. Scenario plausibility and acceptability are examined based on the results of the stakeholder analysis; on the other hand, the assessment of the scenarios, using cost-benefit analysis and multi-criteria analysis, provides quantitative performance indicators adequate to incorporate uncertainties and mutable policy objectives. This framework is applied to assess three management scenarios for a Greek wetland. The results indicate that the continuation of existing management practices is the most efficient alternative unless interventions for the restoration of wetland functions are conservatively budgeted, while a wetland drainage scenario performs poorly both in terms of economic efficiency and social impact.

Keywords Contingent valuation; cost-benefit analysis; functional approach; multi-criteria analysis; stakeholder analysis; wetlands

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Introduction

Sustainable wetland management has received considerable attention under the light of the 60/2000/EC Water Framework Directive (WFD). The implementation of the WFD points out a shift from existing exploitation practices to integrated management schemes that prioritize wetland conservation, by compromising environmental protection with a flow of benefits for society. Under these circumstances, the development of an assessment framework for wetland management scenarios becomes highly policy-relevant. The most common approach involves the estimation of costs and benefits. Costs may include financial costs of introducing a scheme and costs of potential environmental degradation, while benefits are linked to new wetland use practices and improvements in environmental quality. The consideration of costs and benefits in decision-making provides adequate information on the economic performance of alternative management scenarios, but fails to account for their social acceptability. This constitutes another dimension of sustainable wetland management, which must be taken into account.

Previous work on the assessment of wetland management scenarios usually involves a partial examination of their impact. In several studies, monetary valuation techniques are employed for the estimation of changes in a limited number of wetland values due to new management practices (van Kooten, 1993; Steever *et al.*, 1998). In other cases, such as the work of Bodini *et al.* (2000), costs and benefits are estimated using simple economic analysis, which fails to account for non-use values. Skourtos *et al.* (2000) valuate wetland benefits with the Contingent Valuation (CV) method and use qualitative information about stakeholders in an assessment of four alternative management scenarios for Kallonia Bay wetland. An extension to the economic valuation of wetlands is proposed by Brouwer *et al.* (1999) with a meta-analysis of wetland CV studies, providing measures of the monetary value of wetland functions in terms of derived socioeconomic values.

This study describes an integrated methodological framework for the assessment of wetland management scenarios, with an application to a Greek wetland. It is illustrated that the most appropriate criteria for such an assessment are benefits and costs – either environmental or financial – as well as parameters of social impact. The economic value of the wetland is captured into the values of the functions it performs, which are identified through a functional approach of the ecosystem (Bergstrom *et al.*, 1996; National Research Council, 1997), along with relevant goods and services; the latter are then valuated with a CV survey. The social dimension of wetland management, including interactions among affected groups, their perceptions of wetland management and their influence, is examined with a stakeholder analysis, which provides qualitative information for an early assessment of the plausibility of the scenarios. Cost–Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) are employed for the incorporation of economic valuation and stakeholder analysis data into scenario performance indicators.

This framework is applied within Zazari–Cheimaditida lakes catchment, a typical Greek wetland with acreage of 1,687.3 ha. The lakes are protected by EU Habitats and Birds Directives and are cited in Corine Biotope Project; their importance stems from the performance of the following wetland functions: floodwater retention, food web support, groundwater recharge, nutrient export, sediment retention. The wetland's physical characteristics are threatened by intensive agrochemical use in the surrounding farmed area, animal stocking, fishing, hunting and sewage disposal. Given these trends, three alternative management scenarios are assessed. The continuation of existing management practices under "Business as Usual" (BAU) scenario entails further degradation of wetland functions. "Policy Compliance" (PC) scenario involves the drainage of the wetland for the production of 1,000 ha of arable land, but also the loss of wetland benefits, including non-use values. The restoration of wetland functions (Lazaridou *et al.*, 2001) ("Deep Green" (DG) scenario) is expected to improve surface and ground water quality and to upgrade the landscape and ecosystem balance.

