

**ASSESSMENT OF THE PROGRAMME OF MEASURES
FOR COASTAL LAGOON ENVIRONMENTAL
RESTORATION USING COST-BENEFIT ANALYSIS**

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ASSESSMENT OF THE PROGRAMME OF MEASURES FOR COASTAL LAGOON ENVIRONMENTAL RESTORATION USING COST-BENEFIT ANALYSIS.

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Abstract

The Marine Strategy Framework Directive and the Water Framework Directive are the standards agreed in the European Union with the aim of obtaining a good ecological status in marine and coastal waters by applying a programme of measures. This work expounds the implementation of two economic tools to assess the Programme of Measures intended for the environmental restoration of one of the most important coastal ecosystems in Europe, the Mar Menor coastal lagoon (SE Spain). Thus, the Cost-Benefit Analysis (and its extensions) and the Contingent Valuation Method are used to assess the aforementioned programme in terms of economic and environmental profitability. Results prove the socioeconomic and environmental profitability of the actions due to be undertaken, with rates of return of around 10%. From a methodological point of view, there is a clear need to widen the classic CBA scheme by using the Extended CBA and the Dual CBA to gauge this type of environmental restoration actions.

Keywords: cost-benefit analysis, coastal lagoon, pollution, socioeconomic evaluation, environmental restoration, Mar Menor.

JEL classification: H43 Q28 Q57

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1. Introduction

The conservation status of marine ecosystems has important implications on welfare, which strongly depends on the goods and services they provide, such as food, raw materials, natural heritage, climate regulation, monitoring of global change and recreation tourism and education, among others (Hanley *et al.* 2003; EEA, 2010). Coastal lagoons, a special kind of marine ecosystems, are among the most sensitive ecosystems to human pressures. These ecological systems undergo serious environmental problems due to inefficient exploitation of their natural resources, and to the pollution stemming from human activities developed in their vicinity, which are putting at risk their capacity to support human well-being (EEA, 2000).

The need to protect marine and coastal ecosystems has favoured the creation and implementation of ambitious laws related to environmental protection, especially in countries with a high economic development (Humphrey *et al.*, 2000). Regarding the European Union standards, coastal lagoons are tackled by regulations of very different nature because of their exceptional situation of transition between land and marine environments (De Santo, 2011). Some of these are Directive 91/271/CEE, concerning urban wastewater treatment; Directive 91/676/CEE, on the protection of waters against pollution caused by nitrates from agricultural sources; Directive 2006/7/CE, related to the management of bathing water quality; Directive 2000/60/CE or Water Framework Directive (WFD), which sets a framework for Community action in the field of water policy; or Directive 2008/56/CE, known as Marine Strategy Framework Directive (MSFD). Whereas the first three directives take a partial approach —they regulate specific aspects that may affect coastal lagoon management—, WFD and MSFD support a holistic management of aquatic ecosystems in general and marine ecosystems in particular, respectively. MSFD is aimed for each member state to achieve or maintain “a Good Environmental Status in the marine environment by the year 2020 at the latest”. Based on the WFD, which formally introduces the economic instruments in water management (Stemplewski, 2008), the MSFD establishes that an economic and social analysis of both seawater usage and the cost caused by its deterioration should be conducted. From these analyses, a Programme of Measures must be designed in order to achieve the aims of the directive, ensuring that the measures to be taken are environmentally efficient and technical, economic and socially feasible.

Both MSFD and WFD put special emphasis on the usage of the Economic Analysis as a basic tool for decision-making in the management of marine and coastal ecosystems. Despite the fact that this integrated approach is clear in its conceptual and theoretical explanation, its implementation into practice presents some problems, as

some recent studies have pointed out (Turner, 2007). The main analysis tool is the Cost-Effectiveness Analysis (CEA), which provides useful information for the cost and the environmental effectiveness of alternative management options in realizing a given environmental goal; for instance, to reduce pollutants concentration from dumping at a lower unit cost (Elofsson, 2010). The CEA is valid providing that the environmental goal is binding and that the costs incurred are not disproportionate, as the aforementioned EC Directives state –although there are no guidelines as to how to consider a proportionate cost. On the other hand, the next question is raised: how to evaluate non-binding action programmes that consequently compete with other public investments for attracting funds. In this case, the primary method to evaluate public investments, the Cost-Benefit Analysis (CBA), may be applied. The CBA compares the costs and benefits of a programme, plan or project (PPP) in order to determine whether its implementation is economic and/or socially feasible, and to achieve harmonized indicators with which to compare the profitability of alternative PPPs, if it is necessary to prioritize due to budget constraints. As for indirectly productive investments, like restoration measures in coastal environments, the main drawback of implementing the CBA is to determine the benefits. Thus, what is needed is to quantify not the economic value of the environmental asset that is to be restored, but the economic value of the asset new status. Undoubtedly, this is one of the reasons why this kind of integral economic valuations is scarce in PPPs of environmental nature, especially in those involving marine ecosystems.

