PBI-Support – Potential Blue Interventions Support tool

What are the potential interventions that could be applied?

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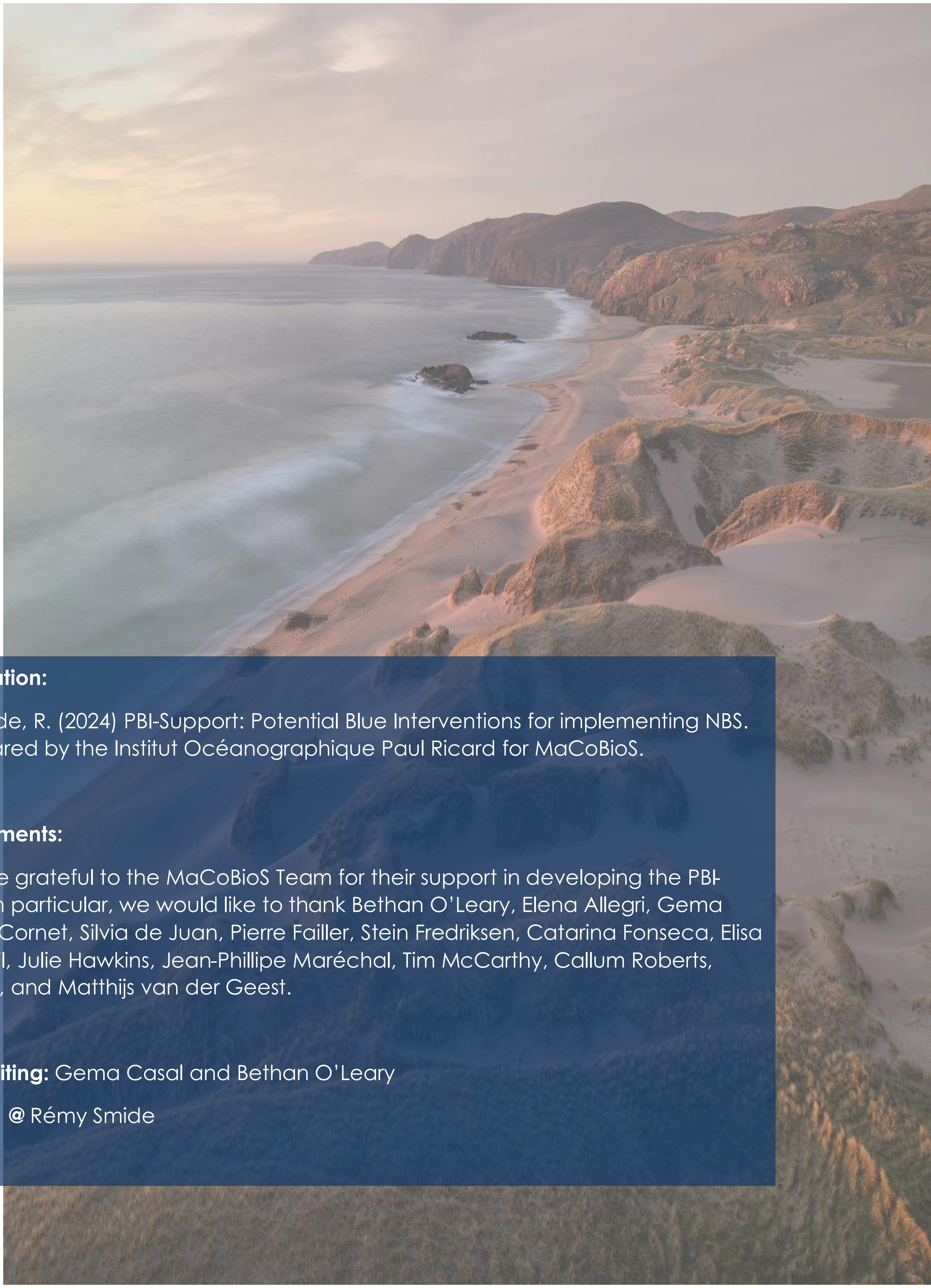
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869710



Suggested citation:

Pérez, G., Simide, R. (2024) PBI-Support: Potential Blue Interventions for implementing NBS. A report prepared by the Institut Océanographique Paul Ricard for MaCoBioS.

