



D9.2 Case Study 5 Report

Improving integrated management of Natura
2000 sites in the Ria de Aveiro Natura 2000 site,
from catchment to coast, Portugal



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About AQUACROSS

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.

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1 Introduction and background

1.1 Freshwater–marine continuum governance challenges

The explicit consideration of human well-being has gained increasing relevance since the Millennium Ecosystem Assessment that was carried out between 2001 and 2005 under the auspices of the United Nations (Millennium Ecosystem Assessment, 2005). One of the challenging questions was – “*what options exist to enhance the conservation of ecosystems and their contribution to human well-being?*” More recently, the United Nations further elaborated through the identification of 17 areas of critical importance for humanity and the planet. These correspond to the Sustainable Development Goals (SDG) for 2030 (UNDP, 2015). It is acknowledged that the answer to the first question and the achievement of the proposed SDGs and targets encompasses several governance challenges, namely regarding the capacity of social-ecological systems to ensure the continuous provision of a desired set of ecosystem services (ES) supporting the economy and human well-being (Gomez et al., 2016, 2017). This is particularly relevant in coastal areas, as human settlements and activities along the freshwater to marine continuum of coastal watersheds have progressively imposed increasing environmental pressures¹. Furthermore, at EU level some of these areas, due to their acknowledged importance, are classified under Natura 2000 Network of protected areas to ensure the existence and conservation of the most valuable and threatened habitats and species (e.g., Rouillard et al., 2018).

Apart from the nature-based classification (Natura 2000 sites), when focusing on an integrated assessment and management of coastal aquatic ecosystems along the freshwater to marine continuum, including science, policy and stakeholders’ perspectives, additional challenges arise, namely:

- ▶ Most natural scientists are specialised in limnology (inland aquatic ecosystems) or in marine ecosystems, meaning that besides combining social and natural scientists, complementary expertise within each of these major domains of knowledge is required (e.g., Lillebø et al., 2015).
- ▶ EU water-related directives - Water Framework Directive (WFD) (2000/60/EC), Marine Strategy Framework Directive (MSFD) (2008/58/EC) and Floods Directive (FD) (2007/60/EC) (European Union, 2016) - and EU Nature Directives - Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC) and associated policy instruments have defined territorial limits, requiring better coordination between policies crossing freshwater, coastal and marine environments (European Union, 2016; Rouillard et al., 2018).
- ▶ Stakeholders’ sectoral activities (including public and private sectors), management actions, spheres of interest (including direct and indirect users) might generate conflicting interests (e.g., downstream loading of nutrients and eutrophication; upstream saltwater intrusion and salinization) that need to be considered.

In this report, we draw on the AQUACROSS Assessment Framework (AF) to apply Ecosystem based management (EBM) and address these management challenges in the Vouga river coastal watershed, specifically the Ria de Aveiro Natura 2000 site, from catchment to coast. EBM planning processes represent a holistic approach that aims to balance the multiple interrelated dimensions of ecological integrity and human well-being. In one sentence, “*EBM stands for any management or policy option intended to restore, enhance and/or protect the resilience of an ecosystem*” (Gomez et al., 2016, 2017).

The EBM planning process involves the coordination of policies, institutions and practices (Drakou et al., 2017; Piet et al., 2017; Rouillard et al., 2018). In this report we apply the six AQUACROSS principles of EBM from Rouillard et al., 2018:

¹ <http://www.who.int/heli/risks/water/coastalmanagement/en/>

1. EBM considers ecological integrity, biodiversity, resilience and ecosystem services
2. EBM is carried out at appropriate spatial scales
3. EBM develops and uses multi-disciplinary knowledge
4. EBM builds on social–ecological interactions, stakeholder participation and transparency
5. EBM supports policy coordination
6. EBM incorporates adaptive management

To address the governance challenges in the frame of Ria de Aveiro Natura 2000 site, the EBM planning approach followed a stepwise procedure in line with resilience thinking and its principles (Gomez et al., 2016, 2017; Martin et al., 2018). Resilience thinking is a multidisciplinary approach to environmental problem solving that links social and ecological perspectives in a holistic way. The concept emerged from resilience science, adaptive management and ecological policy design, and bridges the gap between social and ecological systems by considering ecology, management of natural capital and systems analysis (Curtin and Parker, 2014; Martin et al., 2018). Within the context of the AQUACROSS AF, resilience thinking aims at: 1) *“assessing the relative merits of the current versus alternative, potentially more favourable stability domains, and 2) fostering resilience of the new development trajectory”* (Gomez et al., 2017).