The study consists of two parts, except for introduction and conclusions, the first of which provides the methodological framework for the analysis. In this part, the approaches applied are described along with their inherent advantages and disadvantages. Within the second part the results of the analysis are reported; these include the estimated monetary values of the wetland functions, the stakeholder matrix, which encompasses all stakeholder characteristics, a qualitative assessment of the management scenarios, the results of MCA and CBA and a sensitivity analysis.

Methodological framework

The flow of wetland goods and services that affect human welfare stems from the performance of wetland functions (Turner *et al.*, 2000), which are not of economic nature; however, the valuation of wetland functions provides a framework for establishing linkages between human welfare and natural processes. In this study, wetland functions are valuated indirectly in terms of changes in values of goods and services related to them. Nevertheless, as various goods and services stem from interactions among functions, they are identified through a functional approach, so as to introduce "sub-goods" and "sub-services" attributable to corresponding functions. Apart from ensuring non-omission of certain goods and services, a functional approach allows for an integrated examination of wetland ecosystems by determining transactions between human activities and ecosystem functions, by recognizing ecological and environmental interactions and by precisely targeting ecosystems responsible for particular benefits (Maltby *et al.*, 1999).

The valuation of wetland goods and services, which are often non-marketed or are endowed with non-use values, points to the employment of the CV approach. The sample for a CV survey consisted of 210 respondents, both locals and non-locals, and was representative of the population affected by the wetland (Ragkos, 2004). The Willingness to Pay (WTP) question for the restoration of wetland functions concerned the monetary amount reflecting the difference between the zero value of non-provision of the benefits flow and the value of a maximum level of provision determined by ecological, biological, physical and chemical factors. The data were statistically processed to produce the mean annual WTP.

Changes in the value of goods and services due to the implementation of wetland management schemes are due to changes in the levels of functional performance. The level of functional performance is assessed using the Functional Assessment Procedures (FAPs), as described in an integrated EU project (EVALUWET, EU FP5, Contract No. EVK1-CT-2000-00070). Assuming that WTP for wetland functions depends upon the extent of their performance, the calculation of benefits and costs involves the estimation of the WTP curve. The economic theory predicts that this curve is concave for utility concave in the wetland function, implying decreasing marginal WTP as functional performance increases. This argument stands only if stated WTP is sensitive to the scope of the good. A review of the existing work suggests that careful survey design, such as careful pre-testing of the survey instrument, in-person interviews (Boyle *et al.*, 1994), adequate provision of information (Mitchell and Carson, 1989), close-ended WTP questions and taxation as a payment vehicle (Loomis *et al.*, 1993; Boyle *et al.*, 1994), minimizes insensitivity to scope, apart from compliance to the NOAA Panel's (Arrow *et al.*, 1993) recommendations.

Albeit data from the economic analysis are adequate to provide indicators of scenario performance, social perceptions of wetland management should also be examined. Presumably, stakeholders, considering their conflicting interests and varying influence, may hinder the implementation of a scenario that is desirable in economic terms. A stakeholder analysis is then employed to generate knowledge about actors, so as to understand their behaviour, intentions, interrelations and interests (Varvasovszky and Brugha, 2000). Published sources and focus groups interviews were used to design a questionnaire for a stakeholder survey, conducted along with the CV survey. Data from this survey are used to identify stakeholders and to determine their characteristics. The results of the analysis provide the basis for a qualitative assessment of the plausibility of the scenarios as well as for the derivation of quantitative data for incorporation into scenario assessment models.

The performance of the scenarios is examined under two approaches, MCA and CBA. The former is used to determine the most efficient wetland management scenario under various categories of criteria. The alternatives are ranked following the scores (values) of the criteria and weights that represent the relative importance of each criterion in the decision-making process. Within the latter approach, the algebraic sum of annual discounted benefits and costs from scenario implementation is calculated. Differences in the performance of each scenario are expressed in terms of their Net Present Value (NPV). In order to investigate their stability under uncertainties and variability of policy objectives, the results of both methods are further examined with a sensitivity analysis.

