D9.2 Case Study 2 Report

The Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco

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List of abbreviations

AF	Assessment Framework
AoI	Area of Influence
CS	Case Study
EBM	Ecosystem-Based Management
ES	Ecosystem Services
GBI	Green and Blue Infrastructure
IBRM	Intercontinental Biosphere Reserve of the Mediterranean
PU	Planning Unit
SCP	Systematic Conservation Planning
SDM	Species Distribution Models
SES	Socio-Ecological System

About AQUACROSS

The project 'Knowledge, Assessment, and Management for AQUAtic Biodiversity and Ecosystem Services aCROSS EU policies' (AQUACROSS) aims to support EU efforts to protect aquatic biodiversity and ensure the provision of aquatic ecosystem services. Funded by Europe's Horizon 2020 research programme, AQUACROSS seeks to advance knowledge and application of ecosystem-based management (EBM) for aquatic ecosystems to support the timely achievement of the EU 2020 Biodiversity Strategy targets.

Aquatic ecosystems are rich in biodiversity and home to a diverse array of species and habitats, providing numerous economic and societal benefits to Europe. Many of these valuable ecosystems are at risk of being irreversibly damaged by human activities and pressures, including pollution, contamination, invasive species, overfishing and climate change. These pressures threaten the sustainability of these ecosystems, their provision of ecosystem services and ultimately human well-being.

AQUACROSS responds to pressing societal and economic needs, tackling policy challenges from an integrated perspective and adding value to the use of available knowledge. Through advancing science and knowledge; connecting science, policy and business; and supporting the achievement of EU and international biodiversity targets, AQUACROSS aims to improve ecosystem-based management of aquatic ecosystems across Europe.

The project consortium is made up of sixteen partners from across Europe and led by Ecologic Institute in Berlin, Germany.

1 Introduction and background

AQUACROSS seeks to advance the application of Ecosystem-Based Management (EBM) for aquatic ecosystems to support the achievement of the EU 2020 Biodiversity Strategy and other international conservation targets.

The AQUACROSS Case Studies (CSs) aim to demonstrate how the EU 2020 Biodiversity Strategy will be implemented according to the proposed Assessment Framework (AF; Gómez et al. 2016. The CSs will also help to identify key challenges related to aquatic biodiversity and ecosystem management as well as to learn lessons and up-scale the results.

Among the eight CSs, six are located in the territory of the European Union (EU), one in Switzerland and another is located in a transboundary and transcontinental area in between Europe and Africa through the Strait of Gibraltar (CS2). Specifically, CS2 has been carried out at the Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco (IBRM). This CS has been designated as a showcase to implement the EU Biodiversity Strategy in areas that are located in different countries with very similar natural and biophysical conditions, but different socio-economic contexts and policy frameworks.

In the EBM context of the AQUACROSS, the CS2 provides direct recommendations for the establishment of Green and Blue Infrastructures (GBI) as well as examples of best practices for the management and planning of transboundary water ecosystems.

1.1 Problem statement

The Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) Morocco (IBRM) contains several remarkable protected sites, high biodiversity richness and an important cultural heritage. However, pressures from human activities in the area are threatening these noticeable natural and cultural values. The IBRM presents a high potential for a sustainable economic development that can benefit both conservation of the natural and cultural heritage as well as the human population inhabiting the Reserve. However, for the sustainability of human activities in the IBRM, it is required to appropriately manage and zone the different conservation and exploitation goals, as well as to identify key degraded areas to be restored.

Green and Blue Infrastructure (GBl) is a strategically planned network of natural and semi-natural landscape "green" and "blue" elements with other environmental features designed and managed to deliver a wide range of ecosystem services (European Commision, 2013a). GBl are landscape ecological approaches that consider connectivity as well as the multiple functions that natural environments can provide to human well-being, while at the same time, they respond to local population demands, by allowing public participation during their design. The GBl concept is about maintaining, strengthening and restoring ecosystems and the services they provide (Karhu, 2011). All this makes GBl a useful tool for an integrative spatial planning at the IBRM that addresses the conservation and societal goals existing in the Reserve (see below).

1.2 Brief description of the Case study context

1.2.1 Background

The IBRM was declared in 2006 in a joint initiative of Spain and Morocco with the support of the Man and Biosphere Programme of UNESCO (UNESCO-MaB). Both, the UNESCO-MaB Strategies and the INTERREG III – A (2000-2006), served as the framework to support the development of the IBRM addressing two major challenges: (1) reinforce the transboundary cooperation for the knowledge and management of ecological and cultural processes and, (2) the implementation of an Ecosystem-Based Management (EBM) approach for the conservation of its natural and cultural heritage, favouring a sustainable use of the natural resources.

GBl is part of the EU Biodiversity Strategy (aiming to halt the loss of biodiversity and Ecosystem Services (ES) in the EU by 2020). Specifically target 2 of this Strategy addresses the preservation and restoration of ecosystems and ES by including green infrastructure in spatial planning. The Strategy also gives special attention to implementing an effective management of Natura 2000 sites. Natura 2000 and other protected sites are priority areas to be included in the GBl. However, areas outside these protected sites should also be taken into consideration in its design. In this sense, multifunctional zones where land/sea uses allow maintaining and restoring ecosystems, as well as natural and artificial landscape features acting as corridors for wildlife species, and areas where measures to improve the ecological quality and permeability of the landscape are implemented, should also take part in the GBl (Karhu, 2011).

According to the European Commission, GBI should be integrated in most EU policies, particularly regarding fisheries, transport, energy, and culture (European Commission, 2013a). In Europe, GBl is increasingly recognised as a valuable approach for spatial planning, and has been already applied at different geographic levels (regional, urban, river basin/catchment/watershed, local) in regional and local planning in Europe (e.g., Belgium, Netherlands). Although the number of GBl projects that have been conducted or are being carrying out is still relatively low worldwide, this landscape approach has been applied not only in Europe but also in India, the United States and Japan. Moreover, it seems to be a promising approach, thus the number of GBl projects are expected to increase in the next years (Ghofrani et al. 2017). GBl aims to maintain and restore ecosystems by using ecosystem-based management (EBM) approaches, in contrast to the traditional technical solutions (Karhu, 2011).

1.2.2 Spatial description

The CS2 area encompassed the IBRM in Andalusia (Spain) – Morocco and its area of influence (AoI). The Reserve spans over two continents, Europe and Africa, and the marine area of the Strait of Gibraltar, covering one million hectares that includes river basins, coastal, and marine areas (UNESCO-MAB 2011). The northern section of the IBRM is located in the southern Spanish provinces of Cádiz and Málaga (Autonomous Community of Andalusia). The southern section of the IBRM covers four provinces in north Morocco, namely Tanger, Tetouan, Larache, and Chefchaouen (Planning units and CS area boundaries for the analysis of aquatic ecosystems in the International Biosphere Reserve of the Mediterranean and its Area of Influence in Annex I: Data).

The area of influence coincides with the boundaries of the river basins that overlap the IBRM (Figure 1). According to the stakeholders, this is a key area in terms of supporting the

achievement of EBM objectives, due to the development of activities that impose important pressures on the IBRM (see section 2 in the present document).

The IBRM is characterised by a heterogeneous landscape mosaic with great natural value, highlighting the variety of habitats present in the whole area (List of habitat types, Annex I: Data). The CS2 area comprises various Eastern Mediterranean ecosystem types, which provide a diverse range of Ecosystem Services (ES) and high species richness, with a large number of endemic species (Consejería de Medio Ambiente y Ordenacíon del Territorio de la Junta de Andalucía, 2006). Both sections of the study area have similar natural values, but a different socio-economic context and different environmental policy frameworks. The economic activities in both the northern and southern sections of the case study area are based on agriculture, livestock, fisheries, and tourism, all of which are highly dependent on terrestrial and aquatic resources. The aquatic ecosystems in the CS2 area provide a vital range of goods and services for sustaining human well-being (water and biomass provision, regulation and maintenance ES, traditional cultural uses, among others). In addition, this area is in high demand for recreational and tourism activities.

Even though both sections share similar characteristics, human activities have shaped the landscape differently. For instance, almost 70% of the northern section of the IBRM is protected, while in the southern section only 30% of the Reserve is protected (Molina, Vázquez and Villa, Díaz 2008). Nevertheless, both sections share international conventions, namely the Man and Biosphere Programme (MaB) of UNESCO, the International Convention for the Prevention of Pollution from Ships (MARPOL; International Maritime Organization, n.d.), the Ramsar Convention (Ramsar 1971), the Barcelona Convention, the Convention on Biological Diversity, the Bern Convention (Bern Convention 1982) and the IUCN North Africa Programme 2017- 2020. The northern and southern sections of the IBRM share common policies, for example biodiversity strategies, coastal management plans, protected areas and river management plans (for a detailed description, see section 2.1 in the present document, which Identifying policy objectives). This provides the potential to consider and, subsequently, benefit from synergies among those policies. However, we must keep in mind that the common policies are not always applied in conformity in both sections of the IBRM. For more information see study area section in Annex III: Assessment methods and tools.

1.2.3 Identification of threats for aquatic biodiversity

The main threats identified and focused in the case study area are the total habitat loss and habitat change in the structure/morphology (fragmentation), disturbance of species due to changes in land/sea use and intensification of human activities. They affect overall biodiversity and the capacity of the three realms (freshwater, coastal and marine) to deliver ecosystem services (ES) in the CS2. The results from our analysis of drivers of change and pressures on aquatic ecosystems (Pletterbauer et al. 2017), showed that urban development, fishing, shipping and shore tourism/recreational activities are the activities and pressures acting as the main drivers of change in habitat structure and morphology in freshwater (riparian areas, rivers and lakes), as well as in coastal areas, and causing species disturbance in the marine habitats of the case study area.

Figure 1. Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco (IBRM) and its area of influence (AoI). The areas coloured in yellow refer to the IBRM, while the area in red hues refers to the Moroccan AoI of the IBRM and the area in green colour refers to the Spanish AoI of the IBRM.

Most of the conservation problems caused by human development are more severe in the southern section of the CS2 area than in the northern section. This is due to the drier and rougher climate in the South, higher poverty rates, continuous population growth, greater dependence and unmonitored use of natural resources, and shortages in infrastructure, services and institutional capacities to address the sustainable management of natural resources.

1.2.4 Main challenges and opportunities

The rapid socio-economic growth and technological changes in the IBRM and its area of influence in recent time has increased the demand for freshwater services for tourism and irrigation, leading to excessive water abstraction and the overexploitation of water resources. The demand for freshwater, energy and food will likely increase in the next years, due to pressures from population growth, economic development, urbanisation and climate change (Pascual et al. 2012). However, the demand of natural resources differs considerably between both sides of the Reserve, as exemplified by the Gross Domestic Product (GDP)/ per capita in Morocco ($8600 in 2017 and $8300 in 2015), in contrast to GDP/per capita in Spain ($38200 in 2017 and $35800 in 2015; US Dollar; source: https://theodora.com/wfbcurrent).

Main obstacles faced in the CS2 are represented by the trans-boundary setting of the IBRM and by the three different aquatic realms (freshwater, coastal and marine) contained in the Reserve. Therefore, CS2 required a comprehensive management that addresses different EBM objectives, ready to cope with the specific ecological and societal challenges of the IBRM, consider cross-sectoral interaction between sectors and human activity and be inclusive, i.e. ensure that the community of stakeholders are involved in the entire process. The fact that this area has been nominated as a transboundary reserve of the UNESCO is a great opportunity to put in place the EBM objectives to sustain and enforce habitat and species protection and include public education and involvement.

1.2.5 Stakeholder mapping and assessment

In the context of the CS2, two groups of stakeholders can be distinguished based on their level of influence and interest on the project outcomes. On the one hand, key stakeholders are directly involved in the decisions of the case study, with high level of influence and interest on the project results. The key stakeholders of the CS2 are public institutions that are likely to affect or be affected by the actions proposed in the CS2 and that showed their willingness to participate in the process:

- Regional Ministry for Environment and Planning of the Government of Andalusia
  - Environmental Information Network of Andalusia (REDIAM)
  - Biosphere Reserve's Management Council and Stakeholders Network – Province Delegation of the Government of Andalusia in Cádiz
  - Environment and Water Agency of Andalusia
- Ministry of Energy, Mines, Water and Environment of Morocco
  - Regional Observatory for Environment and Sustainable Development (OREDD)
  - High Commission for Water, Forests and Desertification of Morocco

These key stakeholders have participated in the CS development and they have been interviewed at several stages of the project: identification of conflicts and pressures, ecosystem services and development of scenarios (see Annex II: Stakeholder process).

The secondary group of stakeholders played a different role. This group was identified to get feedback when necessary in specific areas of expertise. They represent different interests that are crucial to anticipate the impact of the possible actions considered at administrative, socio-economic and environmental levels. They have been involved in different consultations during the CS implementation and kept informed on the main results of the project. This group included public authorities of different administrations such as the city councils of Tarifa and Facinas in Spain and Tangier in Morocco, the provincial or regional levels in Andalusia, the Region of Tanger-Tetouan-Al Hoceima, and other national institutions with a specific role in managing and planning natural protected areas and biosphere reserves, it also includes the Permanent Delegations of the Kingdom of Morocco and the Kingdom of Spain to UNESCO. The group also represents different socio-economic sectors such as agriculture, fisheries, tourism, infrastructure, economic development and maritime affairs, as well as researchers, managers of relevant business sectors and NGO's. This group of stakeholders were involved in the identification of the ecosystem services and definition of the management zones for the prioritisation of the GBI.

We engaged stakeholders at different stages through the CS2 development process, using their expertise to identify the key pressures in the area and the most relevant conservation conflicts, definition of the GBI zones and targets. Stakeholders have also been an invaluable source of data and information for the achievement of the CS2 goals (or more information see Annex II: Stakeholder process).

A detailed description of the stakeholder process can be found in the Annex II at the end of this document.

1.3 Solutions proposed

The activities and their pressures on the environment mentioned above have led to the degradation of many of the aquatic ecosystems in the CS2 area. By means of a reduction of pressures, restoration processes and by enhancing the sustainable use of the resources together with a comprehensive spatial management of the region, we can achieve a recovery in these degraded ecosystems to their original biodiversity levels and the services that they initially provided.

The first step for a restoration process in the CS2 was to identify and prioritise geographical areas where the restoration would contribute most significantly to achieving the conservation and societal targets. For this purpose, we applied spatial planning tools to identify the different components of a GBI network. Together with the design of the GBI for the CS2 area, we also identified those areas that might be potential candidates for restoration actions within the GBI, and we recommended measures to be applied following an Ecosystem-based Management approach (EBM).