The aim of this work is to show the possibilities of the CBA application in the assessment of programmes of environmental restoration measures in marine ecosystems, giving the exceptional coastal lagoon Mar Menor (SE-Spain) as an example of coastal environment. The estimation of the environmental benefits is to be developed by means of a double contingent valuation method, which allows not only isolating the total economic value of the programme of measures, but also decomposing this value into its use and non-use components. This decomposition will lead to an improvement in the use of CBA by adding intergenerational equity criteria to the valuation process and facilitating the usage of dual-rate discounting strategies.

2. Analytical framework

2.1. Cost-Benefit Analysis

The Cost-Benefit Analysis (CBA) is an economic valuation technique taken into consideration as a decision criterion in public investment evaluation (Vining and Weimer, 2010). CBA considers the existence of social costs and benefits in the development of an economic activity, as well as the flows included in private or financial evaluations, which only take into account the market flows. These considerations are especially important in environmental PPPs since many environmental goods, such as clean air or biodiversity, lack a market value in spite of the fact that they do have an economic value, which must be fixed so as to be included in the analysis. CBA includes social profitability criteria because this aspect is evaluated in terms of the increase or decrease in global welfare, and hence criteria involving intergenerational equity and sustainability can be incorporated (Hanley and Spash, 1993).

When a PPP is evaluated by means of CBA, six general stages are fulfilled:

1. Identify all the costs and benefits.
2. Value costs and benefits in monetary units.
3. Establish the time horizon of the evaluation.
4. Fix the discount rate.
5. Make selection and/or profitability indicators.
6. Conduct a sensitivity analysis of indicators to the variables of the most uncertain value.

Once the costs and benefits of the PPP are identified and valued in monetary terms, they must be aggregated with the aim of obtaining synthetic evaluation indicators. To undertake this aggregation, it needs to be bore in mind that the resulting costs and benefits are not simultaneous in time, and because of the existing preference for the present, the discount rate must be applied in order to adjust the different times of incidence. The discount rate is intended to represent society's preference for consumption in the present over the future (Henderson and Bateman, 1995). The higher the discount rates are, the higher the preference for present consumption will be, since the benefits to be enjoyed in the present will be more appreciated than those held in reserve to be enjoyed in the future (Gollier, 2002). If benefits and costs are given in real terms (without being affected by price increase), the discount rate is real as well, and real discount rates of around 2-3% are recommended with medium time horizons (30-75 years) (Kokoski, 2010).

With regard to selection indicators, the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Payback Period (PB) are the most commonly used. NPV aggregates all benefits (B) and costs (C), given in a certain period of time usually measured in years (t), applied to a discount rate (r).

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

The viability of a PPP will be confirmed whenever its NPV is greater than zero. This indicator measures profitability in absolute terms, hence it facilitates to make a decision on whether to accomplish a certain PPP. However, the comparison among alternative PPPs is not achievable.

The Internal Rate of Return (IRR) is defined as the discount rate that zeroes out the net present value of flows of costs and benefits of a PPP. It therefore measures profitability in percentage terms and allows to compare alternative PPPs, independently of their size.

Payback Period (PB) is the length of time required for cumulative benefits returns to equal the cumulative costs of a PPP. It provides an indication of a PPP's liquidity and risk because a shorter payback period is viewed as less risky (EC, 2008).

Once the general phases of the evaluation procedure have been described, the following analysis schemes should be differentiated:

- Classical CBA (CBA): It only considers the benefits and costs of the market or those treated as such.
- Extended CBA (ECBA): It considers both the costs and benefits of the market and non-market ones.
- Dual CBA (DCBA): It is an extension of ECBA that applies different discount rates depending on the nature of the costs and/or benefits.

