



Rapid economic impact assessment of nature-based solutions: Illustration of a co-constructed approach

José A. Albaladejo-García^a, María D. Medina-Vidal^b, Julia Martin-Ortega^c, Francisco Alcon^{a,*}

^a Departamento de Economía de la Empresa, Universidad Politécnica de Cartagena, Paseo Alfonso XIII, 48, 30203 Cartagena, Spain

^b Ministerio Para la Transición Ecológica y el Reto Demográfico (MITECO), Government of Spain, Madrid, Spain

^c Sustainability Research Institute, School of Earth, Environment and Sustainability, University of Leeds, LS2 9JT Leeds, United Kingdom

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ABSTRACT

Amongst the multiple advantages attributed to nature-based solutions (NBS) over conventional and grey infrastructure, is their characterisation as economically efficient, i.e. that the benefits that they generate outweigh their costs. However, surprisingly little attention has been paid so far to generating quantified evidence to support this claim in the form of comprehensive cost-benefit analysis informing *actual* and *specific* environmental decisions in given territories. In the absence of such evidence, current enthusiasm for NBS might result in unfavourable decisions, disappointment and abandonment. In this paper, we illustrate a co-constructed approach developed in close collaboration with policy-makers and involving a range of stakeholders. This approach formally evaluates the well-being impacts of adopting NBS *versus* non-NBS alternatives for the mitigation of agricultural impacts in the ecologically stressed Mar Menor lagoon (Spain), building-up the evidence base of the economic efficiency of NBS. More importantly, the paper illustrates how to undertake rapid economic impact assessments that, when exposed and co-constructed with a range of stakeholders in participatory processes, can support complex policy decisions in response to climate and environmental emergencies in ways that are robust, transparent and socially acceptable. By maintaining scientific rigor while simplifying data demands, rapid co-constructed economic impact assessments can not only integrate ecosystem services and economic efficiency reasoning into environmental governance but can also serve as boundary objects for consensus building, awareness raising and collective experiential learning. This is of particularly critical importance in times of growing polarisation over environmental challenges.

1. Introduction

There is an increasing interest in nature-based solutions (NBS) in both academic and policy spheres. There are varying definitions of NBS (Bark et al., 2021), but at a fundamental level they refer to ways of relating and managing our environment inspired and supported by natural processes (King et al., 2023), with the aim of providing benefits for human well-being and the environment (European Commission, 2015; Li et al., 2025). Amongst the multiple advantages attributed to NBS over conventional solutions and grey infrastructure, is their characterisation as economically efficient, i.e. that the benefits that they generate outweigh their costs (Tylianakis et al., 2022; Neumann and Hack, 2022). However, this attribute is to date mostly perceived or expected based on stakeholder judgement (Bark et al., 2021), rather than on widespread evidence based on tailored economic analysis. This

is not to say that there is not ample evidence of the economic benefits of ecosystem services that can be expected to be enhanced by NBS. There are indeed plenty of valuation studies that demonstrate the (monetary) value of ecosystem services (Martin-Ortega et al., 2021; Perni and Martínez-Paz, 2023). We are referring here to *formalised cost-benefit analysis* designed and used to inform actual policy decisions relating to the implementation of specific NBS in given territories, which are significantly much sparser.

If NBS are to be successful in becoming mainstream instruments for environmental management (Feroz and Rana, 2025), such evidence also needs to be mainstreamed. Otherwise, we risk the current enthusiasm and widespread advocacy for NBS falling into disenchantment and/or flawed implementations - as has happened in the past with other environmental management innovations (Leisher, 2015). The urgency for developing and implementing NBS to address the climate and nature

* Corresponding author at: Paseo Alfonso XIII, 48, 30203 Cartagena, Murcia, Spain.

E-mail address: francisco.alcon@upct.es (F. Alcon).

emergencies makes it critical that rapid economic impact assessments are undertaken.

At the same time, it is now well established that ‘wicked’ socio-ecological problems such as the ones that NBS aim to address, have a greater probability of success if they are developed collaboratively with the stakeholders that are ultimately responsible for or affected by their implementation (Duckett et al., 2016; Bark et al., 2021). As NBS are multi-faceted and require new ways of thinking (King et al., 2023), it would be advantageous for stakeholders to collaboratively construct economic impact assessments.

In this paper, we provide an illustration of one such co-constructed process developed together with policy-makers and involving a range of stakeholders, in which the cost-benefit analysis of NBS is used as a boundary object in collective discussions to inform decision-making with an economic efficiency basis. We use a paradigmatic case in which the need for policy action is at its most urgent: The Mar Menor Lagoon in the Southeast of Spain. The Mar Menor is one of the largest most polluted lagoons in Europe, as a result of decades of major agricultural diffuse pollution that have led to its ‘collapse’ as an ecosystem and to major economic damages (Aparicio et al., 2024; Maté-Sánchez-Val and Aparicio-Serrano, 2023). A comprehensive cost-benefit analysis is conducted to assess both NBS and non-NBS alternatives based on the valuation of the ecosystem services they provide, utilising a rapid impact assessment approach that integrates ecosystem services mapping with the benefit transfer method. The ultimate aim is to draw broader lessons on how to couple the urgency of action with the need for rigorous socio-economic evaluation in a co-constructed way.

Thus, the proposed assessment approach addresses a significant gap in the existing literature by providing insight into the co-construction process with decision-makers through a twofold contribution: (I) to estimate the most optimal design of nature-based solutions from a cost-benefit point of view and (II) to understand the feasibility of conducting a rapid economic assessment that has real practical implications for decision-making. Thus, despite the existence of similar studies on the economic viability of nature-based solutions (Neumann and Hack, 2022), this is the first study to approach it from a rapid economic assessment in a collaborative process with decision-makers. The information obtained provides guidance for establishing socially and academically acceptable management policies that have relevant implications for local policy design, offering a potentially more productive approach than those addressed in the literature where the role of decision-makers, and other stakeholders, in complex issues related to the management of degraded natural areas is not usually considered.

We do not claim to introduce a wholly new, universally-applicable ‘rapid’ valuation methodology. Rather, this paper illustrates a fast application of established ecosystem-service mapping and benefit-transfer techniques in a context where substantial prior knowledge and institutional resources were available. The main contribution lies in demonstrating how participatory governance mechanisms can be effectively integrated with established cost-benefit analysis tools to support implementation-ready decisions in environmentally and socially contested territories. The timeframe achieved here relied on three complementary preconditions: (i) existing spatial datasets and simulation outputs that could be re-used; (ii) previously published economic valuations and local studies suitable for benefit transfer; and (iii) strong institutional commitment and stakeholder networks that enabled expedited consultations and data sharing. Where these preconditions are absent, similar studies are likely to require substantially more time and resources.