1.3.1 GBI designation

In order to solve the conflicts and manage the ecosystems in the case study area we propose a strategic spatially planned GBI. Specifically, we tested (1) whether GBI concept can be applied at a transboundary level across different aquatic realms and (2) if the selection for restoration sites where apply EBM measures in the case study area can be implemented within the GBI design framework.

GBl is not new as a concept. Although the number of projects implementing this specific approach worldwide are still scarce (Ghofrani et al. 2017), more than 100 GBl programmes and projects have been or are under development in almost all EU Member States (Karhu, 2011). GBl concept emphasizes the importance of ensuring the provision of valuable ES for human well-being (e.g. recreational opportunities, physical experiences), the provision of goods and services (e.g. food, water, materials) as well as regulatory and maintenance services (e.g. climate regulation, water purification and retention). GBl concept is also about increasing the resilience of ecosystems by improving their functional and spatial connectivity by increasing ecological coherence and by improving landscape permeability (Karhu, 2011). Therefore, GBl favours landscape connectivity climate change adaptation and reduces vulnerability to weather and climate extreme events, while maintaining and preserving biodiversity (European Commission, 2013b). Due to these benefits that GBl provide against habitat loss and fragmentation, as well as against climate change and natural disasters, GBl per se is considered as an Ecosystem-based solution, since it offers a natural alternative to solve these environmental problems in contrast to purely technical solutions. In addition, GBl approach also contributes to sustainable economic development by investing in natural solutions which rely on ES (Karhu, 2011). Finally, GBl allows the integration of several conservation and exploitation objectives expressed by different stakeholders in the same area. From a social point of view, GBI can support transboundary cooperation to promote natural and cultural heritage (EUROPARC Federation 2018) what can be helpful to face the specific challenges occurring in the CS2 area and specifically in the IBRM.

1.3.2 Restoration of degraded ecosystems

GBI is also being increasingly recognised as an important opportunity for addressing the complex challenges of Ecosystem-Based Management (EBM; UNEP, IUCN, TNC, 2014) allowing for an integrated management approach that does not only address the management of ecosystems itself, but the human pressures that are impacting them, considering these pressures during the management decision process (Long et al. 2015). On the other hand, the European Commission, has adopted a new strategy to promote the investment in GBI to restore the health of ecosystems, improve the connectivity thus the ecosystems keep to delivering its ecosystems benefits to human. By means of EBM restoration measures we might improve the GBI, maintaining healthy ecosystems, reconnecting fragmented habitats and restoring degraded ecosystems, so they can provide society with more and better goods (Directorate-General for Research and Innovation 2015) and services.

2   Establishing objectives

2.1 Identifying policy objectives

We conducted an integrative policy characterisation of the CS2:

  ▸ Identification of the key threat and associated drivers, sub-pressures and impacts on the aquatic environment (see section 1 in the present document);
  ▸ Identification of the key policy instruments in the CS2 contributing to ES management (see section 2.1.1);
  ▸ Assessment on the degree of implementation of EBM principles in the CS2 (synergies, gaps and conflicts among policy targets, section 2.1.3);

2.1.1 Characterisation of policies and management in the CS2

We compiled the policies relevant for the management of aquatic biodiversity and ecosystems at the case study area that contribute to the implementation of the EU Biodiversity Strategy (European Commission, 2011), specifically of its target 2. We focused on the policies that improve the knowledge of the ecosystems and their services (action 5, EU Strategy), set priorities to restore and promote the use of the GBI (action 6) and prevent the net loss of biodiversity and ecosystem services (action 7). Given the important role of protected areas to maintain and preserve biodiversity in the case study and generally in the context of GBI, we also compiled policies affecting protected areas, including also sectorial policies. For more information on the prioritization of protected sites to be included in the GBI.

For Andalusia, the policy instruments were sourced from the web site on Environmental Information of the Government of Andalusia. For Morocco, the policy instrument was sourced from the web site of the High Commissioner for Water, Forest and fight against the Desertification (Haut Commissariat Aux Eaux et Forêts et à la Lutte Contre la Désertification 2009). For more information, please see detailed description of policies in the CS2 in Annex I: Data.

2.1.1.1   Policy targets at the CS2 level

Spanish legislation on biodiversity, at national level and at the level of the Autonomous Community of Andalusia, is based on international recommendations, European policy initiatives, national directives and regional initiatives. Moroccan legislation on the conservation and exploitation of natural resources has emerged since the beginning of the last century, through the promulgation of decrees issued by the King of Morocco on the exploitation of forests, on the inland fisheries and on the hunting police. This legal arsenal focused on the conservation of natural resources was strengthened, in the early thirties, by the promulgation of the Dahir on National Parks (Esser and Esser 2015). Below we briefly describe a selection of the most important environmental and sectorial policies affecting the threats identified in the CS2 and their main targets.

  ▸ Morocco Master Plan for Protected Areas H2020: under this plan, the Moroccan administration aims to reclassify the existent protected sites and to increase the area protected.

- IBRM action plan 2011–2015: although this plan does not have clear targets for the identified threats in the CS2, this is the unique policy initiative that offers a common transboundary framework for the establishment of IBRM objectives and strategy;
- Andalusian Integrated Biodiversity Management Strategy 2020 and National Strategy and Action Plan for Biodiversity of Morocco 2016–2020: both national biodiversity strategies share a common framework, vision and time horizon for the conservation of biodiversity and habitats;
- Andalusian Habitats Connectivity Plan: this plan focuses on maintaining and improving the connectivity in Andalusia from an integrative approach that includes different components of biodiversity and ecosystems;
- Andalusia Coastal Corridor Protection Plan; Integrated Coastal Zone Management Morocco (ICZM). In Spain, the main objective of the plan is to preserve from the urbanisation process those lands that have natural characteristics, relevant agricultural or forestry landscapes, or that fulfil specific territorial functions. ICZM is a pilot plan that will be firstly applied in the eastern Mediterranean coast of Morocco that aims to promote sustainable development in the coastal area to protect biodiversity in ecologically sensitive areas;
- Marine Strategy of the "El Estrecho" and Alborán Seas: the marine strategy has important measures to control pressures and specific measures aiming to restore degraded habitats;
- Moroccan national river basin management plans, and "Guadalete–Barbate" and Mediterranean Basins hydrologic plans (in Spain) contribute to improve the state of the aquatic habitats / ecosystems and promote the sustainable use of the water;
- Sustainable tourism strategies for Andalusia and Morocco;
- Andalusian and Morocco strategy for the development of marine aquaculture aims to promote the sustainable and competitive development of aquaculture activities.

2.1.2 Current management alternatives

The economic disparity between IBRM sections mentioned above is clearly reflected in the policy objectives. Below we list the most relevant measures for the management of aquatic ecosystems indicating (in brackets) the policy which they belong to. For more information please see Existent Management Measures in Annex I: Data.

- Development of pilot areas of protected sites in the IBRM in Morocco (IBRM Action plan);
- Exchange and transference of the IBRM experience between Morocco and Spain (IBRM Action plan).
- Integrated interventions for agri–forest–grassland development, soil conservation and water erosion control (Moroccan National Plan for Watershed Management);
- Strengthening the socio–economic infrastructures (Moroccan National Plan for Watershed Management);
- Modifications in the river channel to improve the longitudinal continuity (Hydrological plans);
- Establishment of artificial reefs (Hydrological plans);
- Change the coastal infrastructure for the restitution of the littoral sediment transportation (Hydrological plans);
- Restoration of coastal dunes (Hydrological Plans).
- Zonation of the territory (Andalusian Biodiversity Strategy 2020);
- Development of Ecological Management Units (Andalusian Biodiversity Strategy 2020);
- Development of ecocultural master plans (Andalusian Biodiversity Strategy 2020);

- Elaboration of directives for restoration (Andalusian Biodiversity Strategy 2020);
- Development of plans aiming at promoting the good status of the key species in the functioning ecosystems (Andalusian Biodiversity Strategy 2020);
- Develop a master plan for connectivity, among others (Andalusian Biodiversity Strategy 2020);
- Designation of new protected sites and extending the current protected area (Moroccan Biodiversity strategy – SPANB);
- Development of management plans (Moroccan Biodiversity strategy – SPANB–);
- Reclassification of the existent protected sites (Moroccan Biodiversity strategy – SPANB–);
- Extending the area of marine protected areas (Moroccan Biodiversity strategy – SPANB–);
- Demarcation of a network of protected marine areas (Marine Strategy for the 'El Estrecho' and Alborán seas);
- Regulations for activities in the marine environment (Marine Strategy for the 'El Estrecho' and Alborán seas);
- Investment in strategic tourism projects (Sustainable Tourism and Strategy of Morocco H2020);
- Rehabilitation of mature tourism destinations (Plan for Sustainable Tourism of Andalusia);
- Encouraging sustainable emerging tourism destinations (Plan for Sustainable Tourism of Andalusia);
- Reducing the paper work to help new investors in tourism activities (Plan for Sustainable Tourism of Andalusia);
- Favouring the creation of business networks between service producers and tourist activities (Plan for Sustainable Tourism of Andalusia);
- Encouraging the diversification of agricultural enterprises in rural areas towards non-agricultural activities (tourism), as well as in coastal areas, fishing and marine tourism as a complementary activity to traditional fishing (Plan for Sustainable Tourism of Andalusia);
- Development of the existing coastal settlement and preservation of the natural and semi-natural areas (Coastal protection plan of Andalusia);
- Facilitate the connection between the coastal area with the interior (Coastal protection plan of Andalusia);
- Establishment of the Terrestrial Connectivity Index of Andalusia (ICTA) (Master plan for improving ecological connectivity in Andalusia, 2016; draft);

2.1.3 Synergies, gaps and conflicts among policies

Despite the existence of several common policies, the specific goals and the degree of development and implementation of these policies are not always in conformity between the Spanish and Moroccan IBRM sections. In addition, the IBRM lacks specific targets for each section of the Reserve. Therefore, it is crucial to identify specific measurable and achievable targets based on the existent common policies as well as indicators that allow the monitoring of the progress made towards the achievement of the targets. Regarding the sustainable tourism plans that promote nature tourism, they may likely lead to an intensification of tourism activities in protected areas. In this sense, it is especially important to coordinate tourism and public use policies in natural sites with the policies on conservation, recovery and dissemination of cultural heritage.

In this sense, the GBl design that we propose and its EBM restoration plan associated, which are fully described in section 5 below (see also Barbosa et al. submitted to STOTEN), aim to address these gaps and to provide further support to these synergies.

2.2 Co-design

2.2.1 Stakeholder contribution to the identification of policy targets and management alternatives

We discussed with stakeholders on the pressures, key activities and environmental values of the CS2 area, and specifically of the IRBM, in order to achieve an integrative policy characterisation of the CS2 (see co-design of objectives in Annex II: Stakeholder process). In addition, policy characterisation was possible thanks to the data and information provided by the key stakeholders (see section 1.1.4. in the present document).

The stakeholders have been involved in the development of the management zones. Key stakeholders at this stage were representatives from the regional and local governments of Andalusia in Spain and representatives of the Kingdom of Morocco, a representative from UNESCO Man and Biosphere Program and the Biosphere Reserve Network, representatives from protected sites within the IBRM, and representatives of the main sustainable economic activities developed in the study area, namely farmers, livestock producers, manufacturers, as well as local non-profit organizations devoted to nature conservation and restoration. The descriptions of the zoning scheme were the starting point of the participation process, i.e. the purpose and characteristics of each zone were explained and discussed with the stakeholders. A working group composed by the stakeholders was organized to discuss the GBI zoning and which features (species, habitats, activities), targets, and measures (e.g. protect more than 15% of threatened species) should be implemented as the EBM plan in each zone in order to reach the different objectives (e.g., reduce the current pressures, promote green and blue growth, restore ecosystems and improve their services while protecting biodiversity). These stakeholder preferences were then used as input variables in the scenario development process (see Translation of stakeholder objectives into the modelling approach in section 4.2.2).

3 Assessing the current state of the social-ecological system

GBI aims to simultaneously achieve ecological and societal goals thus, previous to its design, we need to correctly understand the social side (i.e. how human drivers and activities place pressures on ecosystem components) and the ecological side (i.e. how the ecosystem and its biodiversity support ecosystem functions that deliver ecosystem services) that takes place in the case study area. Overall, the CS2 Socio-Ecological System (SES) consists of the ecological system and the social system, each with their own internal processes and complexly interlinked to one another. These two systems are connected through supply-side connections (from the ecological system into the social system) and demand-side connections (from the social system into the ecological system), i.e. human activities and pressures, as well as societal responses aimed at mitigating them. The description of the SES requires an understanding of the ecological integrity, the distribution and conservation status of biodiversity, together with the human activities producing goods and services but also pressures that may compromise achieving the societal and environmental goals. For more information on the methods and assessment of the SES please see Culhane et al. 2018; Teixeira et al 2018.; Borgwardt et al. 2018 submitted to the STOTEN journal. The SES is here described in terms of its capacity to co-produce the ES and abiotic outputs demanded by society. Ecosystem services also have a supply and a demand-side. The supply-side represents the potential and capacity of the ecosystems to supply services, whereas the demand-side constitutes the use of and the demand for ecosystem services made by the human population.

The identified linkages and their weights provide the basis for a general characterisation of the demand side (for ecosystem services) as well as the identification of main activities and pressures affecting ecosystem components and thus biodiversity.

- Matrix 1 linkages between activities and pressures;
- Matrix 2 linkages between ecosystem components and pressures/activities;
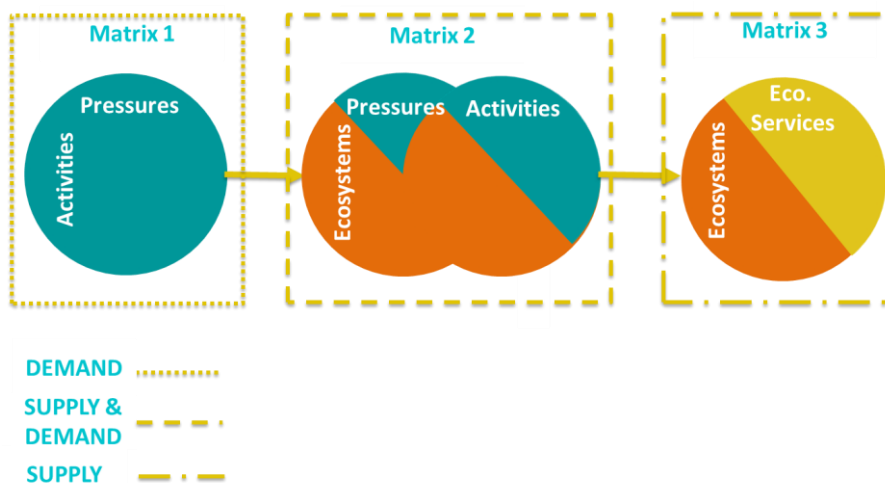- Matrix 3 linkages between ecosystem component and ecosystem services;

Figure 2. CS2 Linkage framework matrices for the characterisation of the demand side and supply side

The linkages were attributed through expert judgement. A common classification has been defined in Pletterbauer et al. (2017) and the results of the AQUACROSS SES assessment have been published by Culhane et al.; Teixeira et al.; Pletterbauer et al. submitted to the STOTEN journal.