Acknowledgements:

The authors are grateful to the MaCoBioS Team for their support in developing the PBI-Support tool. In particular, we would like to thank Bethan O'Leary, Elena Allegri, Gema Casal, Condy Cornet, Silvia de Juan, Pierre Failler, Stein Fredriksen, Catarina Fonseca, Elisa Furlan, Artur Gil, Julie Hawkins, Jean-Phillipe Maréchal, Tim McCarthy, Callum Roberts, Ewan Trégarot, and Matthijs van der Geest.

Design and editing: Gema Casal and Bethan O'Leary

Cover picture: @ Rémy Smide

PBI-SUPPORT

PBI-Support is a decision-support tool that can help practitioners and decision-makers through the first step of planning management measures according to their specific needs and the ecosystem(s) present in their area.

PBI-Support was developed by researchers at the Institut Océanographique Paul Ricard through the EU funded MaCoBioS project (www.macobios.eu)

KEY INFORMATION

- PBI-Support provides an evidence-based methodological approach for identifying potential marine and coastal Nature-based Solutions (blue NBS) that could help address desired societal challenge(s) and be appropriate for an area. The structure of PBI-Support allows different stakeholder groups to better understand why potential intervention option(s) are given and facilitates conversations with stakeholders to identify shared objectives and actions.
- Blue NBS interventions considered by PBI-Support include marine protection (i.e., fully, highly, lightly, and minimally protected areas), restorative activities (i.e., active, passive, and partial restoration, rehabilitation of ecological function and ecosystem creation), and other management measures (i.e., implementation and enforcement of regulations).
- PBI-Support should be used during the initial stages of planning a blue NBS to inform intervention selection.
- PBI-Support uses a hierarchical tree structure which consists of four steps: Challenge orientation, Ecosystem services, Environmental context, and Intervention options. This structure guides the user to answer different questions concerning objectives, ecosystems, and spatial scale level at which an intervention could be implemented to provide a portfolio of potential intervention(s) to implement.
- PBI-Support can be used as a standalone tool, as described here, or as part of a multi-tiered approach to assess suitability for Nature-based Solutions (MAS-NBS).
- To use PBI-Support you will need:
    1. Knowledge of the issue(s) or societal challenge(s) management aims to address. This will strongly depend on understanding both policy and local community concerns and should therefore be informed by stakeholder engagement;
    2. A clear idea of the spatial scale level at which management interventions will be, or could be, possible to implement;
    3. Knowledge of ecosystems present (or potentially present) in the targeted management area and their ecological condition; and
    4. Understanding of the vulnerability of the ecosystem(s) present in the targeted management area to natural and human stressors.

METHODOLOGICAL FRAMEWORK

PBI-Support is a decision-support tool that uses an evidence-based approach to integrate relationships among societal challenges, ecosystem services, ecological integrity, and ecosystem-based management approaches (protection, restorative activities, and other management measures) to identify appropriate blue NBS. PBI-Support takes the following step-by-step approach:

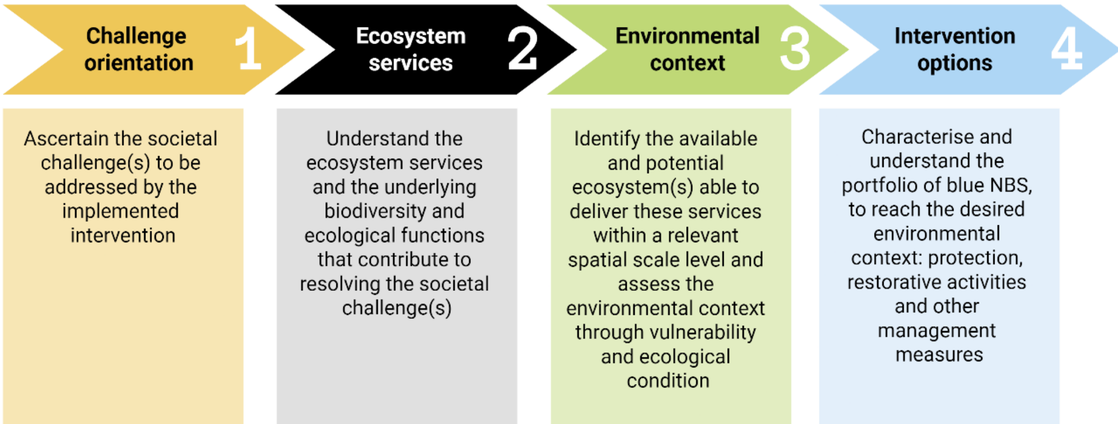


Figure from Pérez et al.,2024

The context-specific nature of blue NBS means that local knowledge and social-economic, as well as environmental, conditions are important for their design, operation, and effectiveness (Pascual et al., 2023). PBI-Support facilitates the identification of potential blue NBS by orienting intervention-selection around specific societal challenges and contextual environments.

Application of PBI-Support requires integration of stakeholders to inform understanding of both policy and local community concerns, ecological knowledge, and social pressures, to help create socially acceptable interventions.

Full details of the conceptual framework that underpins PBI-Support are provided in Pérez et al. (2024).

"PBI-support is based on the theory that the same intervention may be more or less appropriate depending on the state of the ecosystem it is implemented in and surrounding human activities and impacts"

Step 1 Challenge orientation

The first step in determining if a blue NBS is potentially appropriate involves identifying the societal challenge(s) a community wishes to tackle. A societal challenge denotes a major human objective that, if reached, would improve human living conditions. PBI-Support is designed to address societal challenges considered relevant in marine and coastal contexts based on those internationally defined (IUCN 2020; European Commission 2021; UNEA 2022). PBI-Support addresses three categories of societal challenges: climate change mitigation, climate change adaptation, and those required for an intervention to be defined as a blue NBS.

Climate change mitigation corresponds to the contribution ecosystems can make to slowing down climate change through natural processes like carbon sequestration. Multiple aspects contribute to the ability of people to adapt to the effects of climate change. **Climate change adaptation** therefore consists of four societal challenges. Disaster risk reduction relies on the ability of ecosystems to reduce risk from natural hazards (e.g., wave attenuation). Water security aims to sustainably provide water for all over time (e.g., filtration of wastewater, prevention against eutrophication). Food security seeks to ensure safe, accessible, and locally appropriate food for all consistently over time and across space (e.g., support for fisheries). Economic and social development aspires to enhance living standards (e.g., ecotourism activity development).

PBI-Support sets **required societal challenges** for blue NBS as avoid environmental degradation and biodiversity loss and enhance or maintain human health. This is because international NBS definitions require their design to support biodiversity and MaCoBioS considers improved human health and wellbeing an outcome of co-addressing biodiversity loss and other societal challenge(s).

To establish what societal challenge needs addressing, diverse stakeholder engagement is critical to understand Local Community concerns and priorities and embed people in the decision-making process. Once the challenge has been identified, PBI-Support helps inform whether a blue NBS is appropriate to deliver on desired objectives.