Explicitly, we use the AQUACROSS Assessment Framework to apply an ecosystem–based management (EBM) planning process to the Ria de Aveiro region, a Natura 2000 freshwater–marine continuum territory. In line with resilience principles (Martin et al., 2018), our application of the Assessment Framework (and this report) follow the following steps:

- i) Identify a baseline scenario, considering the management measures already/to be implemented in 2018/19;
- ii) formulate objectives related to undesirable pressures that arise as side effects of two of those baseline management measures: the dredging programme and the extension of a floodbank;
- iii) screen measures and instruments to understand ecological and social components and their links, combining fundamental and applied sciences;
- iv) construct a narrative that reflects management measures being implemented, stakeholders’ perception of ecosystem services valuation through Spatial Multi–criteria Analysis (SMCA), and the science–based knowledge that is generated, to support planning the EBM response;
- v) evaluate the proposed habitat restoration measures using EBM criteria, taking into consideration policies and feasibility, to show that compliance is achievable.

1.2 Vouga coastal watershed management challenges

The case study area comprises the freshwater to marine continuum of the Vouga river coastal watershed under classification of Natura 2000 network, i.e., the Ria de Aveiro Natura 2000 site. This site was selected following official reports by the Portuguese Nature Conservation and Forests (ICNF), which is responsible for the Sectoral Plan for the Natura 2000 Network². Natura 2000 network is also the basis of the EU Biodiversity Strategy and EU international commitment to the international Convention on Biological Diversity and its Aichi Targets (e.g., Rouillard et al., 2018).

Previous trans-disciplinary studies acknowledged the importance of the geographic location of the Vouga river coastal watershed combined with its natural capital, which has enabled the development of a wide variety of economic, cultural and recreational activities. As a result, the region is subject to a complex

² available at <http://www2.icnf.pt/portal>

variety of land and water uses and potential conflicts, and a number of anthropogenic pressures that impact the hydro-morphological conditions of the lagoon and the adjacent freshwater section of the Vouga river, the Baixo Vouga Laguna (BVL). The region is also vulnerable to ocean storm surges and coastal erosion, and to torrential rain and flood events, meaning that it often requires human intervention for protection or to enable economic activities (Dolbeth et al., 2016; Lillebø et al., 2015; Sousa et al., 2017). In this context, we focus on two major interventions, which have been under public consultation and have passed institutional fitness check, and are to be implemented in 2018/2019 in the case study area, under the responsibility of the Portuguese Environmental Agency:

- i) dredging programme to enable hydrodynamic equilibrium and navigability in Ria de Aveiro coastal lagoon (RECAPE et al., 2018);
- ii) extension of a flood bank to disable surface saltwater intrusion into BVL agricultural areas named *Sistema de Defesa Primária do Baixo Vouga Lagunar* (DGADR, 2017);

These two management options will cause negative, unintended impacts on biodiversity.

In light of this context, our aims for this case study are:

- a) to contribute to operationalising an EBM planning process in response to the foreseen unintended impacts resulting from the present management options;
- b) to mitigate the unintended impacts from a major dredging programme targeting the hydrodynamic equilibrium (APA, 2018);
- c) to mitigate the unintended impacts from the extension of a floodbank targeting surface saltwater intrusion into agricultural areas (DGADR, 2017);
- d) to make use of the best available information in a trans-disciplinary context.

In this report, we present the AQUACROSS AF to apply EBM considering two spatial scales, the entire Natura 2000 area and the area at the confluence of Vouga river with Ria de Aveiro coastal lagoon, the Baixo Vouga Lagunar (BVL) (Figure 1), in order to better consider current and future stakeholders. For a detailed description of each spatial scale approach please see (Lillebø et al., VSI; Martínez-López et al., VSI).

This case study also aimed to show case for causality links in a linkage chain relating activities, pressures and habitats/ highly mobile biotic groups and ES (see Teixeira et al., VSI), to assess the vulnerability of ecosystem components regarding the provisioning of ES. To this end, in the scope of AQUACROSS WP5 the AquaLinks Tool was developed and tested with this case study data.