3.1 Assessment of current Driver-Pressure-State

The demand side of the SES for the CS2 was assessed using a set of common linkage matrices characterising **Activities-Pressures-Ecosystems components (Habitats/Biotic groups) –** (Figure 2). The full characterisation of the main linkages at the CS2 for the demand side was built from the identification of three key elements:

- ▸ **Activities**
- ▸ **Pressures**
- ▸ **Biodiversity/ecosystems** (represented by ecosystem components: Habitats and Biota)

Connectance is a network statistic used in the assessment of the SES which incorporates the full linkages, from activities and pressures to biodiversity/ecosystems components. This statistic is measured individually for each of these elements. We used "connectance" to identify the most central (i.e. most important) elements. Mathematically, an element's connectance equals the fraction of all possible links in a network that include the element. Greater connectance implies greater centrality (i.e., impact), implying wider impacts. However, there are two caveats to this measure: (1) the structure of the network affects connectance scores, and (2) connectance does not express the strength of the relationships among the elements, just their existence. Accordingly, we combine our assessment of the AQUACROSS Linkage Framework derived from connectance with insights from stakeholders and policy.

In the CS2 a total number of 37 aggregated activities introducing 39 pressures were identified from the existent literature, expert judgment and verified by local stakeholders. In total we determined 369 interactions between activities and pressures; 1032 interaction between ecosystem components and pressures and 1282 interaction between activities and ecosystems components.

3.1.1 Identification of relevant drivers

In the CS2, connectance showed that the activities related to urban dwelling and commercial development have the highest impact on the coastal ecosystems, whereas shipping, in-situ aquaculture, boating, and yachting water sports show high connectance in both coastal and marine waters. Regarding the freshwater domain, connectance indicated that the activities related to mining extraction, rock/minerals, sand/ gravel and salt, urban dwelling and commercial development, and agriculture (crops and livestock) are those that have more links with the pressures affecting these ecosystems components. The connectance of the primary activities to pressures and biotic groups is also high. In-situ aquaculture, mining and extraction of material and agriculture are these main activities (see *Connectance* in Annex I: Data).

3.1.2 Identification of relevant pressures

The disturbance of species the change of habitat structure/morphology, the introduction of microbial pathogens, the introduction of synthetic and non-synthetic compounds and the introduction of litter, are among the pressures showing the highest connectance in the CS2 (see *Connectance* in Annex I: Data). These pressures are introduced by many activities and can affect all biotic groups in both terrestrial and marine ecosystems.

Sublittoral sediment, deep-sea bed, infralittoral, circalittoral rocks, surface standing and running waters have the highest connectance of all ecosystem components. This reflects the exposure of these habitats to multiple activity-pressure combinations. Regarding Biota, cephalopods, followed by mammals showed the highest connectance to pressures and activities combination.

3.1.3 Identification of ecosystem components – biodiversity and ecosystem types and pressures

The sublittoral sediment, deep-sea bed, infralittoral, circalittoral rocks, surface standing and running waters have the highest connectance of all ecosystem components (see section 3.2.1 – Identification of ecosystem components – biodiversity and ecosystem types). This reflects the exposure of these habitats to multiple activity-pressure combinations. On the opposite, all the habitats in riparian areas such spiny Mediterranean heaths, heathlands, scrub and tundra, shrub plantations showed lower connectance since they are in specific locations thus they are less vulnerable to the pressures. Fish and Cephalopods, followed by mammals showed the highest connectance to pressures and activities combination (Connectance of ecosystems components to activities and pressures combinations in Annex I: Data).

3.1.4 Linkages matrices: D-P-S

The activities that have more interactions, occur very frequently, and are acute or chronic, as well as widespread and exogenous (Robinson & Culhane 2017) in the CS2 are: **aquaculture, fishing, shipping, urban dwelling and commercial development and shore recreational activities**. From these activities we selected the most important pressures that affected ecosystem components (i.e. habitats and biotic groups) (Figure 3).
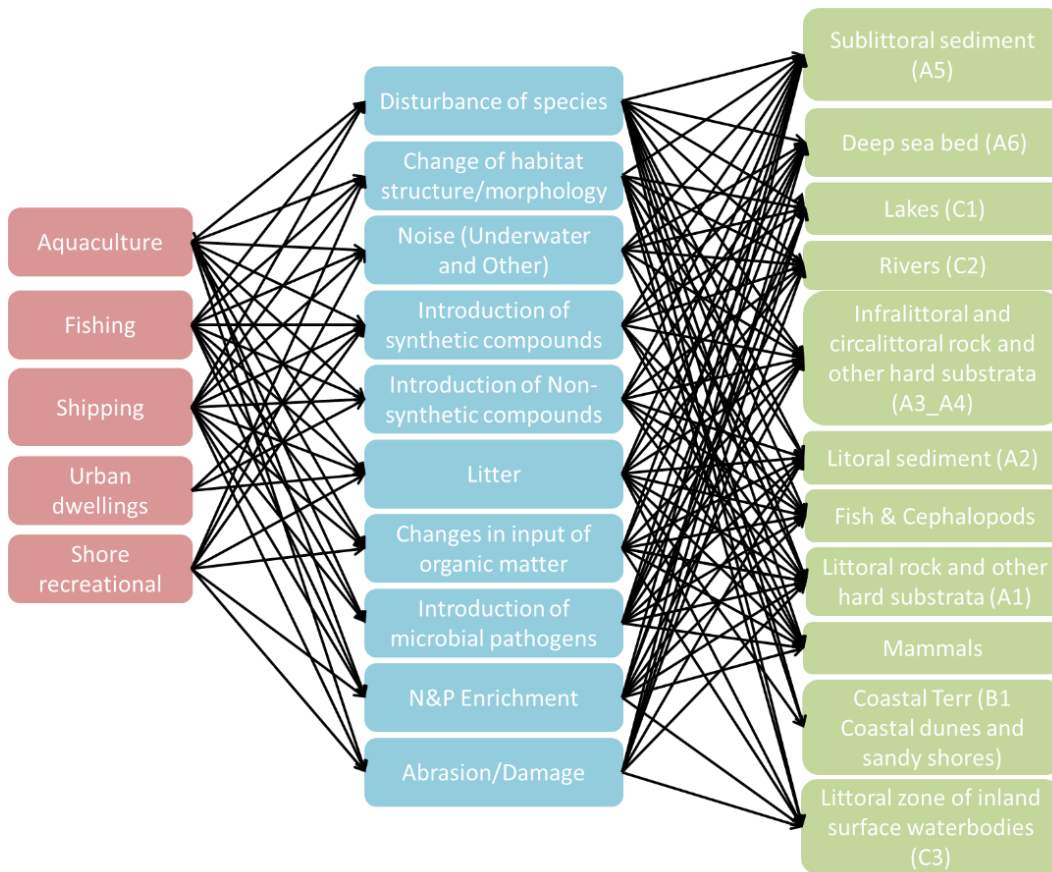
Figure 3. Linkage framework illustrating relevant elements for the assessment of the demand side of the SES in the CS2 components assessment

3.1.5 Mapping and assessing the activities, pressures and ecosystem condition of the case study Intercontinental Biosphere Reserve of the Mediterranean

Based on the linkage framework analysis, we could determine those ecosystem components mostly affected by the identified drivers and pressures. However, beyond this qualitative assessment, a spatially explicit assessment of the activities and pressures is needed to determine the spatial distribution and intensity of these activities and pressures across the case study ecosystems. On the other hand, since the capacity of an ecosystem to deliver services depends on the condition of the ecosystem, prior to the ecosystem service assessment, we needed to determine the ecosystem condition in the case study area. According to the "Mapping and assessing the condition of European ecosystems" (European Environment Agency (EEA) 2016), the assessment of the ecosystem state/condition requires information about drivers and pressures impacting the ecosystems. Accordingly, the sum of all the pressures affecting one ecosystem was considered as a surrogate of the ecosystem condition (see Ecosystem section below).

Data for mapping activities and pressures and ecosystem condition in the case study area were provided by the Environmental Information Network (REDIAM) of the Regional Government of Andalusia (Spain), European and global sources such as the European Environmental Agency, Joint Research Centre, EMODnet and Copernicus. For the Moroccan section, the data was mainly

obtained from global open data sources, namely the ESRI open data portal, Copernicus Global services, global fishing Watch and Open Street Map.

The starting point for the identification of the metrics and indices used in the CS2 was the linkage framework work reported above, which guided our identifi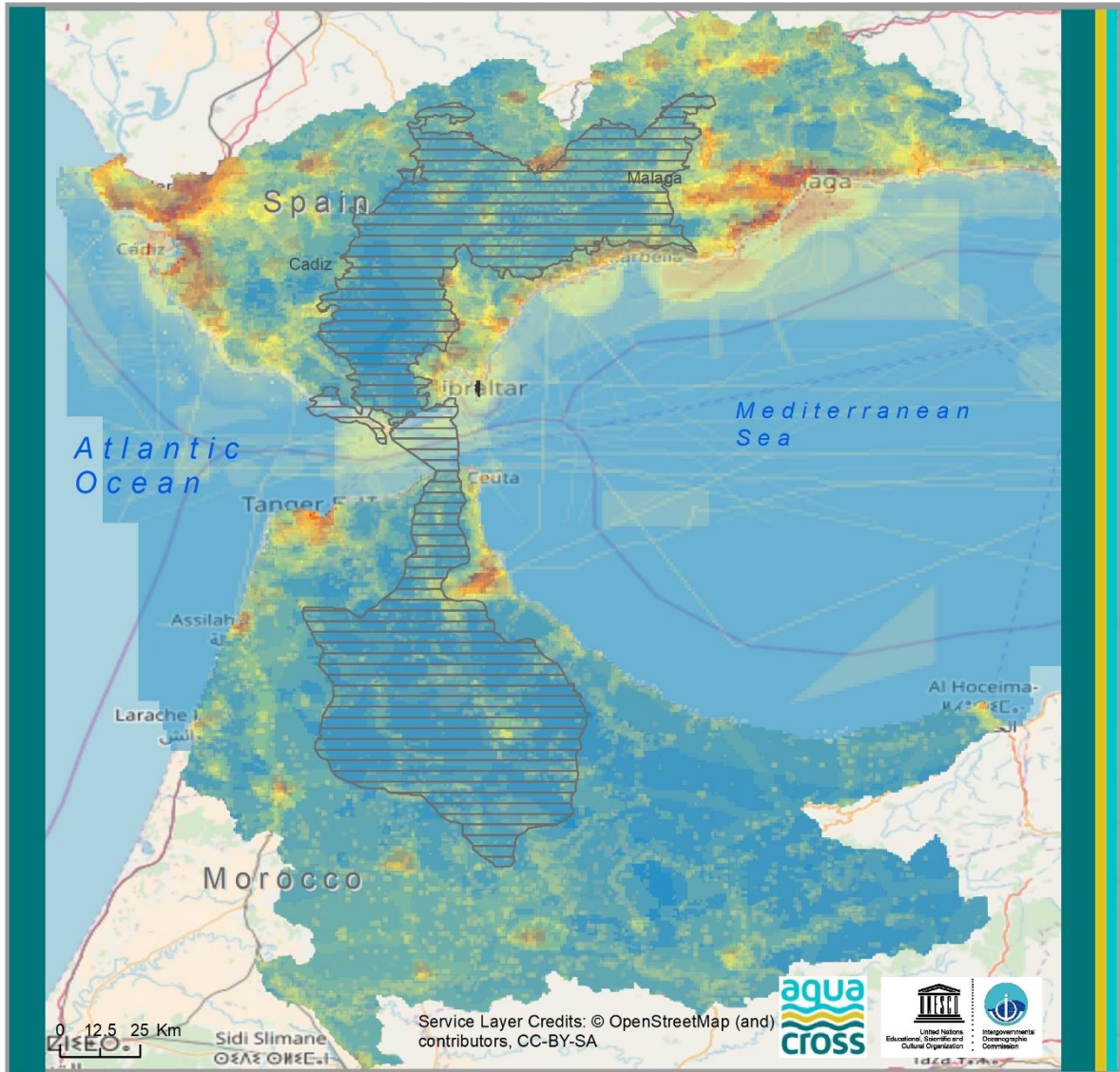cation of spatially explicit indicators based on measures for human activities, pressures and ecosystem condition. The quantification of the indicators was conditioned on the availability of spatial data in both sections of the CS2 area.

3.1.5.1 Ecosystem condition

The Human Footprint Index (HFI) was measured as the anthropogenic cumulative pressures on the aquatic ecosystem in the case study area (Figure 4). The HFI is an aggregated layer of 500 m x 500m – terrestrial area and 1km x 1km – marine area grid cells, created from the integration of several layers covering human activities in the case study area. In total, 70 metrics were used for mapping the spatial distribution of activities and pressures at the CS2 area (see Datasets for mapping activities and pressures in Annex I: Data). From quantiles of the HFI values, we established three different conservation categories (unfavourable–bad; unfavourable–inadequate; favourable) that were assigned to each habitat type (EUNIS level 2) in the CS2 area, representing the ecosystem condition of each habitat (see *List of habitats in the CS2* and *Ecosystem condition* in Annex I). For a detailed description on the methodology, please see Annex III.

Figure 5 shows that about 80% of the habitats identified in the area of interest were marine habitats and nearly 20% were located in Morocco. Habitats of community interest corresponding to aquatic ecosystems in Spain represented only 1% of the habitats in the area of interest. However, the proportion of habitats at an unfavourable conservation status was similar in aquatic and marine habitats in both countries (about 65–70%). Most of the habitats in the area of interest (76%, n=100,543) are at an unfavourable conservation status. However, only 26% of the habitats were classified at an unfavourable–bad conservation status (n=34,381). According to the results obtained, habitats with the largest surface in bad ecosystem condition were marine habitats ("A"), heathland and shrub related habitats ("F6", garrigue), and inland salt steppes ("E6"). Contrastingly, coniferous forests ("G3") was the habitat showing largest cover at favourable ecosystem status.