Results of the analysis

Determination of inputs

Responses to discrete-choice WTP questions provide an indication as to the area under the survival function of the WTP where true WTP lies. The estimation of true WTP

Table 1 Results of maximum likelihood estimation (Logit models) (t-statistics in parentheses)

	Wetland functions				
	Flood water retention	Food web support	Ground water recharge	Nutrient export	Sediment retention
Logit models					
Intercept	− 0.8278	1.8345	0.5198	− 0.7875	− 1.4762
	(− 0.5747)	(1.1709)	(0.3446)	(− 0.6246)	(− 1.0244)
Bid amount	− 0.0830	− 0.1232	− 0.0908	− 0.0599	− 0.1054
	(− 5.1234)	(− 5.7037)	(5.3728)	(− 4.1310)	(5.3503)
Sex	1.7054	− 0.3570	1.5379	1.5668	2.0454
	(2.0894)	(0.4818)	(1.8583)	(2.2370)	(2.4910)
Age	0.0244	0.0400	0.0218	0.0205	0.0675
	(1.2727)	(1.9704)	(1.2247)	(1.1648)	(3.0269)
Income	0.4251	0.3709	0.4211	0.3612	0.3750
	(3.0451)	(2.6120)	(3.1829)	(3.0689)	(2.8259)
Years of schooling	0.1080	0.1740	0.0380	0.0474	0.1246
	(1.5429)	(2.0592)	(0.5330)	(0.7171)	(1.6140)
Permanent resident	− 1.5694	− 1.7163	− 1.4796	− 1.3421	− 2.4696
	(1.8854)	(1.9223)	(1.9151)	(1.9530)	(2.8810)
McFadden R^2	0.324	0.395	0.305	0.203	0.343

involves the construction of a statistical model with utility theoretic considerations, following the methodology of Hanemann (1984, 1989). Maximum-likelihood estimation (Greene, 1997) was employed to estimate a logit model, where the dependent variable is the probability of a respondent accepting the payment of a certain bid and the independent variables are this bid amount and respondents' socioeconomic characteristics. The estimated coefficients of logit models for all wetland functions are presented in Table 1. Occupation was found statistically insignificant and was not included in the final version of the logit models. The particular stakes of each stakeholder were not accounted for in the models, because many respondents were part of two or more stakeholder groups.

Annual mean maximum WTP for wetland functions (Table 2) was estimated based on the results in Table 1, using the formula proposed by Hanemann (1989). This formula is applicable only for non-negative WTP, which is the case for WTP for wetland functions, because the valuation study concerns an improvement. Confidence intervals for WTP were determined using the bootstrapping technique of Krinsky and Robb (1986).

The calculation of descriptive statistics from stakeholder analysis data allows the formulation of a stakeholder matrix (Table 3). Different priorities in interests point to potential conflicts if ultimate decisions promote stakeholder groups of low acceptability or if they fail to compromise stakeholders with opposed objectives. Such implications are particularly undesired when it comes to influential stakeholders – farmers, the Ministry of

Table 2 Mean annual maximum WTP for wetland functions

Wetland functions	Mean WTP (€)	95% Confidence intervals	
		Lower bound	Upper bound
Flood water retention	42.53	37.11	55.38
Food web support	40.15	35.50	47.08
Ground water recharge	43.30	37.70	52.89
Nutrient export	44.43	35.77	65.24
Sediment retention	40.89	35.42	50.31

Table 3 Stakeholder matrix

Stakeholders	Capacity	Status and constituency (Acceptability/Impact of participation)	Opposed objectives	Interests	Commitment	Influence
Farmers	High	High/Positive	Hunters (44.4%) Ecologists (23.8%)	–Higher yields, irrigation –Landscape, health	Very high	Very significant
Fishermen	Moderate	High/Positive	Hunters (43.5%)	–Fisheries quality/quantity –Agriculture	Very high	Scattered
Hunters	Low	Low/Negative	Ecologists (20%)	–Agriculture –Game stocks –Natural resources/Ecology	High	Weak
Ecologists	High	Conflicting/Conflicting	Hunters (33.3%)	–Restoration of the lakes –High standards of living	Very high	Significant
Other residents	Moderate	High/Positive	Hunters (63.1%) Ecologists (23.1%)	–Landscape, sewerage –Ecological balance	High	Scattered
Non-residents	Very low	High/Neutral	Fishermen (12.1%) Hunters (24.2%)	–Ecological balance –Natural resources –Tourism	Moderate	Weak
Ministry of Agriculture	High	Conflicting/Positive	*	–Agriculture –Fishing –Rural development –Ecological balance	Very high, potential delay in participation	Very significant