2. Methodology

2.1. Case study

The Mar Menor lagoon is one of the largest in the Mediterranean region with ecological characteristics that grant it protected status by

the Natura 2000 Network, the SPAMI, the RAMSAR convention and by current Spanish environmental legislation. Despite its ecological value, the Mar Menor has experienced decades of excess of nutrients loading from surrounding agriculture, resulting in successive major episodes of eutrophication (Alvarez-Rogel et al., 2020). One of the observed effects is the massive upwelling of phytoplankton, which limits the entry of light and oxygen, causing mortality and degradation of the marine ecosystem. The episodes of eutrophication that occurred in 2015 and 2019 kept the Mar Menor at the hypoxic limit (around 5 mg/l of dissolved oxygen) for long periods of time. This led to anoxic crises and massive die-offs of fish and all types of marine invertebrates. The degradation of the Mar Menor lagoon has had significant adverse socio-economic impacts on the region, manifested in job losses, declining property values, and a reduction in tourist interest (Perni et al., 2020). This ecological collapse led to the proposal of a new law (Law 3/2020, of 27 July) and other urgent regulations aimed at recovering its environmental condition (Krämer, 2023). Fig. 1 shows the location of the study area and the proposed solutions that will be described in the following sections.

2.2. Co-constructed research process

The research was initiated by the Spanish Ministry for Ecological Transition and Demographic Challenge (MITECO), and consisted of a process involving policy-makers, academics and a range of stakeholders, including local farmers. Fig. 2 shows the timeline of this process, which started with the collaborative identification of alternatives to address the Mar Menor challenges as part of a Priority Actions Programme (MITECO, 2023a), continued with the economic impact assessment of NBS and alternatives emerged along such collaborative process, and concluded with the formulation of the final design for implementation including a final round of stakeholder input. The overall duration was of fourteen months, which we would argue was quite rapid for such an endeavour.

The illustrative economic analysis of the alternatives was undertaken in an adaptive way, i.e. the process was led by the policy-maker (MITECO) and made use of emerging opportunities for data collection along the way, in a true reflect of an evolving ‘real-life’ policy process, rather than a pre-established experimental design – as needed for addressing ‘wicked problems’ of this nature (King et al., 2023). Fig. 2 also indicates the points along this process in which primary data for the economic analysis were collected, as well as the different actors involved at the various stages.

Next, we provide detail on the key stages of the process: 1) identification and description of alternatives, 2) mapping of ecosystem services provision, 3) monetary valuation of ecosystem services, 4) cost-benefit analysis and 5) formulation of final project design.

2.3. Identification and description of alternatives

The co-construction process was conducted through a series of focus groups and meetings with relevant stakeholders and experts. The opinions of the various actors involved in the process were collated through individual questionnaires based on open questions about the NBS alternatives at the conclusion of each session, thus enabling the identification of heterogeneity of views even when these were not expressed verbally during the meetings, as well as through note-taking of group discussions, which allowed recording the deliberation process. The team then proceeded to undertake a thematic analysis of the feedback using grounded coding (Babbie, 2020). All proposals were given due consideration, including minority opinions. Heterogeneity of perceptions in meetings is not considered a methodological obstacle but rather a source of information that enriches the process and improves the social robustness of the final design. Ultimately, it was possible to achieve sufficient levels of consensus in the validation of the ecosystem services and valuation application to move forward the process.

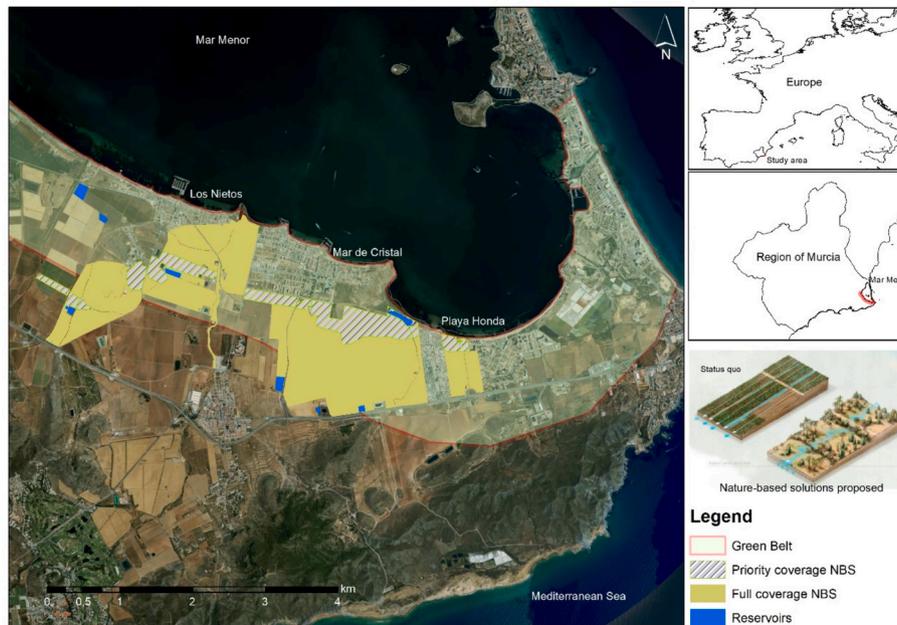


Fig. 1. Case study area, including location of proposed NBS.