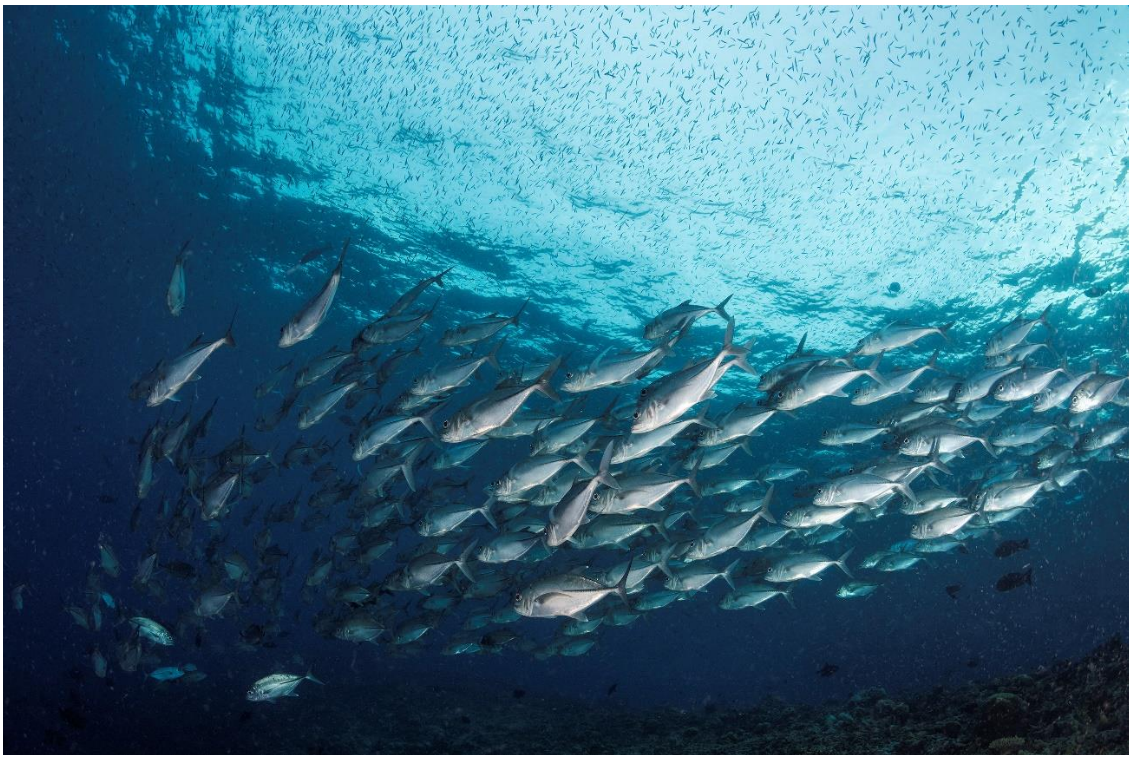
"a blue NBS must be designed to avoid environmental degradation and biodiversity loss while enhancing or maintaining human health"

Step 2 Ecosystem services

Blue NBS can help address societal challenges by improving the ecological condition of marine and coastal ecosystems, thereby supporting their ability to deliver ecosystem services, which represent how people use, benefit from, and value Nature. Different ecosystem services will contribute to addressing different societal challenges. PBI-Support highlights which ecosystem services are relevant to the societal challenge(s) chosen by stakeholders to help inform whether a blue NBS is appropriate in the local context.

PBI-Support incorporates the ecosystems services classification developed by the System of Environmental-Economic Accounting (United Nations, 2021; Edens et al., 2022). It selects from the following ecosystem services: **carbon sequestration and storage** (climate change mitigation); **coastal protection** (erosion and flood control through wave attenuation; disaster risk reduction); **mediation of human waste or toxic substances** (water quality); **provision of food and nursery population and habitat maintenance** (food security); and **all cultural services** (economic and social development).

Ecosystems exhibit specific functions and processes linked to their biodiversity, leading to distinct ecosystem services. Consequently, not all ecosystems can provide the necessary services to address all societal challenges. Therefore, after identifying the required ecosystem services for chosen societal challenge(s), an assessment of the environmental context is essential to determine if a blue NBS offers a viable option.