In the case of environmental costs and benefits, DCBA takes on special significance since sustainability and intergenerational solidarity are not compatible with the application of the same discount rate to both market and environmental flows, for the reason that the discount means to underestimate future generations' preferences (Pearce and Turner, 1990; Rouboutsos, 2010). Consequently, the usual discount rate should be applied to market flows, whereas a lower discount rate (an environmental discount rate) should be used in the case of non-market goods (Almansa and Calatrava, 2007; Kula and Evans, 2010). The NPV is therefore as follows:

$$NPV(r, r^a) = \sum_{t=0}^t \left(\frac{B_t^m - C_t^m}{(1+r)^t} \right) + \sum_{t=0}^t \left(\frac{B_t^a - C_t^a}{(1+r^a)^t} \right)$$

B^m and C^m represent the market flows; B^a and C^a are the environmental flows; r is the usual discount rate; and r^a corresponds to the environmental discount rate. In spite of the fact that selecting an environmental discount rate is not a settled issue, because of the ethical aspect of having to choose a value, there is a consensus in using reduced rates, which would tend to zero if there is absolute intergenerational equity (Sumaila and Walters, 2005).

Owing to its own nature, this approach does not permit to calculate the IRR but a substitutive profitability indicator. The Critical Environmental Rate (CER) is defined as the discount rate that, applied to the environmental effects, after the market effects have been discounted from the usual rate (r), makes the Net Present Value (NPV) be equal to zero. The CER is an indicator of “environmental profitability that the financial cost produces” (Almansa and Calatrava, 2007).

2.2. Contingent valuation

As it has already been pointed out, one of the major difficulties involving the usage of CBA is to measure a PPP's non-market costs and benefits, and therefore to fix a price that represents its value in monetary terms to aggregate the costs and benefits to the CBA flows. As for environmental assets, it is necessary to speak about their Total Economic Value (TEV), which includes market and non-market values and consists of use values (UV) and non-use values (NUV).

UVs embrace extractive values (e.g. commercial and subsistence fishing), non-extractive values (e.g. sport fishing, tourism, landscape viewing), and indirect-use values (e.g. reading a nature magazine). NUVs are those values given by the mere existence of the ecosystem and the commitment to preserve and bequeath it to future generations (Hein *et al.*, 2006).

Environmental Economics has developed several methodologies to calculate the TEV of an ecosystem or one/some of its components (EEA, 2010). Based on the construction of a hypothetical market, the Contingent Valuation method (CVM) is one of the most common methods in economics literature to assess environmental goods and services owing to its capacity to obtain and differentiate use and non-use values of a given ecosystem (Liu *et al.*, 2010). In addition, guidelines dealing with CBA application

in project assessments specifically recommend the use of the CVM to value non-market benefits in environmental restoration PPPs (OECD, 2006; EC, 2008).

This work does not intend to describe the CVM foundations, which can be found in many other studies (Pearce, 2006, Bateman *et al.*, 2002, Mitchell and Carson, 1989). However, it is just needed to point out that the CVM consists in simulating a market by means of questionnaires for the good or service to be valued. The interviewer represents supply and the interviewee constitutes demand. Interviewees are asked what the maximum amount of money they are willing to pay to enjoy the environmental good or service is, or how much they would be willing to receive, at least, if the good or service disappears or worsens. Once all the answers have been dealt with, the obtained average value is extrapolated to the involved population as a whole in order to estimate the TEV of the good or service.

2.3. Background

The use of CBA to assess PPPs affecting both environmental and socioeconomic aspects is increasing nowadays (Birol, 2010; Vining and Weimer, 2010). Nevertheless, this methodology is rarely applied in works related to marine and coastal ecosystems. CBA has mainly been used in studies dealing with the effects of conservation policies and coastal restoration, and in marine resources management (Spurgeon, 1998; Peng *et al.* 2006; Turner *et al.* 2007; Zheng *et al.* 2009), some of them applying ECBA (Dixon and Hodgson, 1988 Cesar *et al.*, 1997, Pet-Soede *et al.*, 1999, Fahrudin, 2003).