Figure 4. Cumulative pressures index map of the IBRM case study.

Figure 5. Ecosystem condition

3.2 Assessment of current B-EF-ES

The supply side of the SES of the CS2 was assessed using a set of common linkage matrices characterising Ecosystem Components (Habitats/Biotic groups) – Ecosystem Functions/Ecosystem Services. The full characterisation of the main linkages at the CS2 was built from the identification of three main elements:

- ▸ **Biodiversity/ecosystems types** (represented by ecosystem components: Habitats and Biota)
- ▸ **Ecosystem functions**
- ▸ **Ecosystem services**

3.2.1 Identification of ecosystem components – biodiversity and ecosystem types

The case study area is characterised by 9 realms and 5 biotic groups. Regarding the habitats, we worked at EUNIS level 2 in the Spanish section. For Morocco, we worked at EUNIS level 2 for the freshwater and costal habitats and level 1 for other habitats (Ecosystem types in Annex III: Assessment methods and tools). Figure 6 shows the share of the three major water domains at the case study area. Inlets transitional water have the highest share of the coastal waters, followed by terrestrial coastal habitats and costal sea. In the freshwater domain, riparian habitats and continental wetlands show the highest representation followed by rivers. In the marine domain, oceanic ecosystems have the highest presence followed by shelf.
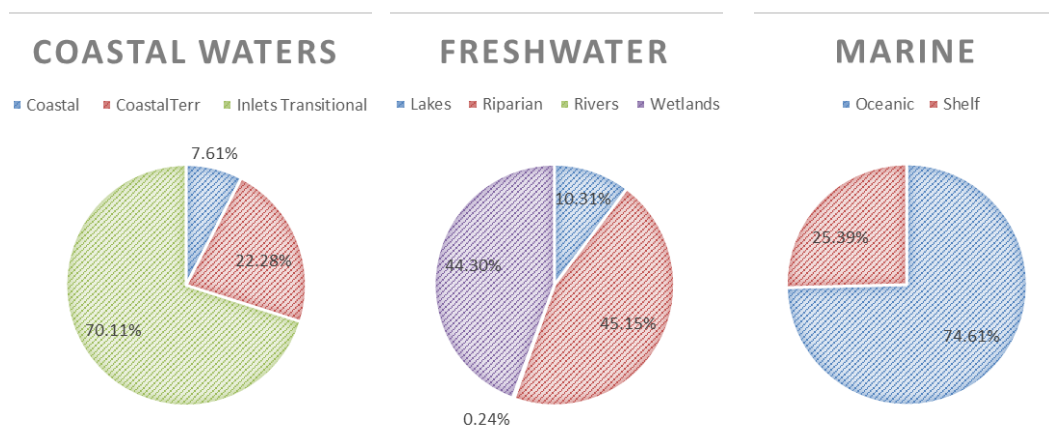
Figure 6. Share of the three major water domains at the case study area: coastal waters, freshwater and marine.

3.2.1.1 Mapping ecosystem types

The definition and delineation of the ecosystems spatially and explicitly is crucial to understand their natural condition, trends and the pressures to which they are exposed. The aim of this section is to define the ecosystem types at the IBRM area and mapping their structure. We used habitat types as proxy of ecosystem typology.

For the ecosystem typology, we have followed the same classification agreed by the EU Member State (MS) and proposed in the MAES framework (European Environment Agency (EEA), 2016). This typology has two levels of ecosystem categories and it can be adapted to the required scale, purpose and data availability. Level 2 is the most disaggregated level, composed by twelve categories of ecosystems: urban, cropland, grassland, woodland and forest, heath land and scrub, sparsely vegetated areas and wetlands; rivers and lakes; marine inlets, transitional

water, coastal, shelf and open-ocean. Level 1 aggregates these categories in to three realms: terrestrial, freshwater and marine ecosystems.

We used three different sources for mapping the Ecosystem types at the IBRM case study:

- Andalusia (Spain) section: Ecosystem types of Europe based on EUNIS habitats from European Environmental Agency;
- Morocco section: Land Cover map at 100 m resolution V1 from Copernicus Global Land Services (crosswalk matrix land use – EUNIS habitats
- Marine section: EUSeaMap 2016 from EMODNET;

For more information (for more information see Ecosystem types in Annex III: Assessment methods and tools).

3.2.2 Biodiversity mapping

Biodiversity is a key conservation feature of our GBI both because of its intrinsic value and of its capacity to support provision of different ecosystem services. Therefore, we also mapped the spatial distribution of biodiversity in the case study area and particularly of endangered species. The resulting biodiversity map was used in the modelling approach as an additional spatial prioritisation feature when designing the GBI (see Annex III). According to the data availability, we considered endangered species at the national level in Morocco and at the regional level in Spain (Andalusia region). Specifically, species of freshwater fishes, aquatic birds, and amphibians were included. In addition, invertebrate species and characteristic plant species of aquatic and associated transitional ecotone habitats (dunes, sand and coastal cliffs) were also considered. To represent marine biodiversity, we used 28 marine species, including invertebrates, mammals and birds (List of targeted species included in the species distribution assessment, Annex I). We developed species distribution models (SDM) for predicting the probability of presence based on these datasets (Figure 8). Species occurrences were aggregated to the CS2 planning units, sub-catchments and grids (Aggregated probability of occurrence of aquatic species per planning unit; planning units for the analysis of aquatic ecosystems in the IBRM, Annex I: Data). For a detailed description on the methodology, please see Ecosystem types in Annex III: Assessment methods and tools.
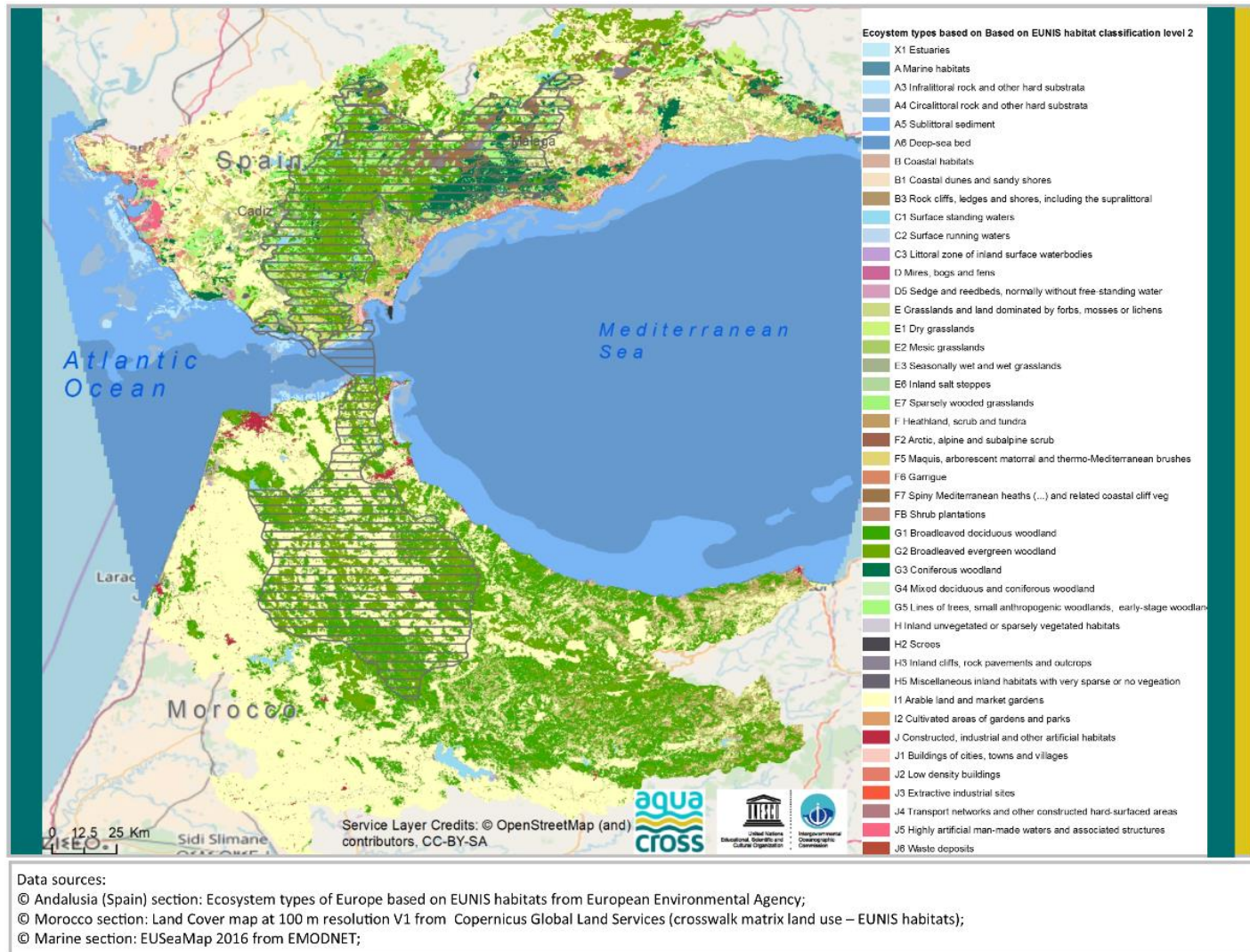
Figure 7. Ecosystem types based on habitat maps EUNIS level 1 and EUNIS level 2 for the IBRM (see legend in Ecosystem types section – Annex 3: Annex III: Assessment methods and tools.
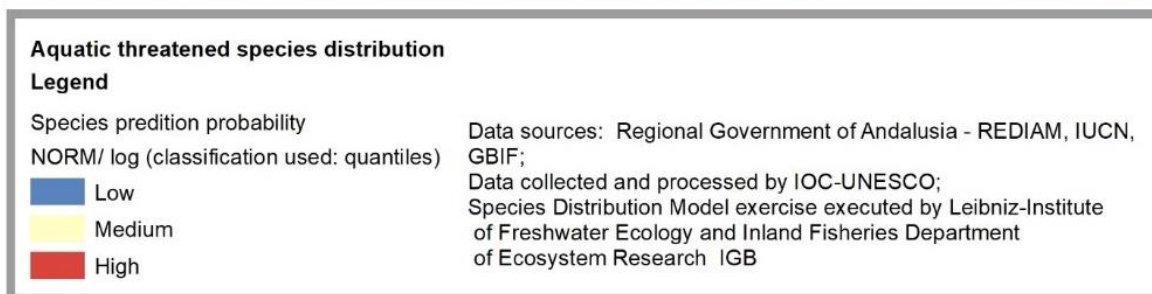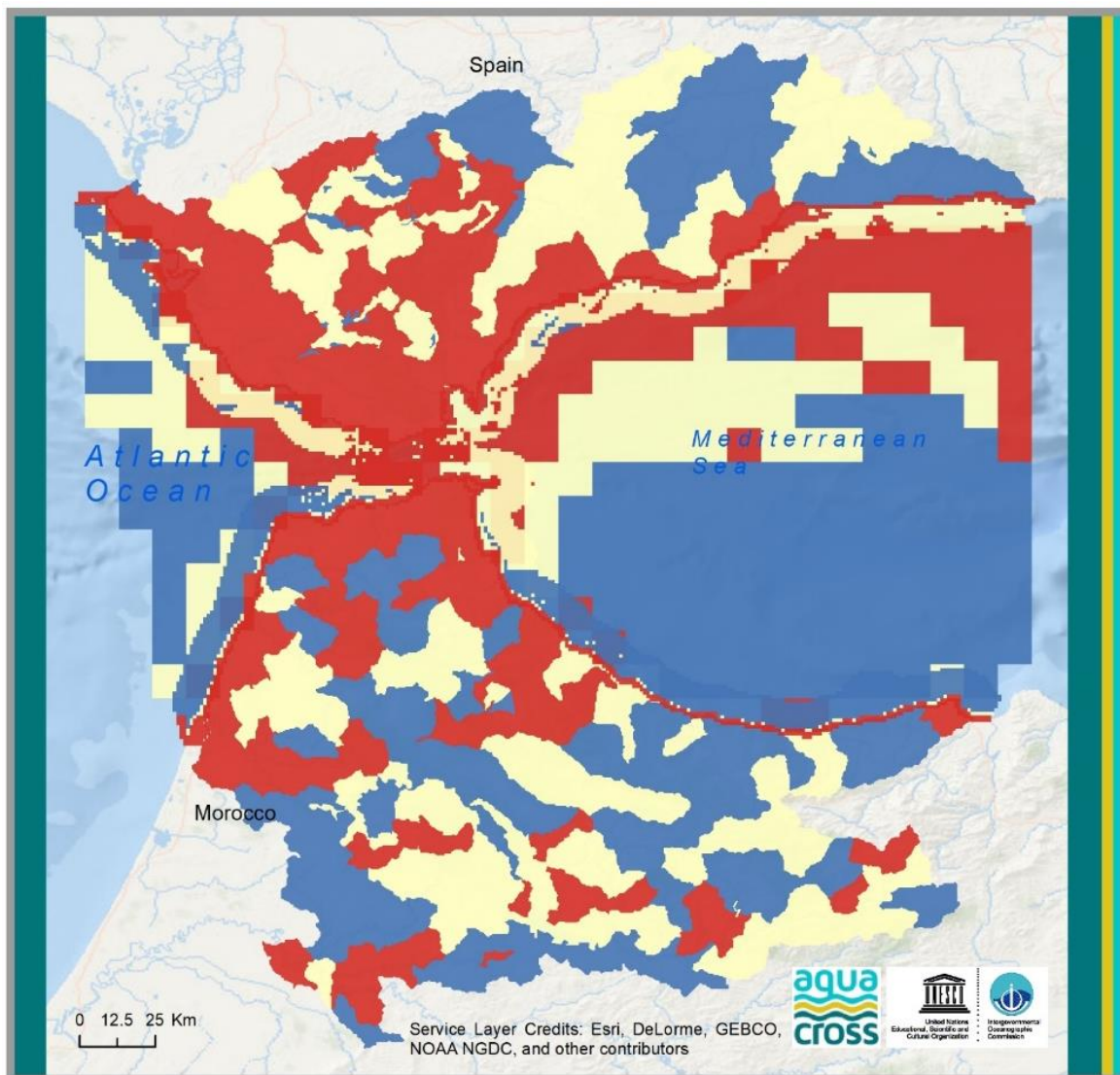
Figure 8. Aquatic threatened species prediction probability.