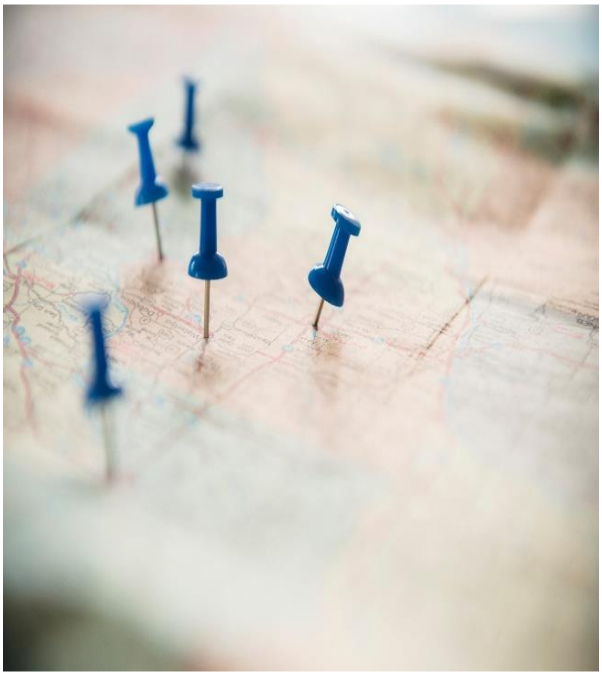
Step 3 Environmental context

For any intervention to operate successfully it needs to be set within the specific ecological and governance context. The suitability of interventions varies depending on factors such as the spatial scale of management, ecosystem condition, nearby human activities, and their impacts, as well as local societal acceptability and feasibility.

To facilitate an assessment of the environmental context related to the chosen societal challenge and related ecosystem services PBI-Support guides the user through four questions:

1. What could be the potential "spatial scale" of the measure you want to design?

To understand the type of intervention that may be appropriate, the user must define the spatial scale of management as this sets the social-ecological system boundaries for any intervention. PBI-Support defines three levels of spatial scale that encompass the dual ecological and governance component: micro, meso, and macro.



Micro: Ecologically, this corresponds to a land- and/or seascape level. In governance, this denotes a community, where residents in a particular area are considered as a cohesive unit under governing structures.

Meso: Ecologically, this corresponds to an area with common ecological drivers, including abiotic (e.g., type of substrate, wave energy) and biotic (e.g., key species density or diversity), as well as human perturbations and natural hazards, that present distinctive geographic characteristics and influence resource availability. In governance, this denotes an area within the same country encompassing multiple communities.

Macro: Ecologically, this corresponds to an ecoregion defined as an area of relatively homogeneous species composition, distinct from adjacent systems, likely influenced by a few ecosystems and/or distinct oceanographic or topographic features. In governance, this encompasses multiple countries and thus requires a collaborative approach across geo-political boundaries.

2. Which ecosystem(s) is(are) or could be available at your spatial scale?

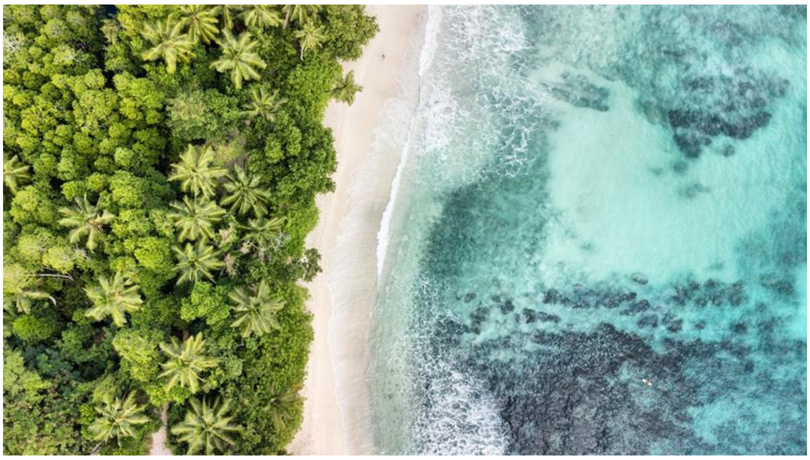
To consider whether a blue NBS is an option to address the chosen societal challenge, it is important to identify whether ecosystems are present in the set spatial scale of management that can deliver the required ecosystem services.