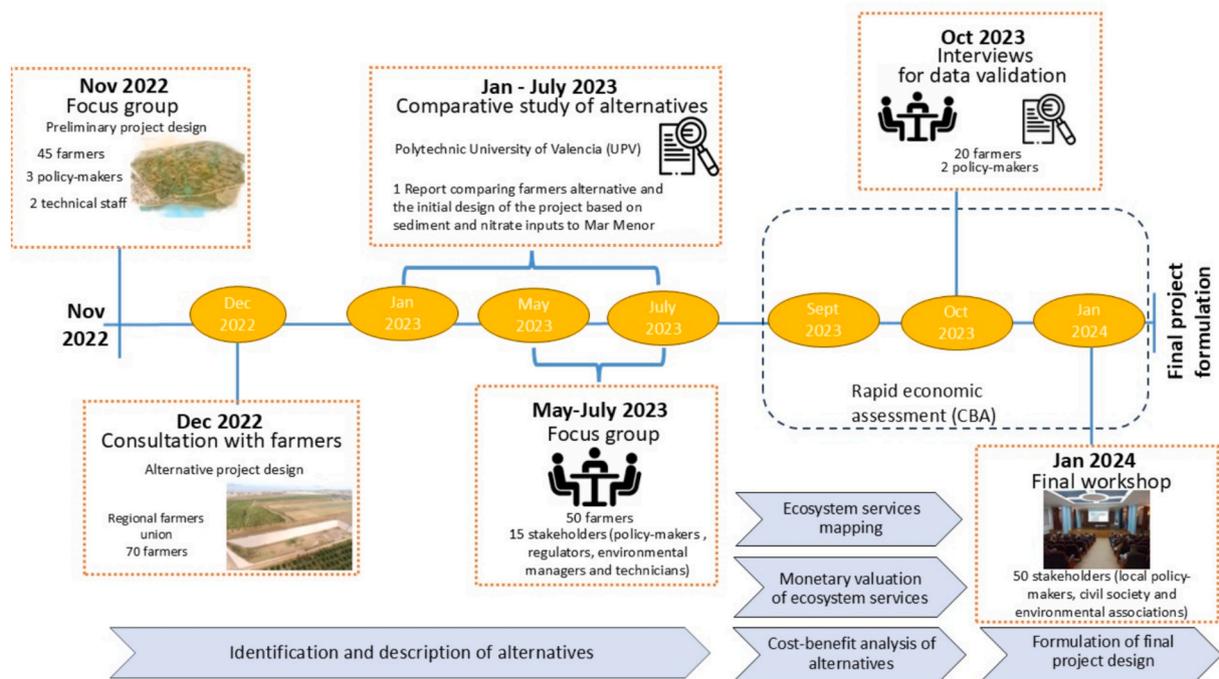


Fig. 2. Co-constructed research process timeline (oval shapes refer to stakeholder events).

The process started with a preliminary focus group held in November 2022, attended by 50 individuals (45 farmers, 3 policy-makers and 2 environmental technical staff from MITECO). As part of the Priority Actions Programme to recover the Mar Menor, MITECO had outlined the creation of a Green Belt to “eliminate the direct effects and seek a buffer effect, as well as a naturalisation of the immediate surroundings of Mar Menor” (MITECO, 2023a). The preliminary framework of the Green Belt project was presented at the focus group, articulating its primary objectives, i.e.: to soften the land slope to retain runoff and soil, recover the traditional landscape of the Mar Menor basin (terraced crops interspersed with natural spaces), improve visual quality, create a network of footpaths for public use, recovery of the vegetal potential of the area

(habitats, biodiversity), and improve the ecological connectivity of the territory. The actions are mainly to be located on agricultural land in the southern area of the Mar Menor, along the perimeter strip of the coastal lagoon, within 1500 m of the coastline (Fig. 1).

Due to the complexity of the environmental restoration actions and its large surface area, two scenarios of NBS were proposed: (1) Full coverage, which contemplates the intervention across the whole area (535 ha); and (2) Priority coverage, focusing on areas considered to be of high priority for action (104 ha) (see also Fig. 1).

In both scenarios, the implementation of the NBS would require the acquisition of private farmland by the government, which was seen as potentially highly controversial. Farmers were therefore invited to

present alternative options that would achieve the objectives of the Green Belt framework. The regional farmer's union [Coordinadora de Organizaciones de Agricultores y Ganaderos (COAG)] presented an alternative in December 2022, consisting of the construction of 8 reservoirs and 7 interception canals that collect runoff. The reservoirs would collect runoff water from the catchment basins that flow into the Mar Menor, covering a surface area of 519 ha of the study area. As the reservoirs have a finite capacity, it was necessary to consider options for managing the runoff stored in each reservoir. Two scenarios were considered: (1) Active draining, with capacity to evacuate the reservoirs' full volume of water and dissolved nitrogen within 60 days so that it would not reach the Mar Menor; and (2) No draining, so that the water was only to leave the reservoir by evaporation. The non-draining scenario represents the situation of minimum effectiveness of these reservoirs. In both non-NBS scenarios, it is assumed that the sediments deposited at the bottom of the reservoirs are collected and landfilled on a regular basis, thus maintaining the usable volume of the reservoirs.

Once the alternative proposed by the farmers was received, it was studied and compared with the NBS proposed in the Green Belt project. To this end, between January and June 2023, the Polytechnic University of Valencia (UPV) was asked to carry out a comparative study of the four alternative scenarios regarding sediment and nitrate input to the Mar Menor (Puertes et al., 2021).

Between May and July 2023, a series of focus groups were conducted with approximately 50 farmers and 15 other stakeholders, including policy-makers (local, regional and national), regulators, environmental managers and technical staff (2 from MITECO's General Directorate of Biodiversity and Desertification, 3 from the River Basin Authority, 2 from Mar Menor's Technical Office, 3 local authorities' representatives and 5 from the regional government). The objective was to present and discuss the findings of the comparative study conducted by UPV. As a result of those discussions, the actors involved (including the famers), concluded on the necessity of conducting a cost-benefit analysis of the alternatives. This work was commissioned to the Polytechnic University of Cartagena (UPCT), which continued with the co-constructed approach between September and November 2023. The urgency to implement a solution face to the Mar Menor's emergency prompted the application of a rapid approach, combining ecosystem services mapping with benefit transfer, as the fastest methods supported by the academic literature, and that we detailed next.

To compare the NBS and non-NBS alternatives, the analysis focused on the area between Los Nietos and Playa Honda to provide a comparable reference point for the entire Mar Menor Green Belt (Priority and Full coverage NBS layers showed in Fig. 1). This analysis is carried out with reference to the year 2022, on which the values of ecosystem service provision and their monetary values are compared.

2.4. Mapping of ecosystem services provision

Under the ecosystem services mapping approach, GIS tools for spatial analysis can be used for most regulating and cultural services using aggregate indicators (Maes et al., 2016), while provisioning services are usually directly quantified using information from farmers and official statistics. Supporting services are often omitted for economic valuation purposes as they are intermediate services that can lead to a double counting (Maes et al., 2012).

In September 2023 a focus group with 8 researchers of the UPCT (including geographers, agronomists, economists, and environmental scientists), 4 from UPCT (agricultural economists) and 2 policy-makers from MITECO identified the most important ecosystem services and indicators to be used in the rapid assessment with the help of a literature review (e.g., Scopus, Web of Science, using keywords such as "ecosystem services," "Mar Menor," "agricultural pollution," and "rapid assessment"). In October 2023, interviews were conducted with 20 farmers and 2 policy-makers to validate the results obtained. Most farmers recognised the importance of provisioning and regulating services (e.g.,

food supply, water availability, erosion control) and showed interest in how these relate to agricultural productivity and regulatory constraints. Cultural services were perceived as less directly related to their daily activities, but important for the image of the region and tourism. Overall, farmers agreed that the selected ecosystem services reflected their main concerns and the local reality. Feedback obtained in this way was used to adjust some of the data and criteria used in the analysis.

This process led to the identification of nine relevant ecosystem services and their respective indicators for the case study, which are described in Table 1 and explained in detail next. (See Table 2.)