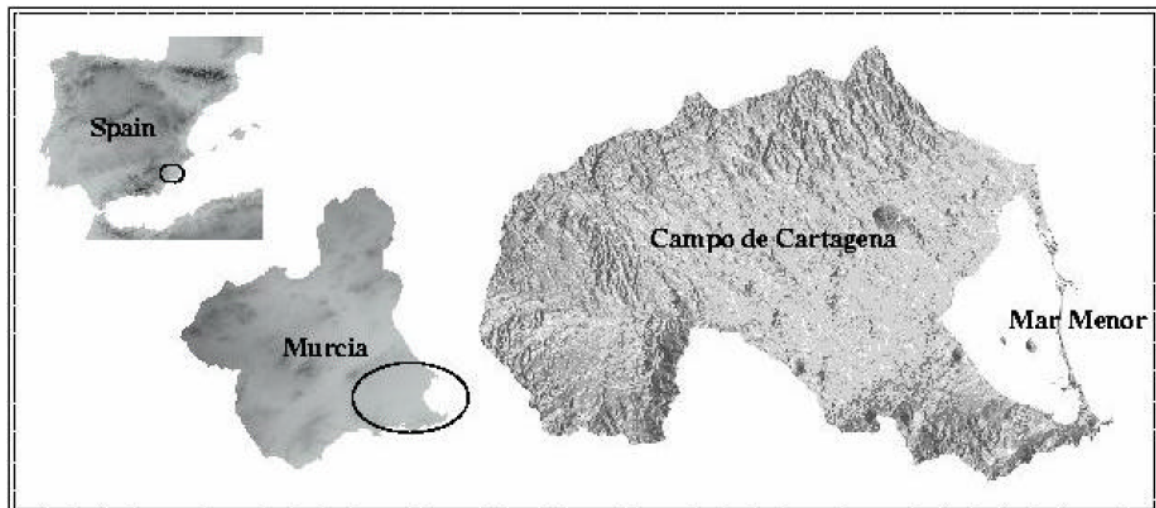
The number of CBA studies that include the CVM results to estimate environmental benefits and costs is also growing. In fact its application was recommended by NOAA Panel to calculate the lost of non-use values as a result of the supertanker Exxon Valdez oil spill (Arrow *et al.*, 1993). Since then this method has been profusely used to value the environmental services of marine and coastal ecosystems (Remoundou *et al.*, 2009). A wide revision on works involving CVM application to marine ecosystems can be found in the studies carried out to EMPAFISH Project (Alban *et al.*, 2008).

3. Study case: the Mar Menor coastal lagoon

3.1. Environmental setting

The Mar Menor, located in the southeast of Spain (Figure 1), is one of the largest coastal lagoons in the Mediterranean Sea. Its surface area is 135 Km² and has an average depth of 2.5 m and a maximum depth of 6 m. It is a hypersaline lagoon with its salinity ranging between 42 and 47. Its average temperature is 12 °C in winter and 30 °C in summer. A sand coastal barrier 20 km in length, known as *Manga del Mar Menor*, separates the Mar Menor from the Mediterranean Sea. This lagoon is connected with the Mediterranean Sea through several channels (Martínez-Fernández *et al.*, 2005).

Figure 1. Location of the Mar Menor lagoon



The Mar Menor receives run-offs coming from the *Campo de Cartagena* basin. This watershed is drained by several ephemeral water courses called *ramblas*, which usually are inactive for the most part of the year. However, during rainfall periods, great volumes of water and sediments are swept along by the *ramblas* to the lagoon (Velasco *et al.*, 2006). There are a large number of salt flats and salt marshes surrounded by dune systems in the mouth of these *ramblas* and in some depressions near the lagoon.

Its high salinity and temperature, and the diversity of wetlands located in the vicinity give the Mar Menor special environmental value owing to the great variety of allochthonous flora and fauna species which have adapted to its environmental conditions. *Arthrocnium macrostachyum*, *Sarcocornia fruticosa* or *Pancratium maritimum* are some examples of plants adapted to salinity. As to ichthyology, there

are some species of high fishing interest such as *Anguilla anguilla*, *Mugil cephalus* and *Sparus auratus*. In addition, over 200 bird species have been located in the Mar Menor and its surroundings; for instance, *Phoenicopterus ruber*, *Charadrius alexandrius*, *Sterna albifrons*, *Podiceps nigricollis*, *Larus geneis* and *Himantopus himantopus* (Martínez-Fernández *et al.*, 2007).

The Mar Menor lagoon and its environs are protected at national, European and international level with the aim of preserving and protecting the current diversity of habitats and species. The Mar Menor and its salt marshes were included in the Ramsar List of Wetlands of International Importance in 1994. The Mar Menor is also considered a Special Protected Area of Mediterranean Interest (SPAMI). EU regards it as a Specially Protected Area (SPA) for birds, and five Sites of Community Importance (SCI) are located in this area. All its four inner islands are protected under the status of Protected Landscape.