3.2.3 Identification of ecosystem services

The CS2 area provides fifteen ecosystem services, the most relevant being the regulation and maintenance of habitat, physical and intellectual interactions and regulation of waste. Regarding the ecosystems components, the sublittoral sediment, infralittoral rock and hard subtracts and surface standing waters, have been identified as key ecosystems in the supply of these services.

Regarding the ecosystem components, surface standing waters, deep-sea bed and sublittoral sediments have been identified as the greater contributors to the overall functioning while the rock cliffs edges and shores, coastal habitats and maquis arborescent matorral in riparian areas contribute the least to functioning.

The linkage assessment provided a good overview of the most important ecosystems components in terms of their capacity to provide services as well as to highlight the most important services that they provide. Nevertheless, a spatially explicit assessment is crucial to support decision-making and enable the implementation of restoration actions that could bring multiple benefits from the Green and Blue Infrastructure (GBI) perspective.

3.2.3.1 Mapping Ecosystem services (ES)

ES were presented as spatially explicit indicators, representing the capacity of provision. We mapped a total of fifteen ES following the Common International Classification of Ecosystem services: (1) provisioning services, (2) regulation and maintenance and (3) cultural services (CICES V5) (Table 2) (see Annex I). Spatial ES indicators on flood regulation, carbon sequestration, pollination, soil retention and potential recreational opportunities were produced using the ARtificial Intelligence for Ecosystem Services modelling platform (ARIES, Villa et al., 2014) (Figure 9 and Figure 11. ARIES is an assessment toolkit that follows a mapping process for ecosystem service provision, use and flow. The outputs from ARIES are probabilistic models that incorporate the uncertainty in the outcomes. ARIES models are based on three elements: (1) the areas where ES and biodiversity are provided; (2) the flow paths between these provision areas and the areas of use; (3) the areas of use of ES and biodiversity, (i.e. where the ES beneficiaries are located).

For ES that we were not able to be mapped based on ARIES due to data availability constraints, we used a simplified approach that allowed mapping the spatial distribution of the capacity based on the ecosystem types and using the linkage framework matrix ecosystem components-ecosystem services (Table 2, Figure 10 and Figure 11). For a detailed description on the methodology, see Ecosystem Services section in Ecosystem types in Annex III: Assessment methods and tools.

In this study the ES were classified as "incompatible" or "compatible", depending on whether they do or do not represent conflicts with conservation goals (Chan, Shaw, Cameron, Underwood, & Daily, 2006; Hermoso et al., 2018). Generally, regulating and cultural services are considered not to cause any conflicts with conservation (i.e., compatible), while provisioning services, even when they are sustainable, usually represent any conflict with conservation goals (i.e., incompatible) due to the material extraction necessary to make use of the ES (Remme & Schröter, 2016). Therefore, provision ES (such as water and biomass provision) were considered as incompatible ES whereas all other ES (maintenance and regulation ES and cultural ES) were included as compatible ES. All ES were mapped at the 100 m resolution, re-scaled to range between 0-1 and aggregated to the respective planning units (see Annex I and III) expressing the average of the data (*Ecosystem Services*, Annex I: Data).

Table 1. List of ecosystem services spatially mapped in the CS2 area (source: Barbosa et al. submitted to the SOTEN journal)

Ecosystem Services					
Common International Classification of Ecosystem Services (CICES) Version 5.		Framework	Indicator (Unit)	Compatibility with conservation	Management zone
Provisioning services	Biomass material from plants and algae	ES capacity based on the ecosystem types	Potential biomass for material production capacity (dimensionless)	Incompatible	Zone 3
	Biomass for nutrition		Potential biomass for nutrition capacity (dimensionless)	Incompatible	Zone 3
	Water supply		Potential of water supply (dimensionless)	Compatible	Zone 2
Maintenance and regulation services	Flood regulation	ARIES	Potential flood regulation supply (dimensionless)	Compatible	Zone 2
	Carbon Sequestration		Potential of carbon sequestration (dimensionless)	Compatible	Zone 2
	Pollination		Mean potential pollination supply (dimensionless)	Compatible	Zone 2
	Soil retention		Avoided potential removed soil (dimensionless)	Compatible	Zone 2
	Soil quality regulation – soil formation	ES capacity based on the ecosystem types	Potential soil formation (dimensionless)	Compatible	Zone 2
	Regulation of mass flows physical barrier		Potential physical barrier to landslides (dimensionless)	Compatible	Zone 2
	Lifecycle maintenance of habitats		Potential to provide habitats for wild plants and animals that can be useful for human (dimensionless)	Compatible	Zone 2
	Water purification		Potential of regulation of water condition (dimensionless)	Compatible	Zone 2
	Pest control and invasive species control		Potential to providing habitat for native pest control agents (dimensionless)	Compatible	Zone 2
Cultural services	Intellectual experiences (e.g. education)		Potential of the habitats to provide characteristics of living systems using nature for education and training (dimensionless)	Compatible	Zone 2, 3 and 4
	Spiritual experiences		Potential of the habitats to provide characteristics of living systems that unable using nature for local emblematic places (dimensionless)	Compatible	Zone 2, 3 and 4
	Recreational opportunities	ARIES	Potential recreational opportunities (dimensionless)	Compatible	Zone 2, 3 and 4
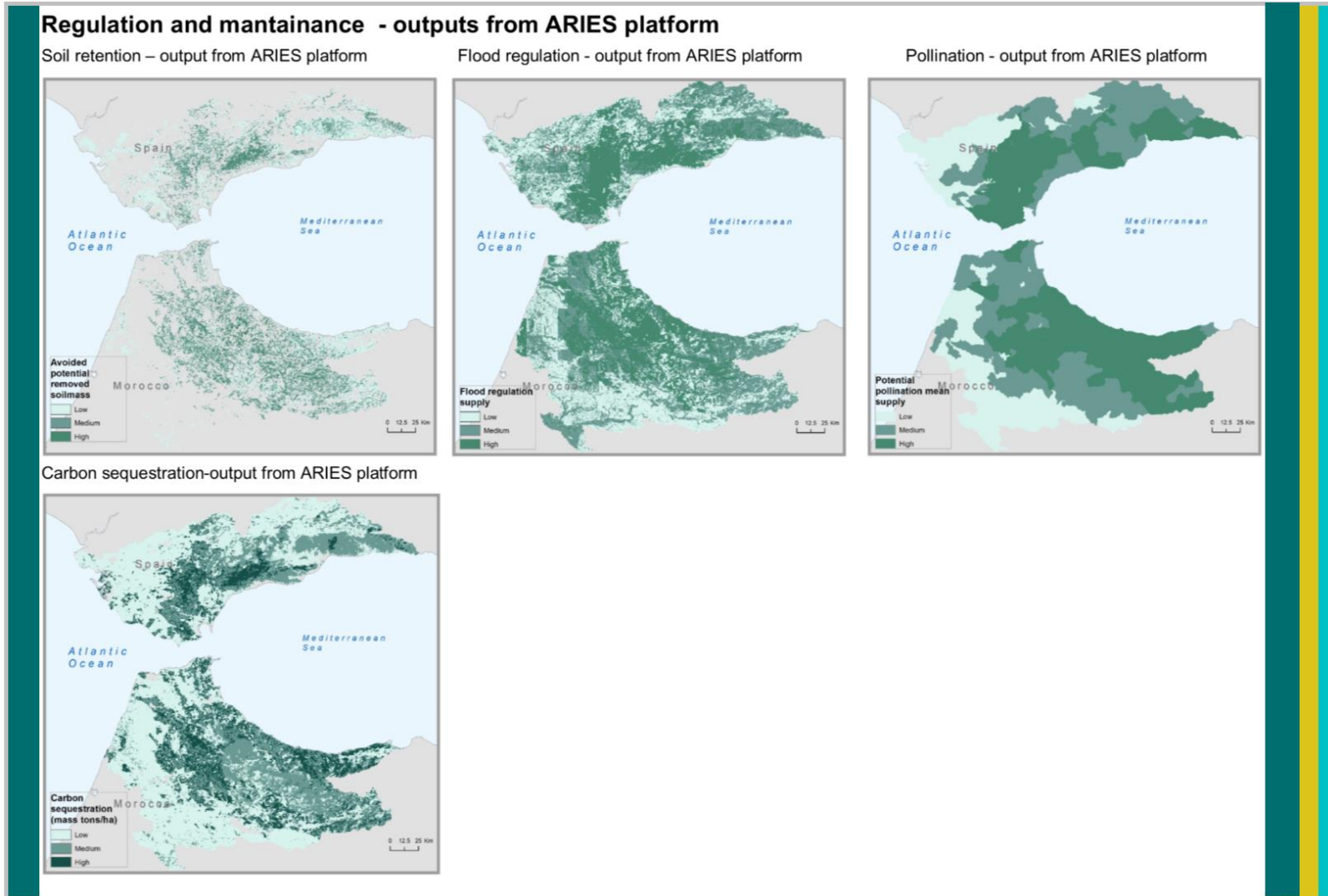
Figure 9. Ecosystem services (Aries modelling framework)
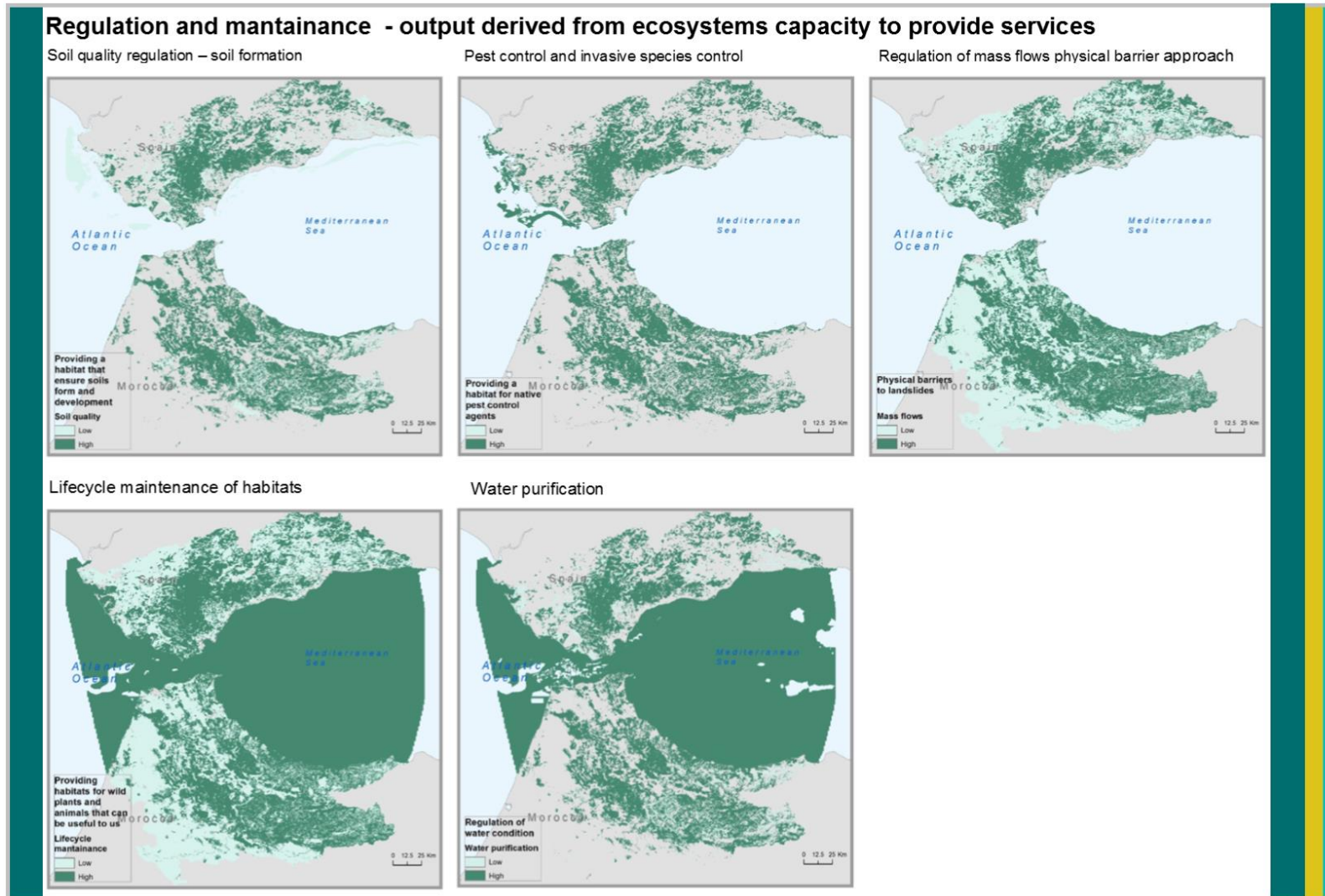
Figure 10. Ecosystem services capacity (regulation and maintaining services
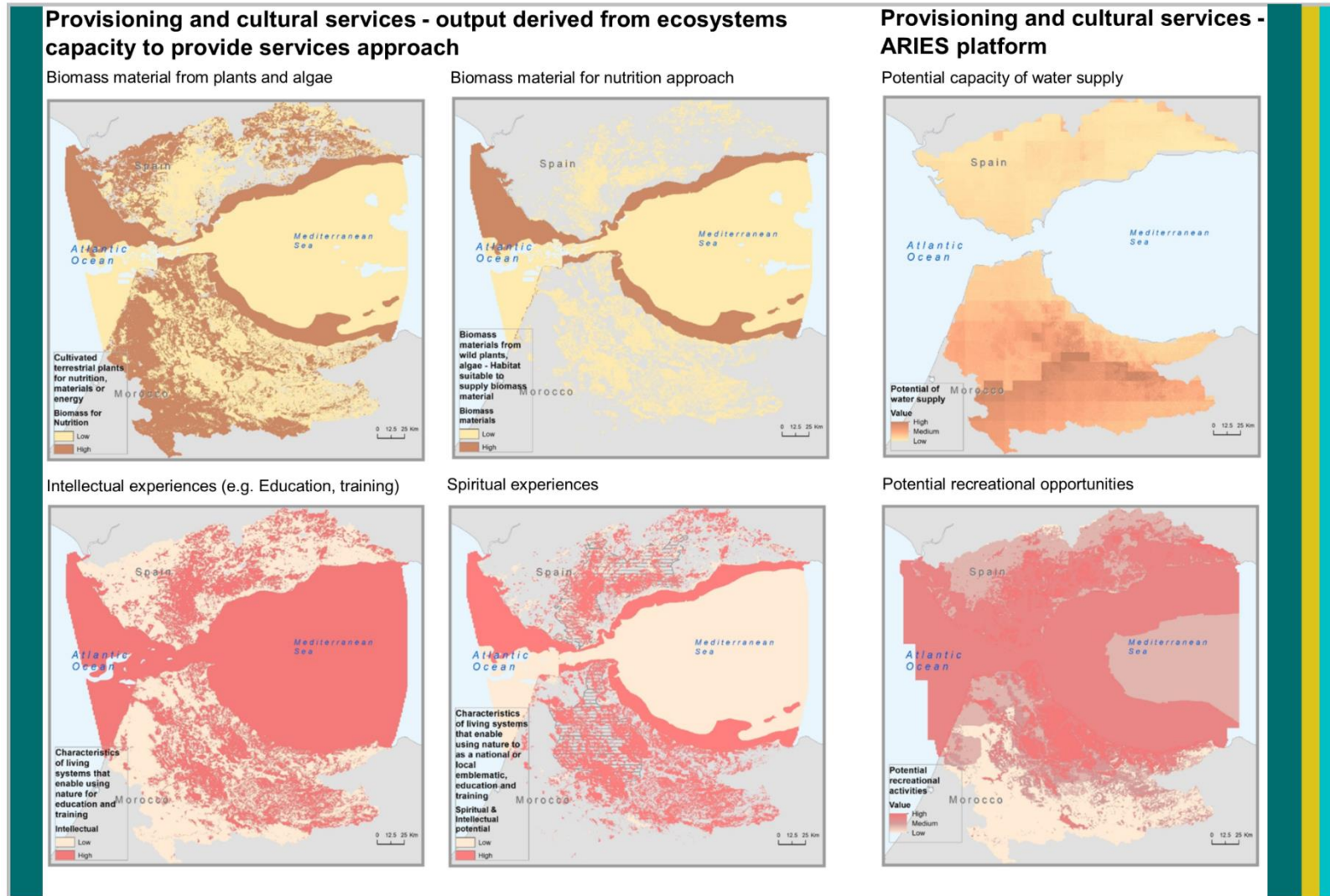
Figure 11. Ecosystem services capacity (provisioning and cultural services)