The combination of models was chosen to balance scientific robustness, data availability, and the time constraints associated with the rapid assessment framework. The choice and application of each of the models was part of the interdisciplinary deliberation with the ecosystem services specialist scientists involved in this participatory process that is central to this work.

The main provisioning service is food supply, for which average annual crop net margins (€) received by farmers for the reference year 2022 was used as an indicator (Zabala et al., 2021a). This is a proxy estimation of the economic yield at market prices. Information on yield, variable and fixed costs, as well as the price received by farmers was obtained from statistical yearbooks and specialised publications (MAPA, 2022a, MAPA, 2022b; García-García, 2018; García-García, 2020; García-García, 2023). Interviews with farmers provided some data on crop yields for the reference year (2022), for which a 30 % reduction was estimated as no fertiliser can be used within 1500 m of the coastline by law since 2020. As this is an estimated value based on interviews with farmers, a sensitivity analysis based on the percentage reduction in net margins was carried out.

Erosion control allows soil retention, reducing degradation due to erosion and the dragging of sediments downstream and the maintenance of vegetation cover. To measure this service, the sediment input (t/year) that is dragged into the Mar Menor obtained from the TETIS model developed by UPV was used as an indicator (Puertes et al., 2021).

Nitrate inputs to the Mar Menor (KgN/year) were used as the indicator to quantify water purification services. The nutrient leaching from irrigated agriculture causes groundwater pollution (Zabala et al., 2021a), as well as surface runoff water, causing nitrate pollution of surface and groundwater bodies in the study area (Alcolea et al., 2019). The data provided by the TETIS model applied to the southern area of

Table 1
Description of ecosystem services indicators used in the ecosystem services mapping.

Ecosystem services	Indicators*	Units
Provisioning services		
Food supply	+ Agricultural net margins received by farmers	€
Regulating services		
Erosion control	- Sediment inputs	Tonnes
Waste treatment and water purification	- Nitrate inputs	Kg
Climate regulation	+ CO ₂ sequestration	Tonnes N ^o
Flood regulation	- Curve number reduction	Index
Maintenance of genetic diversity	+ Biodiversity index	0-1
Cultural services		
Landscape aesthetics	+ Landscape aesthetic index	Index 0-1
Recreation	+ Recreation index	Index 0-1
Environmental education	+ Presence of environmental activities	0/1

* + Indicates positive correlation with social well-being, - indicates negative correlation.

Table 2

Monetary values of ecosystem services per indicator and basis of the benefit transfer process exemplified in this case.

Ecosystem service indicator	Source of the original monetary value	Adaptation of original sources to case study area
Net margins	MAPA (2022a, 2022b); García-García (2018, 2020, 2023)	The unit of this indicator is already monetary, so it was not necessary to apply the benefit transfer method. The values are obtained from official statistics. The data were refined by interviewing farmers.
Sediment inputs	Alcon et al. (2022)	1.40 €/t year was considered from the erosion control of agricultural soil in Campo de Cartagena (study area district), extrapolating the values of this zone.
Nitrate inputs	Lopez-Becerra and Alcon (2021)	77.14 €/kgN year based on the costs of agricultural pollution in the Mar Menor. This may be a generality of the overall benefit expected for the whole Mar Menor, but the proportional impact of the actions is expected to have a real impact on the southern area
CO ₂ sequestration	SendeCeo, 2022	The average European CO ₂ market price of 80 €/t CO ₂ eq/year for 2022 was considered. This would be a conservative average price given that the social value is much higher than the market price (Revesz et al., 2017).
Curve number reduction	Martínez-García et al. (2022)	1245 €/year based on values obtained in wadis in the study area surroundings.
Biodiversity index	Zabala et al. (2021b)	411 €/ha year from biodiversity in agricultural ecosystems in the Region of Murcia (the region of this study area) was considered when bird richness is at its highest.
Landscape aesthetic index	Alcon et al. (2022)	334.29 €/ha year from the Campo de Cartagena basin (study area district) was considered when there is a maximum landscape aesthetics.
Recreation index	Alcon et al. (2022)	225.44 €/ha/year for the Campo de Cartagena basin (study area district) was considered when recreation was at its maximum.
Environmental activities	Alcon et al. (2019)	396.34 €/ha/year is taken from the environmental education of protected natural areas close to the study area.

the Mar Menor (Puertes et al., 2021) were also used to calculate this indicator.

Climate regulation service was measured using CO₂ sequestration (t/year) (González-Sánchez et al., 2012) using information available in the “Calculator of carbon dioxide removals of Spanish forest tree species” (MITECO, 2023b). The accumulated removals (t CO₂) over a 30-year period taking into consideration the different species to be planted in the area.

Flood regulation was measured by the curve number reduction (n°), which is recognised as the water holding capacity of vegetation and soil during a flood event. The curve number is a hydrological parameter developed by the US Soil Conservation Service that allows estimating direct runoff from different physical variables of the environment such as the hydrological group of the soil, slope, or land use (Martínez-García et al., 2022). It ranges between 0 and 100, with higher values being associated with more impervious surfaces with greater transfer of precipitation to runoff.

Bird species richness was used as a proxy for biodiversity. A

Biodiversity Index (0–1) was estimated by aggregating twelve factors that influence bird richness (e.g., degree of naturalness, influence of urban areas, roads, presence of exotic species, etc.) following Beckmann et al. (2019) and its application in Mediterranean agricultural areas (Albaladejo-García et al., 2025a; Martínez-García et al., 2025).

A landscape aesthetics index was used to measure landscape aesthetics, which is defined as the well-being, utility or pleasure that people derive from appreciating the aesthetic qualities of a landscape. The recreation ecosystem service was also measured using a recreation index, which measures how suitable spaces are for recreational and cultural enjoyment. Both indices range between 0 and 1 and are composites made up of nine factors identified in the literature as important for valuing these services. These factors are derived from GIS-based layers, normalised and aggregated. Adapting the method proposed in Albaladejo-García et al. (2023) to the Mar Menor, the landscape aesthetics index includes the presence of a relevant landscape with recognised visual quality (in our case measured by the existence of visual access to the Mar Menor or the coastal mountains), natural vegetation, degree of naturalness, diversity of natural ecosystems, and influence of buildings, highways, and regional and urban roads. The factors making up the recreation index include the degree of naturalness, influence of buildings, highways, regional and urban roads, presence of natural vegetation, protected areas, traditional irrigation infrastructure and presence of paths as derived from the literature (Albaladejo-García et al., 2025a; Martínez-García et al., 2025; Liu et al., 2022).