Local environmental conditions (i.e., social, economic, and ecological factors) drive the presence or absence of different habitats and associated biodiversity. The options for blue NBS depend on which ecosystem(s) is(are) present in the management area, or whether an ecosystem was once present, and the environmental conditions still exist for it to return and persist.

A variety of sources should be used to identify current and historic presence of ecosystems in the management area including stakeholder engagement and local ecological knowledge, public databases, and biodiversity monitoring.

3. What is the "ecological condition" of the present ecosystem(s)?

An ecosystem in good ecological condition will be more resilient to local pressures, climate change, and their cumulative effects, likely delivering more services of better quality than one in poor condition (United Nations, 2021). Ecological condition is defined as "the quality of an ecosystem measured in terms of its abiotic and biotic characteristics" (United Nations, 2021). Abiotic characteristics are the physical and chemical aspects of an ecosystem, while biotic characteristics encompass its composition (e.g., abundance of key species), structure (e.g., total biomass), and function (e.g., primary productivity).



Determining an ecosystem's ecological condition requires the use of a suite of relevant ecological indicators based on the following criteria (Dale and Beyeler, 2001): i) be easily measured, ii) be sensitive to stresses on the system, iii) respond predictably to stress, iv) be anticipatory, v) predict changes that can be managed, vi) be integrative, vii) have known responses to disturbances, anthropogenic stresses, and changes over time, vii) have low response variability. Measuring indicators enables the detection of ecosystem changes, whether negative, positive, or neutral, in structure and functioning. Comparing values with those describing a pre-existing or reference condition allows statistical deviation to inform on an ecosystem's condition and trajectory.

4. What is the "vulnerability" of the present ecosystem(s)?

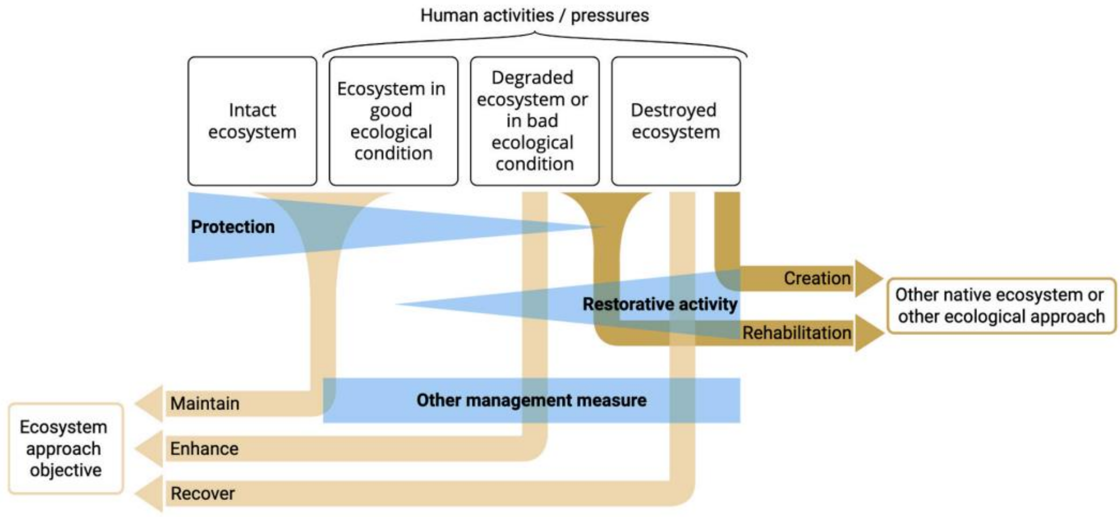
Ecosystem vulnerability depends on its exposure to stresses, sensitivity, and adaptive capacity (IPCC, 2014). Exposure corresponds to the nature and degree of external pressures that the system is likely to experience, which can be natural (e.g., storm surges), climate change driven (e.g., sea level rise), or directly human induced (e.g., management measures). Sensitivity assesses the system's susceptibility to these pressures (e.g., damage from increased coastal flooding due to sea level rise). Adaptive capacity refers to the system's ability to cope with environmental hazards or policy changes with minimal disruption.