3.2.4 Linkages matrices: B-(Habitats)-EF-ES

The regulation and maintenance of habitat, physical and intellectual interactions and regulation of waste are the most important ecosystem services provided in this case study area. While the provisioning of biomass and mechanical for energy are the services least provided in the area. Regarding the ecosystems components, the sublittoral sediment, infralittoral rock and hard subtracts and surface standing waters, have been identified as key ecosystems in supply of services.

The focus of the IBRM case study centres on the ecosystem components that have the capacity to provide more services. According to the linkage between the ecosystem components and the ecosystem services, the key marine ecosystems in this case study are the sublittoral sediment, infralittoral and circalittoral rock. The freshwater ecosystems, including surface standing and running waters, littoral zone of continental waters and riparian habitats (grassland and land dominated by forbs mosses), followed by woodland and forest and coastal habitats are the focus of this case study. The figure below shows the main SES – supply side of the IBRM case study (Figure 12), also identifying how these ecosystem services are enjoyed by society. As ecosystem services capture the value provided by ecosystem functioning, we do not need to additionally include ecosystem functioning in our spatial planning process.
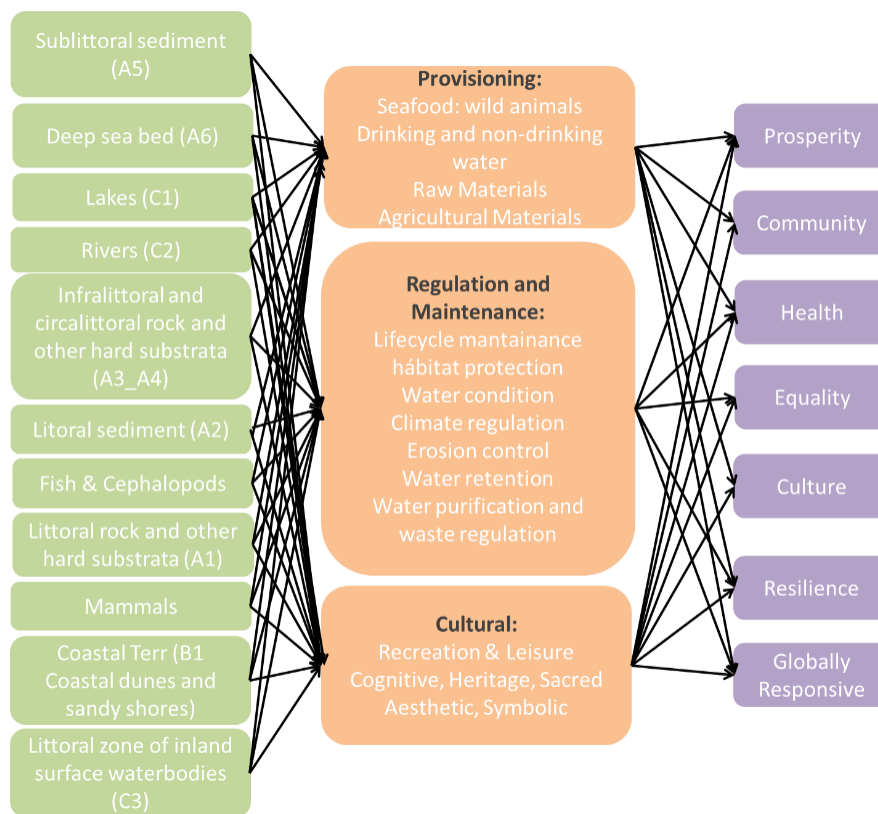
Figure 12. Linkage framework illustrating relevant elements for the assessment of the supply side of the SES in the CS2.

3.3 Co-design

3.2.5 Stakeholder contribution to the priority components and causal relationships of the D-P-S-B-EF-ES

As a first approach, two kick-off workshops were organised to present the project and discuss for the first time the pressures, key activities and environmental values of the CS IRBM.

The outcomes of these workshops served to complete assessment of the SES using the logical framework matrices proposed by AQUACROSS WP4. Namely, they supported identification of conflicts, drivers and pressures and WP5 ecosystem and their services. The technical and local experts were also contacted for the data / information compilation. This contact was made through data request online channels, at the meeting with the local experts, and by email. Afterwards, the key results of the assessment of the SES and the presentation of the spatial explicit assessment of the current baseline were also presented and discussed in a third workshop. One major concern was to ensure the presence of at least one local actor from each sector to be consulted regarding the SES and the EBM goals. For those stakeholders who were not able to attend any of the workshops and meetings, we organised specific field stays to directly visit the stakeholder in his/her working place. All stakeholders were invited to explain their views and interest for the CS area. For this purpose, a wide range of actors from the local community and NGO's were invited and attended to the workshops:

- Regional Ministry of Environment and Spatial Planning of Andalusia (Spain);
- Natural Parks "Los Alcornocales" and "El Estrecho";
- Regional Observatory for the Environment and Sustainable Development of Tanger-Tetouan-Al Hoceima (Morocco);
- Regional Direction for the Environment of Tanger-Tetouan-Al Hoceima (Morocco);
- High Commission for Waters, Forests and Desertification of Morocco;
- The Majors of Tarifa and Facinas and representatives of both City Councils;
- Representatives of the Intergovernmental Oceanographic Commission of UNESCO;
- A representative from UNESCO Man and Biosphere Program and the Biosphere Reserve Network and
- Representatives of the activities, namely a representative of a natural park in the IBRM, farmers, livestock producers, construction, mayors, and local NGO's association for conservation and restoration of a wetland which was transformed to irrigated croplands.

In addition to the workshops, in order to better understand the social system in the case study area, field visits were also organised in both sections of the case study area to meet local stakeholders dedicated to cultural activities, fishery industry, maritime security and enforcement, amongst others. For a detailed description of the Stakeholder process, please see Annex II.

4 The baseline and EBM scenarios

4.1 Objectives of the scenarios

The overarching aim of CS2 is to design a multi-functional GBI and deploy measures for meeting conservation and restoration goals in the IBRM and its AoI. The multi-objective nature of the GBI can be achieved through the designation of multiple zones with specific management objectives within the GBI. This multi-zoning design allows to meet specific conservation targets, minimising the trade-offs between conservation and exploitation goals as well as a comprehensive management planning of ES and biodiversity across freshwater, coastal, and marine ecosystems in the CS2. In addition, this approach provides the most efficient allocation of the EBM restoration measures (in terms of the conservation feature targets achieved, spatial extent and spatial arrangement as well as in terms of costs for specific restoration measures).

We used two different GBI configurations (i.e., scenarios) to assess how the location of EBM restoration measures would affect the optimal GBI design. In addition, by comparing alternative solutions for the same GBI configuration with similar costs, we could evaluate the uncertainty in the resulting GBI design (see sections below).

4.1.1 Scenarios description

We identified two different GBI designs: a baseline scenario which considers the current status and distribution of biodiversity and ES in the CS2 area; and a second GBI design incorporating the restoration of degraded habitats using the EBM approach. In the second design, the results show the optimal allocation of key areas for the improvement of biodiversity and ES potential within the GBI.

4.1.2 Assessment of the current ecosystem condition at the CS2 area

The proportion of habitats at an unfavourable ecosystem condition (about 65–70%) is similar in the Spanish and Moroccan sections of the CS2, both in freshwater and marine realms. Most of the habitats in the CS2 (76%) are at an unfavourable ecosystem condition. However, only 26% of the habitats are classified at an unfavourable–bad ecosystem condition (see section 3.1.5 and Ecosystem condition).

4.1.3 Targets to be achieved

GBI specifically addresses target 2 of the Biodiversity Strategy, preservation and restoration of ecosystems and ES. Particularly, our EBM approach aims to reach the EU Biodiversity Strategy 2020 target 2 (i.e., restoring at least 15% of degraded ecosystems by 2020). However, GBI also contributes to all other targets of the Strategy, particularly to target 1, implementation of the Birds and Habitats Directive and to targets 3 and 4, maintaining and enhancing biodiversity in the wider countryside and the marine environment.

4.2 Scenario development

The assessment of the SES, namely the characterisation of the demand and the supply sides (see section 3 above), was the starting point for the configuration of the GBI baseline and EBM scenarios. It allowed the identification of the key threats and the EBM objectives targeted to reduce the key pressures caused by different activities, and the EBM restoration measures aimed to maintain or even to increase the capacity of the ecosystem to provide services.

Once the baseline was defined, the EBM measures have been identified and the target for each GBI management zone was established, the next step consisted of translating this information into a spatially explicit GBI and evaluating the EBM measures. This process is an interactive process that involves the participation of the modellers/technicians and local experts to adjust the targets and reach an agreement on the final GBI configuration (Figure 13).

Figure 13. Simplification of the participatory scenario process of the CS2 – IBMR Andalusia and Morocco.

4.2.1 Models and modelling parameters (short introduction)

The results from the biodiversity SDM models (*Aggregated probability of occurrence of aquatic species per planning unit*, Annex I: Data), the area covered by protected sites, as well as by different habitat types at different ecosystem condition (Ecosystem condition, Annex I), the averaged value of ES (Ecosystem Services –ES–, Annex I: Data), and the selected sites to be restored in the CS2 area (see Annex III for a detailed description on the Methodology) were included as "conservation features" to be spatially prioritised according to different targets in an analysis using Marxan with Zones software (Watts et al. 2009).

Marxan (Ball, Possingham, and Watts 2009) is a commonly used decision support tool for the systematic allocation of regional spatial planning priorities which has been proven to be a key software to design GBI (Snall et al. 2016; Vallecillo et al. 2018). Marxan with Zones uses a simulated annealing optimisation algorithm to minimise an objective function (Spatial planning approach section in Annex III: Assessment methods and tools). The objective function includes two main components; (1) a measure of the 'cost' of the reserve (configuration of planning units) and (2) a penalty when not achieving various criteria (Watts et al., 2009b). These criteria included penalties for not achieving targets for the conservation features and connectivity penalties for missing connections between planning units in the marine and coastal realms, and along the river network in the freshwater realm (Hermoso, Cattarino, Kennard, Watts, & Linke, 2015) (see Addressing connectivity section in Annex III: Assessment methods and tools). Marxan with Zones optimises the spatial allocation of different management zones, and then the design of the GBI, by minimising the above mentioned objective function.

4.2.2 Translation of stakeholder objectives into the modelling approach

Stakeholder preferences were used as inputs in the Marxan with Zones analyses (see Table 2). The spatial priorities for the EBMs were based on the planning goals expressed by the stakeholders. According to stakeholder requirements, we considered four different GBI management zones including, two with conservation aims (the core zone and conservation zone), one to manage trade-offs between biodiversity conservation, maintenance of compatible ES and incompatible ES (the sustainable use zone)(Hermoso et al. 2018)(Hermoso et al. 2018), and a fourth one to implement the restoration objectives considered in the EBM scenario (the EBM restoration zone) (see Box 1. Green and Blue Infrastructure management zones).

We preferentially selected core zones that are connected through another core zone or through a conservation zone to spatially distribute the management zones in the GBI. Restoration zones were spatially arranged following the same criteria as conservation zones but paying attention to the unfavourable habitats. For a detailed description on the methodology please see GBI management zones in Annex III: Assessment methods and tools.

4.2.3 Conservation targets, costs and other parameters

The selection of areas for potential investment in GBI was based on planning units (PUs) that differed in size across the different realms. For freshwater ecosystems, we used river sub-catchments, including the river reach and its contributing area. Coastal PUs (i.e. 10km buffer from the shoreline) and marine PUs were derived from two regular grids of 1 km x 1 km and 10 km x 10 km, respectively (*Planning units for the analysis of aquatic ecosystems in the IBRM*, Annex I: Data and Planning units: three realms – three spatial structures section in Annex III: Assessment methods and tools). In order to minimise the potential trade-offs and enhancing co-benefits, we applied different biodiversity and ES targets across the different zones (Table 2). Targets for the restoration zone were based on the EU biodiversity strategy which aims restoring 15% of degraded ecosystems (for more details see Conservation targets and costs section in Annex III: Assessment methods and tools).

The costs of each PU have been considered to be the area covered by the respective PU, assuming that the larger the GBI is the more "expensive" its implementation and management gets. The prioritisation of the spatial location of the EBM restoration zone also took into consideration the relative restoration costs associated with the different measures in relation

to the total area within the PU to be restored. Relative restoration costs have been derived from restoration action costs reported for previous projects and studies collected from the available literature (Table 3). Costs reported in Table 3 were then weighted according to the ecosystem condition of the habitats in the area to be restored, assuming habitats in unfavourable-bad ecosystem condition required larger restoration investments than habitats in unfavourable-inadequate condition.