The ability to undertake environmental activities was used as an indicator of environmental education, which can be understood as a process that aims to impart environmental awareness, ecological knowledge, attitudes, and values towards the environment (Ardoin et al., 2020). To calculate this indicator, the presence or absence of activities such as educational workshops, informative talks, tree planting, removal of invasive plants, etc. that favour the dissemination of knowledge, awareness of the natural heritage, and the feeling of belonging of the population to the Mar Menor and its surroundings, was considered. The presence of at least one environmental activity within the spatial unit was sufficient to assign a score of 1. The number of participants or frequency of the activity was not considered in the rapid assessment framework, as the aim was to capture the existence of active local engagement rather than quantify its intensity. This binary approach was chosen to maintain consistency across sites and to facilitate replication in contexts with varying data availability.

Most of the ecosystem services in our exemplification are represented by indicators that demonstrate a positive correlation with social well-being. These include net margins, CO₂ sequestration, biodiversity index, recreation index, and the presence of environmental activities. Conversely, there are some indicators that show a negative correlation with social well-being. These include sediment input, nitrate input, and the curve number. It should be noted that stakeholders were asked to assess the relevance, interpretability, and perceived usefulness of each indicator for local decision-making. Their feedback led adjustments to the scoring criteria to ensure that the final set of indicators reflected both scientific validity and local socio-environmental priorities. This participatory validation reinforced the legitimacy and applicability of the assessment framework.

2.5. Monetary valuation of ecosystem services

The monetary valuation of ecosystem services is complex, resource intensive and takes time (Johnston et al., 2015). This often makes it incompatible with the need to take urgent policy decisions face to environmental emergencies. In such cases, the application of benefit transfers (which adapt monetary values derived from original research for application in a different study context, Rosenberger and Loomis, 2003) might be the only viable option (Johnston et al., 2015; Johnston and Rosenberger, 2010).

Thus, this illustrative work applies the benefit transfer method by

applying monetary coefficients from other studies in literature to the values obtained in the ecosystem services modelling presented above. The benefit transfer carried out in this research considers both temporal variations, through the correction with consumer price indicators (ECONET, 2022), and spatial variations, through the correction with purchasing power parity indicator (World Bank, 2023). A description of the economic valuation employed by each ecosystem service is shown in Table 3. Preliminary exemplifying results from the value transfers were shared with policy-makers who validated and/or adjusted the criteria used for the transfers.

Benefit transfer inherently carries transfer errors, due to the differences between the study of the original source and the case to which is being applied. In this work – and this is critical for the rolling out rapid assessments to assist urgent policy decisions, as will be discussed – a number of principles were employed to minimize the effect of such errors into the overall economic impact assessment: i) where possible, data specific to the same study area was obtained; ii) were not possible, data were transferred from areas close to, or containing, the study area; iii) where specific data did not exist, the value representing the most conservative option was used/estimated, adjusted or transferred. In this way, the benefit obtained for each of the indicators will always be a conservative estimate when carrying out the cost-benefit analysis, avoiding a ‘false’ positive net present value (Ferrini et al., 2015).

2.6. Cost-benefit analysis

Cost-benefit analysis is the main economic analytical tool available to evaluate public investment decisions (Mishan and Quah, 2020). In this case, the benefits (derived from the ecosystem services mapping and benefit transfer as explained above) are compared with the costs of the initial investment of each of the scenarios (NBS and non-NBS) and the subsequent maintenance costs. Cost data were obtained in consultation with policy-makers from MITECO.

The most used profitability indicators in CBA are the Net Present Value (NPV) and the Internal Rate of Return (IRR) (Mishan and Quah, 2020), which are also the ones that used here. The NPV represents the difference between the present value of benefits and the present value of costs, discounted over the analysis period. A positive NPV indicates that the project yields a net economic gain to society and is therefore socio-economically desirable. The IRR, on the other hand, represents the discount rate at which the NPV of a project equals zero—essentially the project's internal rate of return. When the IRR exceeds the reference discount rate, the project is considered economically justified. Using both metrics is especially valuable in participatory and policy-driven contexts such as this study, since these indicators are estimated for the entire life of the project and it allows communicating results in a format easily understood by both economists and non-specialist stakeholders involved in decision-making. The following parameters have been

considered to carry out the profitability analysis of the scenarios proposed:

- Discount rate of 3.5 %, for both market and non-market goods, which is the usual discount rate for public investment (Almansa and Martínez-Paz, 2011).
- Analysis period of 30 years. Given the long useful life of the scenarios evaluated and in accordance with the recommendations of the European Union (European Commission, 2015), the reference year being 2022.

Therefore, an IRR of more than the benchmark rate of 3.5 % indicates that the scenarios under investigation are more favourable than the minimum acceptable return and are therefore considered worthwhile in terms of social well-being.

2.7. Formulation of final project design

After the completion of the CBA, a final stakeholder workshop was held in January 2024 with 50 stakeholders, including local policy-makers, civil society and environmental associations, and the regional Farmers Union. Findings of the comparative analysis of the NBS and non-NBS were presented, and participants were invited to provide feedback on the analysis and their views on the process and outcomes. This feedback was used in the formulation of the final project design, resulting in a combination of the original proposal made by MITECO together with that made by the farmers, in a true reflect of the collaborative nature of the process.

3. Results

3.1. Ecosystem services provision under NBS and non-NBS alternatives

Table 3 shows the values for the ecosystem services indicators for the Status Quo scenario (no actions taken in the Mar Menor) and the four alternatives, i.e. the two NBS ones (Full and Priority coverage) and the two non-NBS (reservoirs with and without active drainage system) serving to illustrate the co-constructed process.

The analysis of the indicators, compared to the status quo (2022), exemplify how the two NBS scenarios obtain the highest values for the provision of regulating and cultural ecosystem services. In the non-NBS scenarios, the main provision of ecosystem services is related to the productive and regulating services. This is supported by the maintenance of net margins at the baseline level, while simultaneously reducing nitrate and sediment inputs to a considerable extent, particularly in the scenario involving the active draining of the reservoirs. If we focus on reducing local pressures (sediment and nitrates) within our case study (southern Mar Menor), Full-NBS produces approximately 35.1 %

Table 3

Illustrative annual values of ecosystem service indicators by scenario of NBS and non-NBS. Baseline: status quo (no action). Reference year 2022.