3.2. Main pressures and impacts

The special geo-climatic conditions of the Mar Menor area have favoured the development of intensive agriculture, tourism, fishing and mining, causing a great impact on the lagoon. Its current ecological balance is mainly threatened by the intensive agriculture carried out in the *Campo de Cartagena* basin, and by the population increase triggered by the massive arrival of tourists during the summer months (Conesa and Jiménez-Cárceles, 2007). Both activities are the direct causes of the eutrophication present in the lagoon. On the one hand, the agrochemical products used in the *Campo de Cartagena* for the last two decades have polluted the nearby aquifers, which reach concentrations of nitrates of 200-300 mg/l. These figures far exceed the 50 mg/l established by the regulations (CHS, 2008). The aforesaid aquifers are connected to the Mar Menor through both subterranean flows and *ramblas*. The major input of nitrates and phosphates to the lagoon takes place through the Rambla del Albuñón, whose water comes from flow returns of the agricultural activities developed in the Mar Menor draining basin (Velasco *et al.*, 2006). For this reason, the Campo de Cartagena area has been declared *vulnerable zone* in relation to nitrates under Directive 91/676/EEC. On the other hand, urban and tourism growth has led to a poor wastewater treatment, which is another major threat and the reason why the lagoon has been declared *sensitive area* according to Directive 91/271/EEC concerning urban waste water treatment.

The Mar Menor has undergone many ecological changes that are affecting local economic activities as a result of eutrophication and other aspects that are altering the

lagoon natural conditions, such as widening of communication channels between the lagoon and the Mediterranean (Pérez-Ruzafa and Marcos, 2008). The following are some of the most remarkable changes: the expansion of the alga *Caulerpa prolifera* replacing the autochthonous phanerogams *Cymodea nodosa* and *Posidonia oceanic*; invasion and rapid spread of Mediterranean jellyfish, with the ensuing degradation of the touristic image of the area; and the decrease in the fishing of autochthonous species substituted by other Mediterranean species (Conesa and Jiménez-Cárceles, 2007).

3.3. Measures to improve the Mar Menor water quality

The measures proposed to improve the environmental quality of the Mar Menor lagoon are included in the reports previous to the Segura River Basin Management Plan, written by the *Confederación Hidrográfica del Segura* (CHS), main organism charged with the lagoon management. The action plan focuses on the reduction in diffuse pollution caused by agricultural activities in *Campo de Cartagena*; improvement in the treatment of wastewater coming from lagoon-side municipalities; and the subsequent treated water discharge into the Mar Menor. A summary of the measures to be implemented in order to improve water quality in the Mar Menor is shown in Table 1. They are subdivided into basic and additional measures. Basic measures are legally binding actions, which are not enough to restore the Mar Menor by themselves. For that reason, another series of additional measures are implemented to decrease the input of nutrients into the lagoon (CHS, 2008).

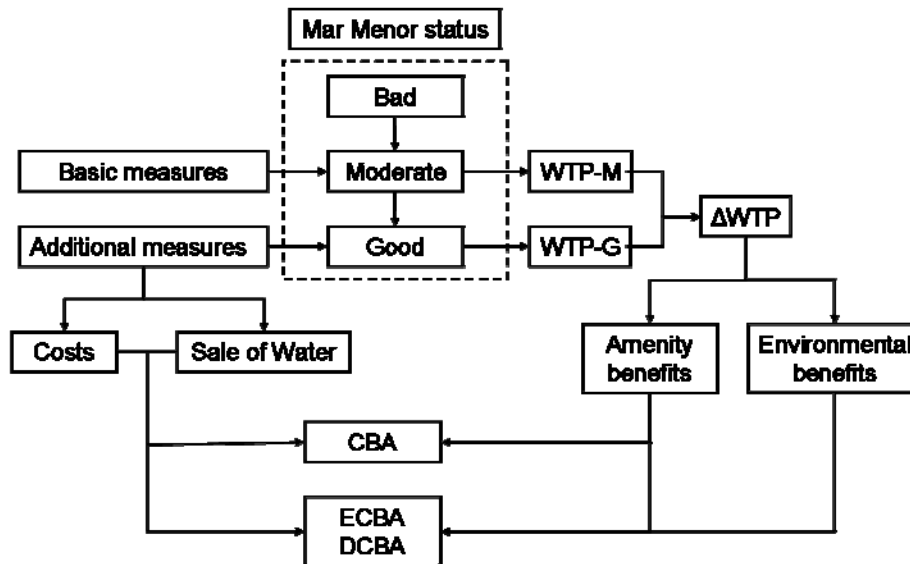
Table 1. Environmental restoration measures in the Mar Menor

	Measure	Purpose
Basic	Creation and modelling of sewage treatment plants	To achieve the overall treatment of urban waste water in the area
	Code of good agricultural practice	To reduce the usage of agrochemicals in agriculture
Additional	Desalination of flow returns	To treat the flow returns from <i>Campo de Cartagena</i>
	Set of wells at the perimeter of the lagoon	To extract polluted groundwater to treat it
	Storm tanks	To collect urban wastewater to treat it, avoiding certain unwanted spillages
	Cleaning of the Rambla del Albujón	To remove litter and rubble out of the <i>rambla</i> banks
	Restoration of the Rambla del Albujón	To revegetate with autochthonous species to favour the retention of nitrates and phosphates