Ecosystem vulnerability is specific to each ecosystem at a particular scale and relies on understanding the ecosystem's response to likely hazards (e.g., storm surges, hurricanes, human pollution, fishing pressure). When the system's adaptive capacity cannot compensate for its level of exposure and sensitivity, ecosystem vulnerability is high, and vice-versa. High vulnerability suggests that in the presence of stressors, the ecological condition of the ecosystem is likely to be impacted. Conversely, low vulnerability suggests better ecological condition, likely greater resilience and, therefore, an ecosystem more likely to be able to provide services to address the societal challenge. Assessing ecosystem vulnerability provides crucial information for selecting interventions to minimise impacts on ecosystem condition.

"Ecosystem vulnerability is specific to each ecosystem at a particular scale"

Step 4 Intervention options

To inform the choice of intervention approach, PBI-Support considers responses to Steps 1 to 3 together to provide a blue NBS portfolio of protection, restorative activities, and/or other management measures that could be used to support the desired objectives.



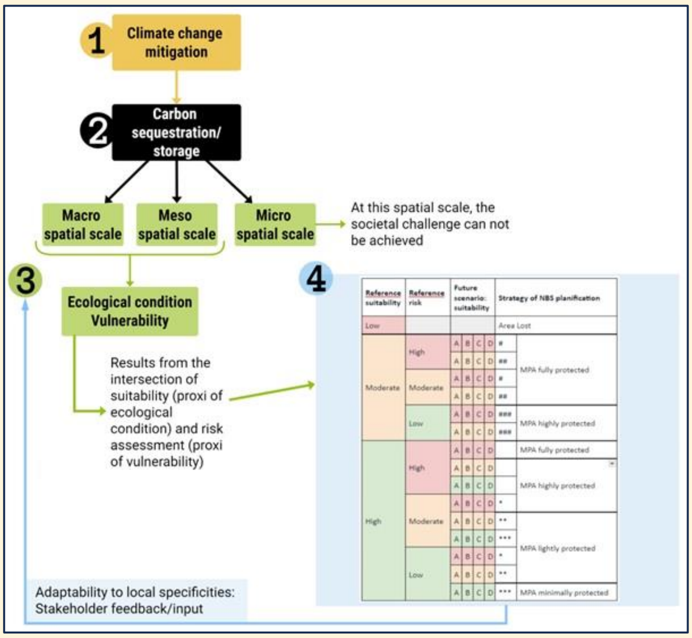
Summary of conservation objectives based on ecological condition of an ecosystem and available blue NBS intervention options (protection, restorative activities, and management) to achieve them. Figure from Pérez et al., 2024.

Real-world blue NBS implementation requires appropriate policy drivers to be in place, proactive stakeholder engagement and collaboration, and adequate time and resources. The outputs of PBI-Support can help inform a blue NBS planification strategy, but stakeholder engagement is crucial to consider the feasibility and desirability of prioritised interventions to support more localised application. Further iterations of PBI-Support can incorporate additional local knowledge and community goals, informing intervention choices based on objectives, stakeholder engagement outcomes, human pressures, trade-offs, expertise availability, capacity, and resources. As a result, blue NBS interventions cannot be implemented without the participation and support of local stakeholders.