Box 1. Green and Blue Infrastructures management zones

Green and Blue Infrastructures zoning:

1 – The "core zone" acts as a hub for GBI maximising the synergies between biodiversity conservation and delivery of regulation and maintenance ES (compatible ES). The goal of this zone is to prioritise biodiversity, habitats at favourable ecosystem condition and compatible ES, while restricting incompatible (provision ES) and cultural ES.

2 – The "conservation zone" prioritises non-protected areas but still contains high levels of biodiversity, habitats at favourable ecosystem condition which provide large amounts of regulation and maintenance services, as well as other compatible ES (i.e. cultural ES). These areas buffer the potential negative impacts of the uses allowed in the sustainable use zone (see below) on the core zone.

3 – The "sustainable use zone" encourages a balance between provision ES (biomass and water for nutrition and material) and regulation and maintenance ES, as well as between compatible human activities and biodiversity and habitat conservation, which emphasises the multifunctional nature of rural areas. The aim of this zone is locating the sustainable exploitation goals of the GBI outside the core and conservation zones, allowing a sustainable use of resources. This zone also preserves the GBI against the pressures arising from the outside area (i.e., classified as available zone in Marxan with Zones).

4 – The "EBM restoration zone" has similar conservation targets as zones 1 and 2. However, it is focused on the ecosystems in unfavourable ecosystem condition which are suitable for the implementation of an EBM restoration plan. Zone 4 is embedded in Zone 1 and 2. Prioritisation of this area is also based on the costs (in terms of proportion and level of habitat degradation in each PU, as well as the financial costs for implementing particular EBM restoration measures.

Zone	Scenarios quantitative targets (in percentage)									
	Core		Conservation		Sustainable use		Restoration		Total	
Scenario	BS	EBM	BS	EBM	BS	EBM	BS	EBM	BS	EBM
Biodiversity	9	9	5.25	5.25	0.75	0.7	–	0.7	15	15.7
Endangered species	12	12	7	7	1	1	–	1.0	20	21.0
Protected areas covering aquatic ecosystems	100	100	0	0	0	0	–	0	10	100
ES regulation and maintenance	9	9	5.25	5.25	0.75	0.7	–	0.7	15	15.7
ES cultural	0	0	9	9	6.00	6	–	1.3	15	16.3
ES provisioning	0	0	0	0	75	75	–	0	75	75
Habitats at unfavourable status	0	0	0	0	0	0	–	15	–	15
Habitats at favourable status	9	9	5.25	5.25	0.75	0.7	–	0.7	15	15.7

Table 2. Scenarios, management zones and targets. Targets are provided as a percentage of the total amount of each conservation feature in the study area. BS: baseline scenario; EBM: EBM restoration scenario

Key habitats	Annual costs/ha (dollars; 2010)
riparian	187.37
coral	1,826,651.00
seagrass	82,140.00
saltmarshes	31,965.71
coastal wetlands	35,438.18

Table 3. Monetary costs for restoring riparian habitats (based on Natural Water Retention Measures (NWRM; European Commission – Directorate-General for Environment, 2014) and for restoring all other habitats (Bayraktarov et al. 2016)). Annual rates are based on the mean duration of the restoration projects reported by Bayraktarov et al. (2016).

4.2.4 EBM restoration measures

We defined restoration features as those areas where EBM measures can potentially be implemented to improve the current ecosystem condition and therefore increase ES provided by the GBI. Target achievement for these restoration features in Marxan with Zones was based on the target 2 of the EU biodiversity strategy (restoration of at least of 15% of degraded ecosystems). Specifically, we focused on these EBM measures: (1) the restoration and regeneration of riparian buffer strips on farmland, (2) the restoration of wetlands and (3) the restoration of marine habitats (i.e. cold-water corals and seagrass) (for more information please see EBM restoration measures in Annex III: Assessment methods and tools).

5 Evaluation

We assessed how EBM restoration measures would affect the GBI design by comparing the GBI configurations obtained in the baseline and in the EBM restoration scenarios. We proposed a design of the Green and Blue infrastructure (GBI) based on the Ecosystem-Based Management (EBM) approach. We offer a multi-zoning management scheme that tackles the interactions within an ecosystem to design a GBI that maximise the co-benefits between ecosystem services and biodiversity at the same time that minimised the costs of implementing GBI and EBM measures and restore degraded ecosystems (Chapter 3 and 4). The indicator used to measure the general progress of the implementation of the GBI is the ecosystem condition (Chapter 3). Specifically, it provides cost-effective spatial solutions based on the minimum area covered by the GBI achieving specific conservation targets (in terms of biodiversity and ecosystem services), and on EBM restoration action costs, by an optimal spatial allocation of conservation features, ecosystem services and allowed human activities among zones with different management schemes. Our cost-effective spatial solutions also take into account connectivity patterns as expected in the design of the GBI.

We firstly design the GBI management zones based on the current situation (baseline scenario), i.e. current biodiversity, ecosystem services, ecosystem condition and protected areas. This GBI was then compared with an alternative scenario where the GBI restoration management zones are allocated assuming that 15% of the current degraded ecosystems will be restored (EBM scenario). Different habitats and ecosystems (coastal, marine and freshwater) will be part of the GBI. In addition, the transboundary nature of the IBRM will also be considered when designing the GBI.

5.1 EBM solutions

We defined restoration features as those areas where EBM measures can potentially be implemented to improve the current ecosystem condition and therefore increase ES provided by the GBI. Specifically, we focused on these EBM measures:

- Designation of multifunctional zones which promote human activities compatible with biodiversity protection and conservation as well as with maintenance and regulation ES. This is achieved through the designation of a GBI based on the recommendations derived from the CS2 (see Marxan with Zones results in Barbosa et al., under review journal).
- Reduce disturbances caused by main pressures identified at the IBRM (to be applied mainly in GBI core and conservation zones) and increasing the targets in a dedicated management zone for the sustainable uses:
    - b1. reduce fishing pressures;
    - b2. reduce tourism pressures;
    - b3. reduce urban pressures.
- Restoration of degraded aquatic ecosystems (at least 15%) in the IBRM and AoI
    - c1. freshwater – Restoration of damaged components of riparian zone habitats;
    - c2. coastal – Restoration of coastal wetlands
    - c3. marine ecosystems – Restoration of marine degraded seafloor habitats

From these locations, only areas overlapping with habitats in unfavourable ecosystem condition were kept (*Ecosystem condition*, Annex I). Further details are available in Annex III.

The impacts of these measures over ecosystems can either be direct, such as in the restoration (measures type 2), or indirect, as a result of regulation of the activities of co-producing ecosystem services or affecting their driving factors (measures type 1).

The location of these general measures in the GBI is being determined using a modelling approach (presented in Chapter 4). The modelling approach is based on the achievement of conservation targets (i.e. biodiversity, habitats at favourable ecosystem condition, and ecosystem services) in the GBI through the prioritisation of the different zones according to their relative costs (i.e. areal and connectivity costs, costs of restricting certain types of human activities, costs for not achieving conservation targets). The prioritisation of the spatial location of the EBM measures in the GBI also takes into consideration the relative financial restoration costs of the measures as well as the ecosystem condition of the habitats to be restored, assuming habitats at poor ecosystem condition require larger restoration investments. Relative restoration costs have been derived from restoration action costs reported for previous projects and studies which have been collected from the available literature.

The planning units for the EBM location have been identified through the modelling approach. Specific EBM measures have been further identified as a result of the assessment of the SES, namely the identification of the key activities, pressures caused by these activities and ecosystem components affected, and the specific restoration requirements of the habitats in each particular area.

The restoration of the wetlands, riparian zones and marine ecosystems aims to "return" the ecosystem to its original community structure, natural complement of species, and natural functions (Lammerant et al. 2014). According to the optimal solution method applied through the modelling approach, the selected zones for EBM restoration will be those with the highest potential (in terms of potential biodiversity, ecosystem condition and ecosystem services) and simultaneously the "cheapest" ones (in terms of connectivity and financial costs). Therefore, we also achieve the effectiveness and efficiency of the restoration measures i.e. zones that are under unfavourable ecosystem condition but are good candidates for the implementation of the measures because they can reach the biodiversity and ecosystem services targets once the restoration measures are implemented (Chapter 4).

5.2 Setting the evaluation criteria

Relative restoration costs were derived from restoration action costs reported for previous projects and studies collected from the available literature (Table 3). Costs were then weighted according to the ecosystem condition of the habitats in the area to be restored, assuming habitats in unfavourable–bad ecosystem condition required larger restoration investments than habitats in unfavourable–inadequate condition.

5.2.1 Assessing the achievement of targets in baseline and EBM scenarios

5.2.1.1 Effectiveness: reaching targets

Almost all targets for biodiversity and ES were achieved in the baseline scenario. Only protected areas were underrepresented according to the targets specified. However, more than 56% of the aquatic habitats in protected sites of the CS2 area were covered under the core zone (26%) and conservation zone (30%) of the best GBI solution in the baseline scenario, although coastal-

marine PUs included less than 1% of the total marine protected sites. Achievement of targets in the EBM scenario was very similar to that of the baseline scenario. Restoration targets were achieved for all the conservation features in both realms, except for the representation of habitats at poor ecosystem condition in coastal and marine realms, where only about 90% of the 15% target was reached.

5.2.1.2 Efficiency: making the most for human welfare; evaluation of socio-economic impacts

According to both baseline and EBM restoration scenarios, probability of conflicts between conservation and exploitation goals in the GBI was relatively high, particularly in the freshwater realm, as shown by the high incidental representation of incompatible ES (i.e., provisioning ES) within core and conservation zones (Figure 16). Similarly, the proportion of conservation features included in the sustainable use zone was also high. However, the multi-zoning design of the best GBI solution (optimal spatial solution with minimum costs, Figure 14) allowed to meet the specified conservation targets within the conservation zones (core and conservation), minimising the trade-offs between conservation and exploitation goals.

5.2.1.3 Equity and fairness: sharing the benefits

The different management zones of the GBI (core, conservation, sustainable use as well as priority areas for restoration purposes) were well distributed over the CS2 area, thus costs and benefits of implementing the GBI in the CS2 are highly shared across different regions within the CS2. Finally, as one of the priorities expressed by the CS2 stakeholders was the restoration of degraded habitats, EBM restoration scenario shows a more equitable GBl design compared to the baseline scenario.

5.2.2 Assessing the system capabilities to introduce EBM measures

5.2.2.1 Resilience, adaptability, transformability

Ecosystem restoration, as implemented in areas which have unfavourable ecosystem condition, probably will not reach an equal level of good ecosystem status as a previously non-degraded ecosystems (Rey Benayas, Newton, Diaz, & Bullock, 2009; Schneiders et al., 2012). However almost 75% of the habitats in the CS2 area are classified at an unfavourable-inadequate ecosystem condition. The expectancy of a successful restoration in these habitats is higher compared to ecosystems at unfavourable-bad status. Moreover, according to Vallecillo et al. (2018), areas characterised by low human pressure, but with high biodiversity values, exhibit a high capacity to deliver ES, particularly regarding regulating and cultural services (Chan et al. 2006; Schneiders et al. 2012). Therefore, restoration of these areas is expected to enhance ES provided by the GBI (Vallecillo et al. 2018). The high availability of habitats at unfavourable-inadequate ecosystem condition supports the likelihood of successfully introducing restoration EBM measures in the CS2.

5.2.2.2 Implementability, financial feasibility (budgetary considerations)

Similarly, costs of restoring ecosystems are presumably lower for habitats at unfavourable-inadequate status compared to habitats at unfavourable-bad ecosystem condition (Budiharta et al. 2014). The high availability of habitats at unfavourable-inadequate ecosystem condition facilitate the implementation of the restoration EBM measures in the CS2 in terms of financial feasibility. The multiple protected sites in the CS2 area, and specifically the IBRM, facilitates fundraising from different sources such as the Moroccan and Andalusian Biodiversity

strategies, regional and national coastal protection plans, river management plans, regional action plans for biodiversity protection and action plans for wetlands restoration and conservation, Marine and coastal integrated coastal management plans, among others.

5.3 Results (comparing scenarios/measures)

5.3.1 Evaluation of baseline and EBM restoration scenarios

According to the GBl designs obtained in both scenarios, although the several protected sites included in the CS2 area account for an important amount of the biodiversity and the ES provided by the ecosystems, there are also high value sites in terms of conservation and ES provided outside the current network of protected sites that should be managed accordingly. Similarly, we observed that habitats currently degraded in the CS2, and consequently of low conservation value and providing limited amount of ES, can be restored and successfully integrated into the GBl network, improving the connectivity of the core and conservation zones of the GBl (Figure 14). Our results show that local environmental and related policies in the CS2 area should pay attention to relevant areas in terms of biodiversity and ES, even if they are outside protected areas, and they should promote the investment on EBM restoration actions in key sites for the connectivity of the identified GBl. In addition, policies should lead to a spatial planning of the CS2 area based on zoning the conservation and exploitation goals, in order to minimise the high potential for conflicts among them, as well as to promote the sustainable development and the benefits that the human population inhabiting the area can obtain from nature.