Scenarios	Ecosystem services								
	Food supply	Control erosion	Water treatment	Climate reg.	Flood reg.	Genetic diversity	Landscape aesth.	Recreation	Env. education
	Ecosystem service indicator								
	Net margins (€)	Sedim. inputs (t)	Nitrate inputs (kg)	CO ₂ Seq. (t)	Curve number (n°)	Bio. index (0–1)	Aesth. index (0–1)	Recre. index (0–1)	Env. activities (0 or 1)
Status Quo	538,470	1329	20,113	0	0	0.21	0.33	0.45	0
NBS Full coverage	0	1069	13,055	820	40.46	0.84	0.88	1	1
NBS Priority coverage	0	242	19,132	75	10.74	1	1	0.87	1
Reservoirs – Active draining	538,470	1126	16,930	0	0	0.20	0.12	0.44	0
Reservoirs – No draining	538,470	775	16,457	0	0	0.20	0.12	0.44	0

less nitrates and 19.6 % less sediment per area compared to the status quo. Priority-NBS produces approximately 81.8 % less sediment, but only 4.9 % less nitrate per area, while reservoir scenarios produce intermediate reductions. Extrapolating the impacts of the assessed scenarios to the entire lagoon, it is assumed that reductions within the sub-basin would proportionally impact on the entire lagoon. For illustrative purposes, full-NBS would reduce annual nitrate loads to the lagoon by approximately 3.5–10.5 % and sediment loads by approximately 2.0–5.9 % per area. It should be emphasized that these are extrapolations that would require joint modelling and monitoring (García-Ayllón, 2017). While the interventions under each of the scenarios cover different areas, the impact is assessed in terms of variation of ecosystem services flows affecting the Mar Menor, making the impact of scenarios comparable when biophysical indicators are translated to economic values and compared with the costs of the interventions.

Table 4 shows the translation of these results into monetary values, as per the well-being gain and losses associated with the changes in the ecosystem services provision.

Table 4 shows that, for this example, the greatest monetary gain in the nature-based scenarios is the reduction of nitrate inputs to the Mar Menor, which practically compensates for the economic losses suffered due to the disappearance of agriculture from the area. Significant economic benefits are also observed from environmental education and biodiversity. In the non-nature-based scenarios, there would be an economic loss, especially from the provision of cultural services such as landscape aesthetics and recreation, and biodiversity, but in any non-nature-based scenario the benefits from reduced nitrate inputs would not outweigh the nature-based ones. In addition, it is also exemplified that private benefits to farmers would be maintained in non-nature-based scenarios compared with the status quo situation.

Although Tables 3 and 4 provide point estimates for biophysical and monetary values, these should be interpreted as reference values. Both the GIS-based indicators and the benefit-transfer coefficients carry inherent uncertainty, arising from spatial data resolution, model assumptions, transfer errors, and the lack of standard errors in some of the source studies. Our use of conservative valuation coefficients was conservative intended to avoid overestimation, but we acknowledge that the resulting figures remain subject to significant uncertainty. The approach should therefore be interpreted as producing illustrative order-of-magnitude estimates adequate for rapid decision-making—not as a substitute for full probabilistic modelling or primary data collection.

3.2. Economic profitability of NBS vs. non-NBS (cost-benefit analysis)

Adding up all the monetary values (Table 4) per scenario, as the sum of differences of all ecosystem services value with the status quo, shows the total annual benefits shown in Table 5. The full coverage NBS are clearly the scenario with the highest economic benefits, being around three times the benefits of the non-NBS scenarios. Table 5 also presents

Table 4

Illustrative monetary value (€/year) of ecosystem services by scenario compared with the status quo scenario for the year 2022.

Scenarios	Ecosystem services								
	Food supply	Control erosion	Water treatment	Climate reg.	Flood reg.	Genetic diversity	Landscape aesth.	Recreation	Env. education
	Ecosystem service indicator								
	Net margins	Sedim. inputs	Nitrate inputs	CO ₂ Seq.	Curve number	Bio. index	Aesth. index	Recre. index	Env. activities
NBS Full coverage	-538,470	365	544,514	75,920	58,900	138,415	98,364	66,335	212,043
NBS Priority coverage solutions*	-76,355	24	75,684	10,942	13,219	33,740	23,293	9847	41,220
Reservoirs – Active draining*	0	230	245,612	0	0	-3511	-38,199	-2793	0
Reservoirs – No draining*	0	722	282,067	0	0	-3511	-38,199	-2793	0

* The priority nature-based solutions (104 ha) and reservoir scenarios (519 ha) have been calculated with the proportional surface of the study area.

Table 5

Illustrative total costs and benefits (€/year) of the scenarios considered.

Scenarios	Initial investment	Annual maintenance costs	Total benefits
NBS Full coverage	9,889,340	54,000	656,387
NBS Priority coverage	1,248,622	18,000	131,615
Reservoirs – Active draining	2,275,823	450,000	238,285
Reservoirs – No draining	2,275,823	450,000	201,339

the initial investment and maintenance costs of the proposed scenarios.

The two economic efficiency indicators obtained per scenario comparing costs and benefits (Table 6) show that, for this example, the four scenarios are justified from a socio-economic perspective, i.e. they all yield net economic benefits. This is supported by the positive NPV for all scenarios and an IRR that exceeds any real interest rate prevailing in the market.

From a socio-economic perspective, the suitability of carrying out these scenarios can be prioritized according to the economic efficiency indicators calculated. The order of priority would be as follows: 1. NBS Full coverage; 2. NBS Priority coverage; 3. Reservoirs – Active draining; 4. Reservoirs – No draining.

However, due to the high sensitivity of the results to changes in the values of net agricultural production margins (set at a 30 % reduction given the current agricultural restriction), Fig. 3 shows how increasing reductions in net crop margins increase the profitability of the NBS. On the contrary, the non-NBS would be more profitable if there were no reductions in net margins because of the implementation of the environmental legislation confined to the Mar Menor environment (Law 3/2020, of 27 July).

Overall, the minimum percentage reduction of the net agricultural production margin to be considered for the NBS Full coverage scenario to be socio-economically viable is 21.59 %. At this value, the implementation of this scenario would be economically justified. It is also important to consider the predictions of local farmers, who indicated that net margins are likely to decline gradually over time due to restrictions on the use of fertilizers and phytosanitary products. This could

Table 6

Economic efficiency indicators for the four scenarios.