3.4. Overall outline of the valuation

The general methodological system applied in this work is shown in Figure 2. Two improvement scenarios have been identified according to the kind of measures taken. The first stage constitutes a moderate improvement in the lagoon ecosystem after basic measures are applied. On the other hand, when additional measures are implemented, the lagoon good environmental status would be achievable, which represents the second scenario. The CBA of the programme of additional measures considers financial costs of implementation of measures (McCrea-Strub et al, 2011), income from selling the water produced, and amenity and environmental benefits brought by the transition from a moderate to a good environmental status. An exercise of contingent valuation has been designed to estimate amenity and environmental benefits. It consists in calculating the willingness to pay (WTP) in each of the aforesaid scenarios. Given that basic measures are legally compulsory, they would be left out of the economic analysis proposed, since its purpose is to determine whether or not a project is justifiable from an economic, social and/or environmental point of view (Zanou *et al.*, 2003).

Figure 2. General Methodological Framework



4. Willingness to pay for the environmental improvement of the Mar Menor

4.1. Survey design

The Contingent Valuation Method (CVM) has been used in the present work to estimate the Willingness To Pay (WTP) for the improvement of the Mar Menor environmental quality. Thus, a survey addressed to the citizens of Región de Murcia, geographical area where the lagoon is located, was conducted.

The question about the WTP was put in mixed format: one dichotomous question and two open-format questions, one for each improvement scenario. Firstly, interviewees were asked whether or not they were willing to pay an additional tax on the water bill intended for the Mar Menor environmental restoration. Secondly, they were asked about the maximum amount they were willing to pay to achieve each of the improvement scenarios. Thirdly, other questions related to psychographic and socioeconomic variables were included. In addition, interviewees were provided with a brochure describing the features of both scenarios with the purpose of reducing the uncertainty typical of this type of valuation methods (Blomquist and Whitehead, 1998).

The valuation exercise was conducted through personal interview in April 2010. The citizens over 18 years of age of Región de Murcia were the target population¹ (1.140.887 inhabitants), and the random sample size was of 344 individuals (stratified by areas of Región de Murcia), with a maximum error of estimate of 4%.

4.2. Constitution of the hypothetical market

The composition of the hypothetical market created by the contingent valuation method is structured from individuals' answers to the dichotomous question about the WTP and the reasons for their answers. Out of the 344 interviewees, 47.7% (164) declared that they were willing to pay, whereas 52.3% (180) were not. This last group can be divided into two factions: real zeros and protest zeros. Protest answers are given by individuals who reject the valuation exercise, and declare their unwillingness to pay although they do have a positive opinion on the good (Bateman y Langford, 1997). In this study, protest zeros are constituted by those individuals who argued that

¹ About 50% of the tourists visiting this area come from Murcia, where they own a second home; thus, the summer population of the Mar Menor has been taken into account by our sampling.

“the Mar Menor environmental restoration is within the competence of the Public Administration”. A total number of 148 interviewees gave a protest answer, whereas the remaining 32 have been considered real zeros within the hypothetical market, which finally consists of 196 individuals.

4.3. WTP analysis and modelling

By using the answers of the 196 individuals who participated in the hypothetical market, the average WTP is 20.11 € per year in the moderate improvement scenario (WTP_M), and 35.35 € per year in the good improvement scenario (WTP_G). The descriptive statistics of the WTP in both scenarios is shown in Table 2.

Table 2. Descriptive statistics of the WTP (€/year)

	Minimum	Maximum	Average	Median	Standard deviation	Mean confidence interval (95%)
WTP_M	0	100	20.11	10	23.18	16.85 – 23.38
WTP_G	0	200	35.34	25	39.60	29.76 – 40.92

WTP_G is higher than WTP_M for all individuals, which proves answers consistency, since the environmental improvement achieved is superior in the first case. Besides, both WTPs show a positive and significant correlation.

This WTP represents the individual total economic value of the enhancement; therefore it can be divided into use WTP and non-use WTP. The first one embodies the monetary value of the direct enjoyment of the Mar Menor, that is, amenity services (EEA, 2010), whereas non-use WTP represents the environmental value. The value of use WTP derives from the users' WTP, while non-use WTP is calculated as the difference between users' WTP and non-users WTP. Finally, use WTP and non-use WTP for the programme of additional measures are obtained as the increase between the WTP of both programmes, shown in Table 3.