Agriculture and ecologists; on the other hand, care must be taken in order to ensure non-exclusion of weak stakeholders from management benefits. Following the information in Table 3, PC scenario is the least desirable policy option, as only farmers are bound to benefit from the drainage. BAU scenario fails to satisfy most of stakeholders' objectives and is linked to particular losses for fishermen and ecologists. On the other hand, DG scenario provides a satisfactory compromise of stakeholder interests and ensures equal treatment for all groups. This scheme is also favoured by the Ministry of Agriculture, which is a secondary stakeholder in charge of scenario implementation.

Alternative management scenarios imply various levels of functional performance, which are quantified using the FAPs. The outcome of the FAPs was combined in order to conclude for the overall quantitative evaluation of a function, expressed as a percentage of the function being performed at 100% (Table 4).

The benefits and costs of each scenario are estimated based on the previous results, mean WTP for wetland functions, the budget for planned interventions on the wetland and a farm management survey (2003). Annual benefits for BAU scenario are calculated in terms of WTP, extrapolated to the local adult population. The implicit costs of the continuous degradation of wetland functions under BAU scenario depend on the pace of degradation; for this reason, expert judgements (Greek Biotope Wetland Centre) were used to simulate future trends in wetland functional performance. Benefits from PC scenario derive from the use of additional 1,000 ha of arable land; however, limited irrigation opportunities will bring about a substantial loss of annual gross margin during the following period. The opportunity cost of wetland drainage under PC scenario corresponds to the benefits of DG scenario. The annual benefits of DG scenario equal the annual maximum WTP for wetland functions, extrapolated to the local adult population. The costs of the scenario include the construction cost of planned interventions (4.63 mil. €) and maintenance costs.

Multi-criteria analysis

The MCA of management scenarios requires that the weights assigned to wetland functions indicate stakeholders' characteristics, in order to be consistent with the socioeconomic characteristics of the catchment. This task obtains the form of a MCA problem, within which wetland functions (alternatives) are ranked according to stakeholder preferences (criteria). The latter are expressed as the stakeholders' mean WTP for wetland functions (scores) for large stakeholder groups. For small stakeholder groups a qualitative scale assessment procedure is adopted, based on the results of the stakeholder analysis. Criteria weights are calculated in terms of stakeholder influence, using pairwise comparison. The results of this MCA model were obtained using DEFINITE package. Sediment retention function is ranked 1st (0.57) and is followed by ground water recharge function (0.56). Food web support is ranked 3rd (0.51) and nutrient export and flood water retention functions are ranked 4th (0.39) and 5th (0.22) respectively.

Table 4 Wetland functions performance under alternative management scenarios

Wetland functions	BAU (%)	PC (%)	DG (%)
Flood water retention	95.0	0.0	100.0
Food web support	96.7	0.0	100.0
Ground water recharge	3.3	0.0	100.0
Nutrient export	45.0	0.0	100.0
Sediment retention	40.0	0.0	100.0

Source: Results of the Wetland Decision Support System (WEDSS), developed within EVALUWET

The basic MCA model for ranking of the three scenarios includes their benefits and costs, discounted for a period of 30 years. Weights for the main criteria – implementation costs, non-environmental benefits and wetland function benefits – are set to be equal (0.333) while weights for sub-criteria of wetland functions benefits criterion are assigned following the preference indicators obtained by the first MCA.