Scenarios	Net Present Value: NPV (€)	Internal Rate of Return: IRR (%)
NBS Full coverage	1,189,779	4.43
NBS Priority coverage	840,981	8.26
Reservoirs – Active draining	723,658	5.01
Reservoirs – No draining	44,133	3.7

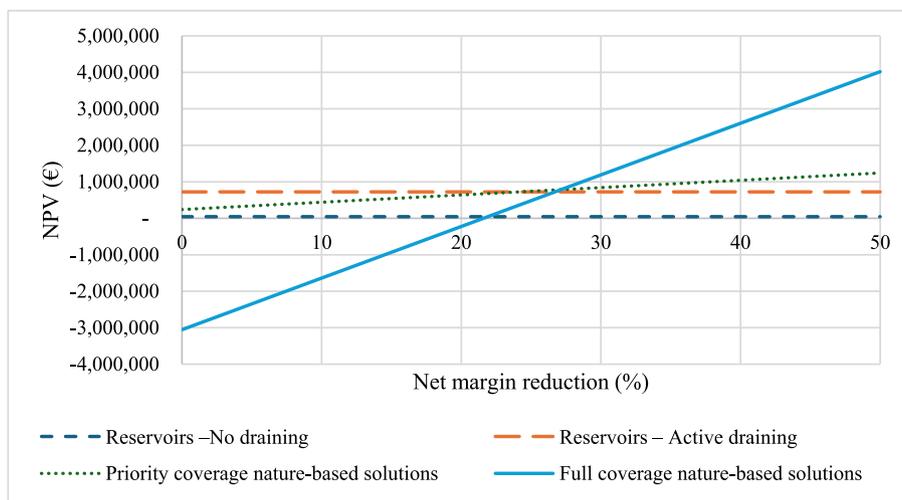


Fig. 3. NPV performance according to changes in net agricultural production margins.

result in a 50 % reduction, which would have significant implications for the profitability of nature-based scenarios.

3.3. Final project design

As explained and in reflect of the true collaborative nature of this process, the results of the CBA analysis were shared with stakeholders, leading to the formulation of the final project design with their input. This final design involved adding to MITECO's original design some of elements of the farmers' proposals. Namely, the excavation of a series of reservoirs on the ground, aimed at collecting the significant runoff that causes damage to agricultural areas and population centers. These reservoirs fulfil the 'sediment trap' and water accumulator effect proposed by the farmers, and at the same time generate a space that promotes biodiversity (amphibians, birds) and that is visually integrated thanks to the planting of various species around its perimeter. Farmers provided observations of areas where runoff accumulations were occurring in the field and of the performance of the sediment traps already built in the area.

This served to appease opposition from the farmers, while still being soil-efficient and allowing for the re-naturalization of the environment. The final project design is available at MITECO (2024).

4. Discussion

4.1. Analysis of the main findings

The rapid assessment conducted here for the Mar Menor shows NBS that consistently enhance the provision of a range of ecosystem services in this case, including climate regulation, erosion control, water treatment and purification, landscape aesthetics, recreation, environmental education and awareness, biodiversity, and flood regulation. Conversely, non-NBS sustain the provision of the food supply service and enhance the provision of erosion control and water treatment and purification services. These findings corroborate arguments put forth in the literature regarding the role of more naturalised spaces in providing services centred on regulation and cultural aspects (Brockerhoff et al., 2017; Keesstra et al., 2018; Ihmezie et al., 2023). The role of less naturalised solutions in maintaining the agricultural production of the ecosystem is also substantiated (Zabala et al., 2021a; Alcon et al., 2022). This illustrative CBA shows that, with the considerations applied in this case, both NBS and non-NBS alternatives have the potential to generate economic benefits. This is particularly noteworthy in the case of NBS, as the reduction in net margins resulting from the cessation of farming activities is offset by benefits generated from regulation and cultural

services, which represent significant economic contributions of NBS. Therefore, as suggested by other studies (Mitten and Brymer, 2022; Albaladejo-García et al., 2023), regulation and cultural services can contribute to the socio-economic development of the territory through recreation, environmental education and the generation of regulating activities with the natural environment. Comparing across both, the CBA exemplified NBS as more economically profitable than non-NBS in this case, even when adopting the most conservative estimates in the benefit transfer supporting the monetary impact assessment of ecosystem services.

Beyond increasing the still scarce body of evidence on the economic profitability of NBS, our study mainly provides opportunity for reflecting on the value of the co-constructed (yet rapid) approach. To start with, the co-construction process facilitated a more substantial transfer and advancement of knowledge between academics and the policy-makers in charge of addressing this particular environmental emergency. In the absence of this tight collaboration, it would be considerably more challenging to achieve the level of detail of the economic analysis in such short period of time (in terms of accessing data, identifying relevant indicators and establishing meaningful criteria). The process itself proved to be an effective tool for informing the economic viability of NBS and providing scientific knowledge that is readily interpretable by policy-makers.

The co-construction process also enabled a participatory strategy with a range of other stakeholders, including local farmers and national, regional and local authorities and technicians, and representatives of civil society organisations. This not only enriched and facilitated the economic analysis itself (through the input provided by these stakeholders), but also led to heighten stakeholder awareness of the value of NBS (Bayulken et al., 2021; Viti et al., 2022) and, importantly, resulted in much reduced opposition to the government's plan. As explained, the final project design included proposals made by the farmers, providing an optimal solution in terms of meeting the environmental aims pursued by the policy-makers and social acceptance. This is not a minor issue, as we see increased societal polarisation resulting from the politization of environmental issues (Chinn et al., 2020). As ever more across Europe and elsewhere (Scheidel et al., 2020), the Mar Menor has been subject to significant societal conflicts of an environmental origin, with the intertwined effects of conflicts across administrations at various levels of different political signs (Cabello and Brugnach, 2023). These represent major challenges for any intervention. The careful participatory approach undertaken here is testimony that co-construction can have positive effects on decision-making processes in environmental management (Chambers et al., 2021; Soini et al., 2023), complementing previous participatory research on the Mar Menor that has generated

substantial knowledge about stakeholder perceptions and governance challenges (Guaita-García et al., 2021; Guaita-García et al., 2022; Perni and Martínez-Paz, 2013; Martínez-Paz et al., 2013; Rashidian et al., 2025). This approach not only provides useful input to the specific interventions in the site but, through collective awareness and shared understanding, it helps establishing a reference point for the economic viability of NBS in other areas of the lagoon (and beyond). Participatory approaches bring a different kind of “value”—institutional and social resilience—that complements traditional measures of economic efficiency. Participatory assessments of ecosystem services help internalize local knowledge, mitigate political conflicts, and ensure the sustainability of environmental measures over time (Albaladejo-García et al., 2025b), even if they do not always coincide with the highest monetized net benefit.

Our analysis is clearly not exempt of limitations. For example, the indicators utilised to illustrate ecosystem services were derived from GIS mapping, which involves a certain degree of imprecision (Albaladejo-García et al., 2023). With respect to the monetary valuation of ecosystem services, benefit transfers carry – inherently – transfer errors (Johnston et al., 2015). These limitations could be improved via fieldwork (e.g. measuring of ecosystem services delivery, primary valuation data collection), which is of course something that should be strived for, but that might not always be compatible with taking fast decisions. Our analytical choices can also be subject to debate. For example, it is possible that more sophisticated supplementary indicators could have been devised to facilitate comparison of results for the same ecosystem service; or some of the assumptions we made in the transfer of values from the study to the policy site may be questioned. The point is that these choices were shared and discussed with a range of stakeholders, leading to more transparent, policy useful and locally accepted outcomes, while still being sufficiently robust (the example of using conservative estimates of benefit transfer illustrate this: even with lower-bound benefit estimates, NBS came out as profitable). The availability of the economic analysis (Alcon et al., 2024) and the implementation design - including the various interim proposals by the government and the farmers with the input from stakeholders, MITECO (2024) -, allows for those analytical choices to be scrutinised (and eventually revised if deemed appropriate or as more information becomes available), from a stance of collective understanding and collaboration. In this sense, the proposed framework should be viewed as a flexible decision-support tool rather than a fixed methodology, capable of being recalibrated to reflect the ecological and socio-economic realities of other regions.