Table 3. WTP of users and non-users (€/year)

Concept	(WTP_M)	(WTP_G)	$\Delta WTP = (WTP_G) - (WTP_M)$
Use WTP (Amenity)	5.30	13.65	8.35
Non-use WTP (Environmental)	15.81	24.27	8.46

5. Cost-Benefit Analysis of the Programme of Additional Measures

5.1. Characterization of costs

Table 4 shows the financial costs (investment and maintenance) and the lifetime of the programme of additional measures, which are included in their technical projects (CHS, 2008).

Table 4. Characterization of the measures costs

	LIFETIME (years)	INVESTMENT (€)	MAINTENANCE COSTS (€/year)
Desalination plant	20	39,245,600	4,100,200
Peripheral wells	50	10,035,000	1,998,000
Wastewater tanks	50	87,940,000	1,104,000
Restoration of Rambla del Albujón	50	2,106,000	51,340
Cleaning of Rambla del Albujón	10	498,100	12,607
TOTAL		139,824,700	7,266,147

5.2. Characterization of benefits

The first thing to be considered has been the income yielded by selling the water produced in desalination plants for agricultural activities. The treatment forecast is 9.7 Hm³/year of flow returns, with a freshwater output of 7.76 Hm³/year. The price of water has been initially fixed at 0.3 €/m³, representing the opportunity cost of an alternative source of supply in the area (Colino and Martínez-Paz, 2007).

Secondly, the benefits generated by the improvement in the Mar Menor environmental quality after the implementation of additional measures have been estimated from the values of use/non-use Δ WTP achieved by means of the CVM. These benefits are classified into environmental and amenity benefits. Environmental benefits are produced by multiplying total population by the use Δ WTP for the Mar Menor enhancement. Amenity benefits are calculated in the same way but using the population of users (81.12% of the total population).

The target population to be included in the CBA during the analysis period 2011-2059 has been determined from the recent figures of the total population over 18 years of age of Región de Murcia, by using an autorregresive model according to Hildreth-Lu procedure².

² The Hildreth-Lu procedure (HL) adjusts a linear model for serial correlation in the error term. This model is a variant to the Cochrane–Orcutt procedure (CO) for small samples (Aschheim and Tavlas, 1988). Taking account of a range 1 autoregressive model: $P_t = \alpha + \beta P_{t-1} + \varepsilon_t$. The error term ε_t can be

$$\hat{P}_t = 97,840 + 0.929 P_{t-1} ; \rho = 0.110 ; \bar{R}^2 = 0.991 \quad F(1, 9) = 859.732; p = 0.000$$

t-stat (2.712) (23.710)

For instance, the amount of amenity benefits would be 7,877,604 €/year in 2010 and 9,322,490 €/year in 2059, and the number of environmental benefits would be 9,838,980 €/year and 11.643.616 €/year in the same years.

5.2. Profitability indicators

The CBA of water enhancement measures in the Mar Menor will be implemented from the above-mentioned costs and benefits, and the approaches included in section 2: CBA, ECBA and DCBA.

An analysis period of 50 years has been settled, considering the measures maximum lifetime and introducing periodic replacements of the least-lasting measures. Results of the analyses are shown in Table 5.

Table 5. Profitability indicators

Indicator	CBA (2%)	ECBA (2%)	DCBA (2%, 1%)
NPV (€)	-62,154,975	274,820,021	363,180,403
IRR (%) - CER (%)	-	9.55	14.70
PB (years)	-	12	11

Classic CBA has been conducted by exclusively using market flows, which include costs of measures, income from water sale and amenity benefits. The NPV is -62,154,975€, reason why the implementation of the programme of additional measures, only taking market flows into account, unprofitable and, in turn, rejected.

As ECBA indicators confirm, the implementation of the programme of measures would be fully justified from an economic and social point of view, because NPV is greater than zero and the internal return rate (9.55%) is much higher than any existing interest rate applicable in the market. The Payback Period (PB) is 12 years, meaning

serially correlated over time. $\varepsilon_t = \rho\varepsilon_{t-1} + e_t$, $|\rho| < 1$. The CO procedure transforms the model: $P_t - \rho P_{t-1} = \alpha(1 - \rho) + \beta(P_{t-1} - P_{t-2}) + e_t$. Then the sum of squared residuals (e_t^2) is minimized with respect to (α, β) , conditional on ρ , using an interactive technique of bisection search for the HL (Neter *et al.*, 1989).

that, in scarcely the quarter of the period, investment is recovered and the programme of measures starts generating net profits.