Frequency of selection of the planning units across the different runs (a total of 100) in Marxan with zones (Figure 15) highlights the relatively high degree of uncertainty in the GBl design. This is a consequence of the potential conflicts between conservation-core zones and sustainable use zones that we mentioned above. This uncertainty means that several GBl designs can offer equally valid alternative solutions (i.e. with minimum costs). This is an advantage in terms of stakeholder involvement and management flexibility, since the final GBl design to be implemented in the field can be selected among different minimum cost modelling alternatives, according to overall policy and stakeholders priorities in the CS2.
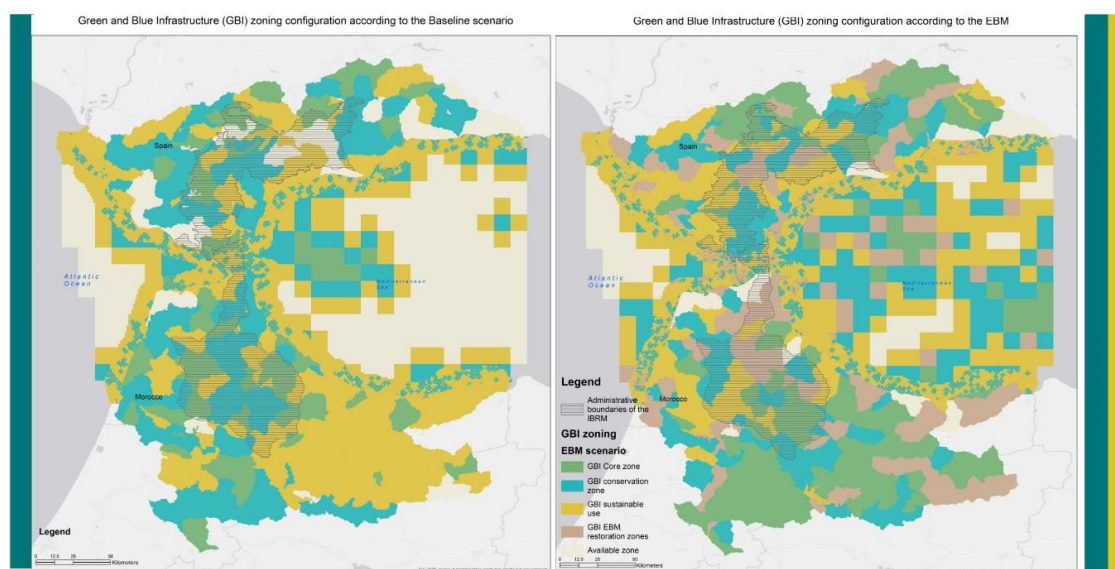

Figure 14. Spatial configuration of GBIs for the baseline and the EBM restoration scenarios
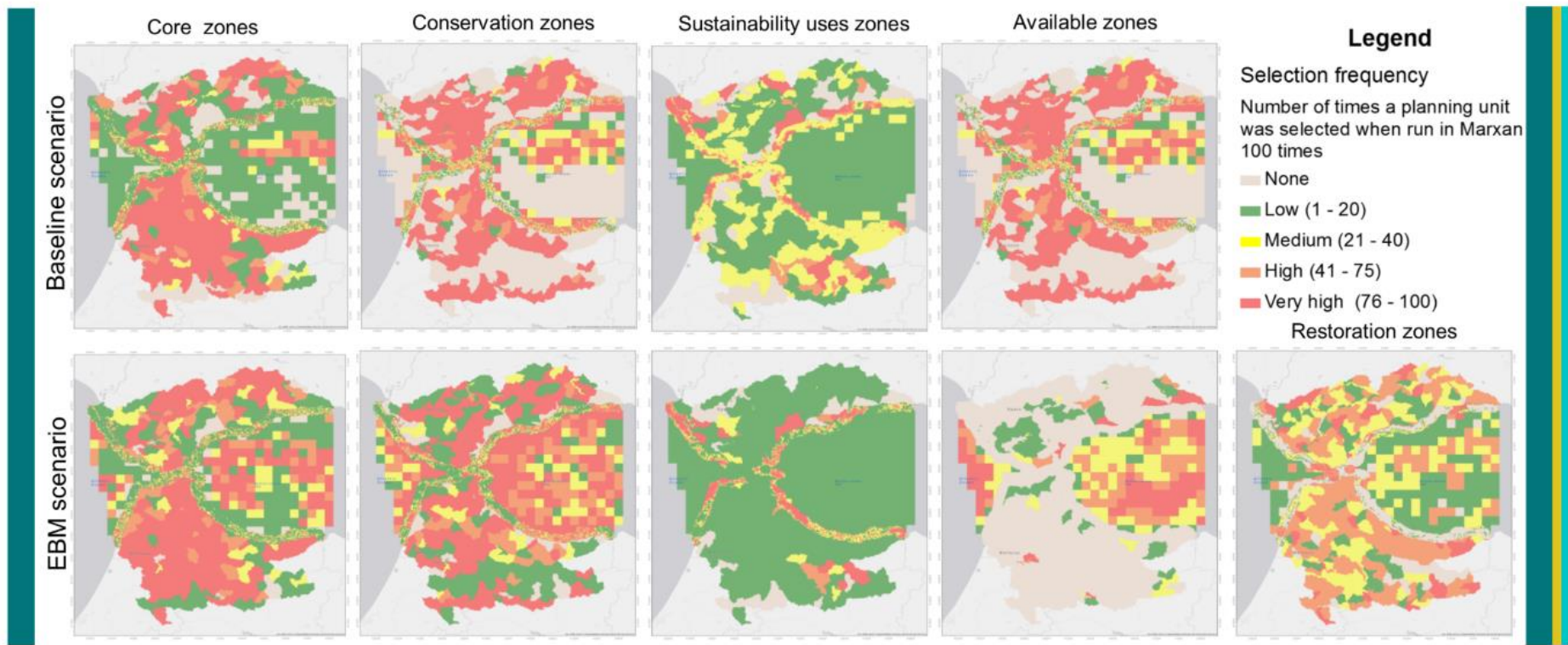
Figure 15. Selection frequency of the different management zones. Darker hues correspond to higher selection frequency. Each figure corresponds to a management zone for the baseline (left) and the EBM scenario (right).
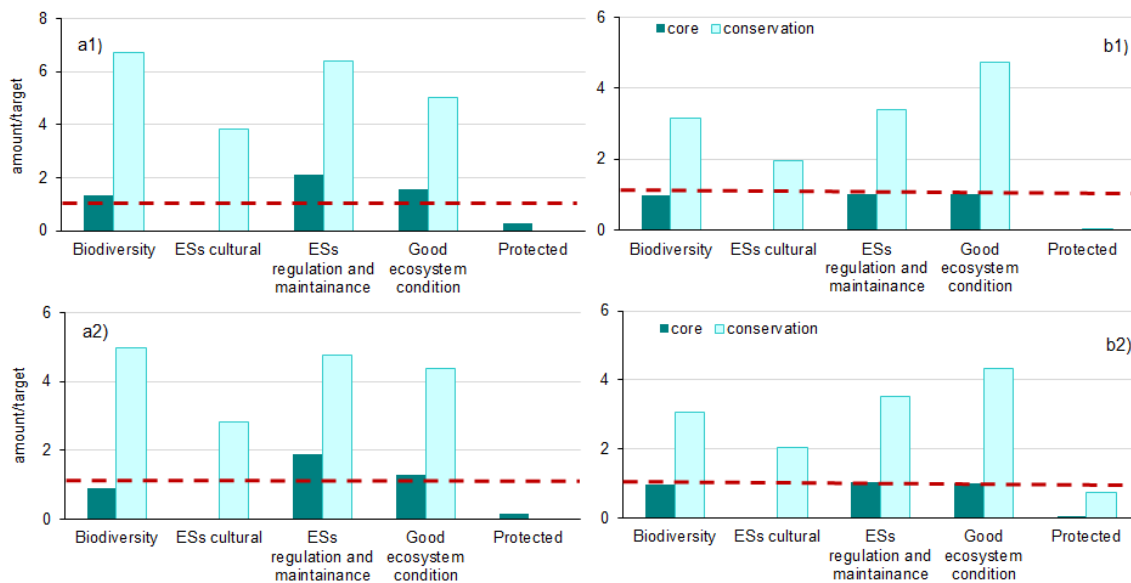
Figure 16. Targets met for conservation features as a ratio between the amount of the conservation features held in the core and conservation zone and the targets specified for the conservation features (see Table 4). (a1) Scenario 1 (i.e., baseline), freshwater realm; (b1) Scenario 1, coastal and marine realms. (a2) Scenario 2 (i.e., EBM scenario), freshwater realm; (b2) Scenario 2, coastal and marine realms (Source: Barbosa et al. under review)

5.3.1.1 Stakeholder views/perceptions of results

Upon reviewing these results, stakeholders' main concerns regarding the implementation of the GBI are related to the limitation of the resources (monetary, infrastructure, human power, among others) currently available in both IBRM sections. Private investment with sustainability purposes is still low in the area, and public investment is mainly focused on protected sites. Moreover, funds available (from EU policies, for instance) are frequently project-dependent and work in a timeframe shorter than the long-term restoration actions required in the CS2 area. For successful ecosystem restoration, the policy instruments must address not only the restoration *per se*, but the control of the pressures responsible for the habitat degradation. Additional costs of restoration are associated with the setting up of the policy instrument (usually the agency responsible for implementing the restoration) as well as the costs related to monitoring and reporting after restoration from the regulating entities. Together with these limitations in the availability of the resources, according to the perception of the stakeholders, the abundant number of protection categories in the area, particularly in Spain, which implies many different policies, laws and institutions, both public and private, hinder the communication and coordination among the different actors required, and water down the importance of the IBRM. Finally, restrictive measures related to preserving core-conservation

areas, and limiting the allowed economic activities in the CS2 area are very unpopular among the local population because they are perceived as reducing incomes. For instance, regarding fishing, one of the main economic activities carried out in the CS2 area, the quotas and policy instruments applied to reduce pressures may have costs for fishermen caused by a reduction in the number of fishing hours during a fixed period or by the closure of certain zones, as well as increase the surveillance on this activity in the area, due to verification, monitoring and reporting from regulating entities (Greenhalgh et al. 2014).

In spite of all these caveats, all the stakeholders (national and regional governments, protected site managers, non-profit organizations and local entrepreneurs, among others) are aware of the importance of promoting the transboundary cooperation at the IBRM. Accordingly, they highly support initiatives such as this case study, which attract attention to the values present in the area and which promote their potential sustainable economic exploitation. Due to the social and financial situation of the human population in the IBRM, however, stakeholders are mostly interested in the cultural services (mainly recreational ES in relation to touristic exploitation of natural and cultural resources), and to a lesser extent, to the provision services that they can obtained from the GBI, whereas regulating and maintenance services are of lower concern.

5.4 Pre-conditions for successful take off and implementation of "qualified" EBM solutions

From the point of view of the administrations (both in Spain and Morocco) in charge of the policies in the CS2 area and main responsible of implementing the measures, the key factors that could hinder the successful implementation of the EBM measures are:

▸ The willingness of the institutions to adopt and implement the measures (i.e, allocation of economic resources, infrastructures, manpower, others);
▸ The capacity and the endorsement competencies of the institutions involved (i.e., search for financing, coordination among policies, coordination among different categories of protected sites and cooperation with private land owners);
▸ Institutional transparency and responsibility to ensure the transboundary cooperation and coordination required to achieve the EBM measures here proposed;

The main changes that would need to be introduced to ensure the successful take-off and the implementation of the measures would be to emphasise the human dimensions and implications for local communities and other stakeholders in the implementation of the overall design of the Green and Blue infrastructure and, specifically, in the development of the restoration measures. Among the local population, highlighting the importance of the ES provided by the IBRM and the sustainable ways for their exploitation is advisable. In addition, ensuring that the local population is aware of the ways that the GBI will maintain and enhance these ES could also incentivize the take off.

6 Discussion

According to the European Commission, GBIs should be integrated in most EU policies particularly regarding fisheries, transport, energy, and culture. We show that EBM restoration measures can be explicitly included in an optimal spatial planning process of a GBI. By including EBM measures in the design of the GBI, we consider not only the current condition of the potential GBI areas, but also the future changes that would take place when implementing GBI. This spatially-explicit approach prioritised the location of EBM measures, while minimising the costs and conflicts between conservation and exploitation trade-offs previously identified by the stakeholders in the study area. Hence, the framework we use here may be useful in guiding the investments on GBI at regional level and its integration in different policies, at EU level and international/global level (Figure 14).

Our design meets some crucial GBI principles, such as the protection and enhancement of biodiversity and ecosystem condition, the provision of ESs as well as the promotion of an economic growth that uses natural resources in a sustainable way (i.e., green and blue growth, Europe 2020 strategy). The resulting GBI offers an optimal management-zoning scheme, in terms of cost-effectiveness and arrangement of the zones. Due to the high level of human disturbance in the study area, particularly in the northern section, our results indicated that conflicts between conservation and exploitation goals in the GBI are potentially high (Figure 15). The multi-zoning approach, however, explicitly accounts for potential trade-offs, and also maximizes opportunities for co-benefits, between management effort to maintain ESS and biodiversity. In addition, the transboundary nature of the study area was contained in the resulting GBI. Hence, the GBI networks obtained with Marxan with Zones successfully connected the study area along the river network of different sub-catchments in both Spain and Morocco, whereas planning units in coastal and marine realms were selected at the supranational scale, applying a trans-border optimisation.

The approach implemented in this case study allowed us to determine the most efficient allocation of the EBM restoration measures (in terms of the conservation feature targets achieved, spatial extent and arrangement as well as in terms of costs for specific restoration measures) to meet the target 2 of the EU biodiversity 2020. According to our results, the EBM restoration zone improved the connectivity among the PUs contained within the GBI, reducing the patchiness of the core-conservation zones in both transboundary sections in all realms. Lower levels of patchiness are expected to reduce the potential conflicts between available areas outside the GBI and the core and conservation zones.

Our results highlight the relatively high level of uncertainty in the GBI design. This is a consequence of the high degree of potential spatial conflicts between conservation-core zones and sustainable use zones in the GBI. This uncertainty means that several GBI designs can offer equally valid alternative modelling solutions. Uncertainty in the GBI model is an advantage in terms of stakeholder involvement and management flexibility, since the final GBI design to be implemented in the field can be selected among different minimum cost modelling alternatives, according to overall policy and stakeholder priorities in the CS2.

7 Conclusions

Our approach proposes a GBI design based on systematic conservation planning where the optimal allocation of potential EBM restoration measures is implemented in the GBI design itself. Our results are applicable to both marine and terrestrial conservation planning across three different realms - freshwater, coastal, and marine - allowing for a transboundary and comprehensive management. The proposed planning solution delivers an EBM outcome that balances conservation, ecosystem condition and ESs, and provides a visual tool to easily communicate the obtained results to stakeholders.

The application of the spatial planning in this study area was very complex due to the differences between the northern section and the southern section (Europe and Africa, respectively) of the CS2 area. This is partly due to the differences in terms of population, activities pressures, different cultures and different conservation agendas in this region. In CS2, the same policy objectives have been applied in both the northern and southern sections. However, a further improvement would be to assign country and/or river basins specific targets to achieve different policy goals based on country-specific or region-specific policy agendas.

In agreement with the GBI principles, we show that win-win situations where exploitation and conservation goals are concurrently met, are possible. Our results could be used to guide onsite policy decisions on GBI investments and management in the IBRM and its influence area. In addition, the framework we used here may be applied for guiding the investments on GBI in other areas of interest in the EU or beyond the EU borders.

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* For a detailed list of references regarding methodological issues, please see Annex III.

Annex

All annexes are available on the AQUACROSS website Case Studies page.

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