4.2. Reflections on methodological learning and transferability

It is important to clarify how the approach developed here relates to previous frameworks, particularly the bottom-up environmental cost-benefit analysis proposed by Carolus et al. (2018). Our work does not intend to introduce a new valuation paradigm, but rather to operationalize established ecosystem-service mapping and benefit-transfer techniques within a co-constructed and time-sensitive decision context. Like the bottom-up approach, local knowledge and stakeholder preferences contributed to frame the alternatives and the criteria considered in the economic assessment. However, the present study differs in that the co-construction focused less on building the valuation functions themselves and more on the joint definition, refinement and evaluation of policy alternatives under conditions of high urgency and institutional pressure. While Carolus et al. (2018) place stakeholders at the centre of generating economic values, our approach places them at the centre of designing and validating the assessment process that informs rapid policy action. In this sense, the contribution of the study lies not in methodological novelty per se but in demonstrating how participatory governance and established cost-benefit analysis tools can be productively coupled to support implementation-ready decisions in environmentally and socially contested territories.

Beyond the specific insights gained from the Mar Menor – which are

subject to the assumptions made and the uncertainties explained, our experience offers broader methodological lessons for researchers and practitioners aiming to apply similar co-constructed economic assessments elsewhere. The process demonstrates that rapid economic assessments are possible, but rely significantly on the availability of existing data and institutional capacity. Therefore, before attempting to replicate the approach, practitioners should assess the availability of spatial datasets, previous valuation studies, and relevant stakeholder networks that can be activated early in the process.

The quality and representativeness of stakeholder engagement are crucial for both legitimacy and analytical robustness. In our experience, a minimum of three rounds of interaction — problem framing, validation of indicators, and interpretation of results — proved essential to maintain both participation and analytical consistency. These meetings need not be large in number but should ensure diversity in representation (policy-makers, local producers, technical experts, and civil society) and foster trust-building (Reed et al., 2018).

Our process highlights that ensuring the interpretability and acceptance of indicators and valuation variables by stakeholders is the key. What matters most is not methodological uniformity or sophistication (Martin-Ortega et al., 2015), but shared understanding of the assumptions made, so that consensus can be built and decision-making can be advanced. Transparency is also important, so that choices can be revisited if, for example, better estimates become available. Researchers and policy-makers should therefore prioritize processes that facilitate co-learning and trust-building rather than seeking a rigid set of pre-defined indicators. The combination of participatory validation and benefit transfer makes this framework particularly suitable for urgent decision contexts, such as environmental crises, where time and resources are limited. By maintaining scientific rigor while simplifying data demands, this approach serves a doubly beneficial purpose: on the one hand, it serves as a replicable template for integrating ecosystem services and cost-benefit reasoning into environmental governance. On the other hand, it allows cost-benefit analysis, which is a relatively easy tool to understand by non-specialists, to serve as a boundary object for consensus building. When confronted with the government plans, farmers in our process became more amenable to discussion because they could get behind the cost-benefit rationale. Using CBA in this manner, i.e. by making it a ‘hands-on’ object of participation and collective discussion, can enhance experiential learning, which has been shown to increase awareness over environmental issues and improved land management practices amongst framing communities (Okumah et al., 2021).

Readers should interpret our results as demonstrating the feasibility of a rapid, co-constructed application of established methods under favourable conditions rather than as evidence that the same timeline or the same level of detail is achievable in data-poor or institutionally weak settings. Where those enabling conditions are absent, we recommend investing additional time in primary and expert data collection, in-depth modelling, or phased implementation linked to monitoring plans.

An additional methodological consideration arises from the ecological characteristics of the study system. The Mar Menor is likely to contain inherited nutrient reserves and internal loading processes (release of sediment-bound nitrogen, groundwater flows, seasonal episodes of anoxia) that may delay or attenuate ecological responses to reductions in external loading (García-Ayllón, 2017). Therefore, even a 10 % decrease in external nitrate loading may not immediately translate into ecological recovery; monitoring and (ideally) combined hydrodynamic and biogeochemical models are required to predict timelines and potential ecological outcomes. In this sense, even modest reductions across the lagoon are valuable when combined with broader measures in the watershed. Localized benefits should be considered complementary to broader watershed programs (e.g., measures in other sub-watersheds, changes in fertilization practices, groundwater interventions) and not as stand-alone solutions. This highlights that when applying similar co-constructed economic assessments elsewhere, researchers need to

account for system-specific ecological dynamics, which may affect both the timing and the magnitude of observable socio-environmental outcomes.

5. Conclusions

Despite the great interest in NBS and the centrality of the economic argument in their advocacy (i.e. being promoted as cost-effective approaches), surprisingly little attention has been paid so far to generating evidence of comprehensive cost-benefit analysis applications supporting *actual* and *specific* environmental decisions. In the absence of such evidence, wide spreading NBS might result in unfavourable decisions or disappointment and abandonment. Such lack of attention is in part understandable, considering the time and resource constraints under which many decisions need to be taken face to the climate and nature emergencies.

Through the illustration of a comparative cost-benefit analysis of NBS and non-NBS for the mitigation of agricultural impacts in the ecologically stressed Mar Menor lagoon in Spain, this paper builds the evidence base of the economic efficiency that NBS can have in given territories and contexts. Regardless of this specific result for this particular case, more importantly, though, the process presented here illustrates how by maintaining scientific rigor while simplifying data demands, rapid co-constructed economic impact assessments can not only integrate ecosystem services and economic efficiency reasoning into environmental governance, but also can serve as boundary objects for consensus building, awareness raising and collective experiential learning in the context of urgent and complex policy decisions. Such socially supported processes are of particularly critical importance face to the growing polarisation over environmental challenges that we are currently witnessing.

Our illustration is not *universally* rapid, but relying on three complementary preconditions: existing spatial datasets and simulation outputs, previously published economic valuations and local studies suitable for benefit transfer, and strong institutional commitment and stakeholder networks. This signals the importance of investing in local capacity building and data generation and fostering a culture of trust amongst stakeholders in support of NBS implementation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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