DCBA has been also applied due to the diverse nature of the flows of the project (market and non-market flows). To calculate DCBA the same discount rate (2%) applied to market flows has been used, with a reduced rate (1%) in the case of environmental benefits (Almansa and Martínez-Paz, 2011). It is noticeable that the NPV attained with this approach would also recommend the performance of the investment, with a Payback Period (PB) of only 11 years. The high value attained for the CER (14.70) highlights the outstanding environmental profitability of the aforementioned programme of measures.

5.3. Sensitivity analysis

One of the parameters of this analysis is the selling price of water produced in the desalination plants. This price is uncertain at medium term because of the changes in energy price and in water policy, which is increasingly focused on the recovery of water services costs. For this reason, fluctuations in the price of the water treated in desalination plants have been considered by way of sensitivity analysis. Variability of water prices ranges between 0 and 0.6 €/m³ (maximum price of desalinated water in the area). Table 6 presents fluctuations in the profitability indicators of the different types of CBA according to water price rises.

Table 6. Profitability sensitivity analysis of water price fluctuations

Water price (€/m ³)	CBA		ECBA		DCBA	
	NPV (2%)	IRR (%)	NPV (2%)	IRR (%)	NPV (2%, 1%)	CER (%)
0	-133,026,777	-	203,948,219	7.79	292,308,601	7.30
0.1	-109,402,843	-	227,572,153	8.38	315,932,535	8.84
0.2	-85,778,909	-	251,196,087	8.97	339,556,469	11.06
0.3	-62,154,975	-	274,820,021	9.55	363,180,403	14.70
0.4	-38,531,042	-	298,443,955	10.13	386,804,336	22.00
0.5	-14,907,108	1.43	322,067,889	10.70	410,428,270	46.47
0.6	8,716,826	2.32	345,691,822	11.27	434,052,204	-

Given the fact that water sale is a benefit of the programme of measures, price rise has a positive effect on profitability indicators of the three schemes. To summarize, every additional cent of euro in water price generates a 2,362,393 € increase in the NPV, and a 0.6% increase in IRR. The decision rule would not change after this analysis, since the CBA approach continues advising against the programme implementation at almost all price levels. However, approaches taking into account environmental benefits prove the programme profitable, even in the case of no profits

produced by water sale. In order to complete this section, it would be interesting to analyse the sensitivity of other CBA parameters, for instance the discount rates (Almansa and Martínez-Paz, 2011).

6. Conclusions

The necessary environment conservation has given rise to a wide spread of environmental protections rules in developed countries. The Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD) include the guidelines for EU marine and coastal water management. Both directives urge member states to propose a Programme of Measures aiming for the good ecological status of these ecosystems. In many cases, it is needed to implement corrective and restoration measures requiring large amounts of public investment that must be economically assessed by including social and environmental profitability criteria.

This work puts forward a methodology for the valuation of the measures implemented to environmentally enhance coastal ecosystems. This methodology, applied to the restoration programmes of the most important inland sea in the Western Mediterranean (Mar Menor, SE-Spain), comprises the Contingent Valuation method (CVM) and different approaches of the Cost-Benefit Analysis (CBA).

The CVM designed for this study has allowed to isolate the assessment of the effects produced by the environmental restoration programme of measures in the Mar Menor from the value the ecosystem itself has before the execution of such a programme. As representative mean figures of the analyzed programme, 8.5 million €/year represent amenity benefits, and 11.1 million €/year constitute environmental benefits.

The valuation results reveal the economic unprofitability of this type of actions if analyzed with the Classic CBA. Nevertheless, if environmental benefits yielded by the ecosystem restoration are included, the planned investment is far justified. This is possible by using either a CBA with environmental externalities or a dual approach that reduces the discount rate for environmental benefits, as it has been suggested in the latest studies on environmental discount rate (Gollier, 2010). In this way Internal Rate of Return (IRR) of nearly 10% can be attained, which would far justify the public investment (EC, 2008). The Critical Environmental Rate value proves the exceptional environmental profitability produced by the financial investment in this programme of measures. All these results surpass the sensitivity analysis of the most uncertain variable in the model, water price. Despite the quantitative modification of indicators and changes in water price, the directions of the action remain invariant.

Finally, it is important to underline the need for an increase in the number of empirical works making use of this methodology when assessing policies of coastal and marine ecosystems conservation. These studies allow to appropriately justify public investment according to the MSFD and WFD principles, as well as to improve and adapt these valuation techniques to this field.

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