Case study: NBS planification strategy for *Posidonia oceanica* in the Mediterranean Sea

Here, we demonstrate application of PBI-Support to develop a regional blue NBS planification strategy for *P. oceanica* in the Mediterranean Sea. For this showcase, climate change mitigation is selected as the focal societal challenge, but in practice involving a range of stakeholders is essential at this stage (**Step 1**). This allows ecosystem services provided by *P. oceanica* relevant to climate change mitigation to be identified - carbon storage and, to a lesser extent, carbon sequestration (**Step 2**). Addressing climate change mitigation requires blue NBS interventions at a meso (involving multiple communities within the same country) or macro (across multiple countries) scale to make significant contributions to mitigation efforts. For this showcase, a macro scale is taken.

The next stage consists of an initial assessment of the ecological condition of *P. oceanica* beds in the Mediterranean Sea and their vulnerability to cumulative pressures, including their likelihood of persisting under future environmental conditions (**Step 3**). Potential management strategies to avoid future loss of long-term carbon storage can then be developed (**Step 4**).



Example of PBI-Support´s blue NBS planification strategy.

Potential management strategies PBI-Support may offer the user include protection measures, restorative activities, or other sustainable management measures. PBI-Support may also identify areas where blue NBS are less likely to deliver desired outcomes. For example, PBI-Support considers *P. oceanica* beds in areas with low baseline environmental suitability, particularly to climate change, as being likely to have high vulnerability to pressures and, therefore, unsuitable for blue NBS implementation for climate change mitigation.

To develop a realistic strategy for blue NBS aiming to enhance the role of *P. oceanica* in climate change mitigation, focus should be on areas where effective ecosystem maintenance or improvement is achievable. For example, PBI-Support considers blue NBS an appropriate intervention strategy for *P. oceanica* beds in areas with high or moderate environmental suitability. In particular, PBI-Support highlights that protection measures (e.g., through marine protected areas) offer the best chance to maintain *P. oceanica* beds in acceptable or good ecological condition, prevent potential habitat loss, and sustain their function as carbon sinks. Supporting management measures to alleviate local pressures may also be required.

CONCLUSIONS

PBI-support provides a versatile portfolio of potential interventions that cater to the specific needs of each ecosystem rather than imposing a rigid, one-size-fits-all model to blue NBS design. This tool serves as a valuable resource for decision-makers by facilitating alignment between existing knowledge, desired outcomes, and feasible actions. By helping engage and inform discussions with stakeholders, PBI-Support could help enhance the effectiveness of interventions ultimately progressed through greater transparency and engagement in decision-making.

PBI-Support can help inform the selection of a potential blue NBS intervention by bringing together a variety of factors that need to be considered together during design. However, implementation of any action needs to be considered alongside available resources and capacity. It also needs to be implemented holistically to balance management objectives across environmental and societal needs. While PBI-Support can provide a decision-support system to help with blue NBS design, ultimately stakeholder engagement will be critical to meaningfully advance blue NBS.

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The Institut Océanographique Paul Ricard was founded in 1966 as a non-profit organisation located in Les Embiez Island (Var, France). The mission of this institute is to share knowledge with the general public, policymakers and the research community. The Institut Océanographique Paul Ricard is a founding member of the Ocean Climate platform which worked at the COP21 to ensure that oceans were placed front and centre of international negotiations on climate change. Patricia Ricard is the platform's spokesperson and vice-president, and Chair of the Paul Ricard Oceanographic Institute. Just as Paul Ricard was committed to serving the public interest, today's research programs are all targeted at the major challenges of the decades to come: management of resources, biodiversity conservation and the fight against climate change.

Marine Coastal Ecosystems Biodiversity and Services in a Changing World (MaCoBioS) was a four-year research project running between 2020 and 2024 funded by the European Union's Horizon 2020 research and innovation programme. Its objective was to inform efficient and integrated management and conservation strategies for European marine and coastal ecosystems to face climate change by: (a) advancing the scientific evidence base on ecosystem functioning, and (b) developing tools to assess vulnerability and advancing understanding of potential management options.