The results of the MCA are presented in Table 5. For equal weights, BAU is ranked first (preference indicator 0.54), followed by DG (0.47) and PC (0.33). Nevertheless, the broad range of priorities that policy makers encounter is bound to alter considerably the assigned weights, which might disturb the original ranking of the scenarios. A weight–sensitivity analysis (Table 5) shows that BAU scenario is favoured if cost-effectiveness is a priority; DG achieves the highest performance indicator if maximization of environmental benefits is intended; PC scenario is the least preferable policy option, unless robust farmer-friendly policies are in force. Similarly, a price–sensitivity analysis shows that, for equal weights, any changes in the benefits of BAU scenario and costs less than or equal to 2.52 mil. € (375% of budgeted costs) do not disturb the original ranking. On the other hand, DG scenario will be ranked first if costs are reduced to 3.57 mil. € (35.8% reduction).

Cost-benefit analysis

The results of a CBA for the three scenarios show that the NPV of PC scenario is negative (−2.02 mil. €) due to the low gross margin of non-irrigated crops. The NPV for BAU scenario is 6.22 mil. €, which exceeds the NPV of DG scenario by 39% (3.80 mil. €). This implies that a "no-action" option is preferable to the restoration of wetland functions, for the budgeted costs of proposed interventions. Nevertheless, the calculation of the NPV of DG scenario for lower levels of construction costs (Table 6) indicates a strongly positive influence of conservative budgeting on the performance of the scenario. A 47% reduction in these costs (2.43 mil. €) yields a NPV equal to the NPV of BAU scenario. A sensitivity analysis of the results shows that if the discounted benefits of BAU exceed 4.33 mil. € (that is a 35.8% reduction) or the discounted costs are less than 2.95 mil. € (455.3% rise), the NPV of this scenario is higher than the NPV of DG scenario.

Table 5 Results of the Multi-Criteria analysis

	Scores/Ranking of alternatives		
	BAU	**PC**	**DG**
1. Scores for equal weights	0.54	0.33	0.47
2. Weight sensitivity			
i. Implementation costs			
< 0.1468	3	2	1
0.1469 – 0.2319	2	3	1
> 0.2320	1	3	2
ii. Non-environmental benefits			
< 0.4128	1	3	2
0.4129 – 0.4473	1	2	3
> 0.4474	2	1	3
iii. Wetland function benefits			
< 0.0405	2	1	3
0.0406 – 0.2290	1	2	3
0.2291 – 0.4529	1	3	2
> 0.4530	2	3	1

Table 6 NPV of management scenarios and influence of construction costs on the NPV of Deep Green scenario

Management scenarios		NPV* (mil. €)
1. Policy Compliance (PC)		−2.02
2. Business As Usual (BAU)		6.22
3. Deep Green (DG)		
Construction costs	4.63	3.80
	4.17	4.31
	3.71	4.82
	3.24	5.33
	2.78	5.84
	2.43	6.22
	2.32	6.35

*The NPV for 6% discount rate a period of 30 years

Conclusions

Decision-making for sustainable wetland management policies has been under discussion lately, mainly because of the introduction of the WFD. Alternative management options usually involve changes in the performance of wetland functions as well as different levels of achievement of stakeholders' objectives. Within this study, three alternative management scenarios are presented and assessed in terms of costs and benefits, as well as of impact on related parts. An economic valuation of wetland functions and a stakeholder analysis provide the necessary inputs; the findings of the stakeholder analysis are used to conclude for scenario plausibility, while CBA and MCA techniques are employed to provide indicators of scenario performance. The results of the assessment indicate that the scenario of enhancement of wetland functions (DG) is the most desirable option among stakeholders. Nevertheless, if interventions for such an enhancement are not budgeted conservatively, the continuation of existing management practices (BAU) is favoured by the results of both CBA and MCA. This implies that environmental protection policies are realistic only when they are linked to efficient allocation of disposable funds. On the other hand, the hypothetical scenario of wetland drainage (PC) produces a negative NPV and is ranked low, because the cost of environmental degradation exceeds the expected benefits.

The reliability of the results is contingent upon the accuracy of estimated costs and benefits, related to the hypothetical nature of valuation of environmental resources and the quantification of stakeholder characteristics. A sensitivity analysis of the results is employed to derive intervals for the estimated costs and benefits, which are found adequately broad to guarantee reliable results. Furthermore, a sensitivity analysis of the weights assigned to criteria for the MCA approach is employed to forecast for changes in the ranking of the examined scenarios following particular objectives of policy makers.

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