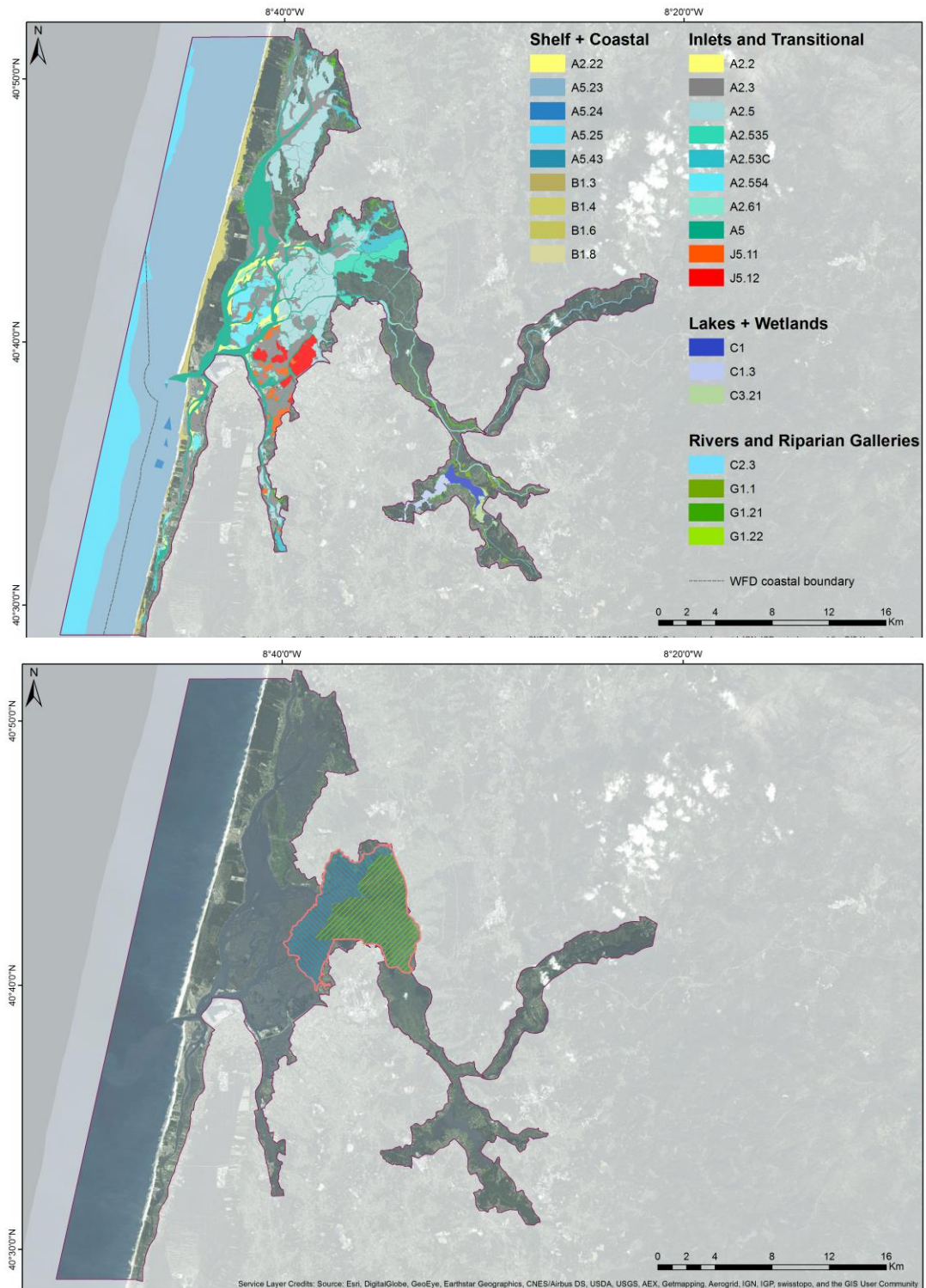


Figure 1 – The location of the freshwater to marine continuum of Vouga river coastal watershed under classification of Natura 2000 network with the identified aquatic habitats following EUNIS classification (top), and the location of Baixos Vouga Lagunar (BVL) (lowest). In the BVL map, green indicates upstream and blue the downstream area of the floodbank.

2 Establishing objectives

2.1 Identifying policy objectives

As a first step in the EBM planning process, in this section, we identify the overarching policy plans, programmers, and objectives relevant to managing biodiversity within the case study. We also introduce the key governance institutions, who also play an important role in managing the catchment. Key management options foreseen at local/regional level under consideration are the dredging programme, named *Sediment Transposition for Optimization of Hydrodynamic Equilibrium in the Ria de Aveiro*, that takes place in 2018/2019 (APA, 2018); and the extension of a floodbank to prevent surface saltwater intrusion into agricultural areas, at the confluence of the river Vouga and the Ria de Aveiro coastal lagoon, that also takes place in 2018/2019 (DGADR, 2017). The most relevant policy plans and programmes, and objectives for the planning process of EBM responses are presented in Table 1. In Table 1a) the relevant policy plans and programmes are linked to EU policies, whilst in Table 1b) the link to Regional/local policies is shown. The most relevant institutions to be considered, both at national and regional levels in the planning process of EBM responses are presented in Table 2.

Table 1 – Identification of the relevant policy plans and programmes, and objectives for the planning process of EBM responses in the selected Natura 2000 area, as well as the links to EU policies a) and regional/local policies b), from (Lillebø et al., VSI).

Selected policy plans and programmes	Objectives	a) Link to EU Policies
River Basin Management Plan (PGBH - RH4) Portuguese Environment Agency (APA/ARHC) Sectoral Plan for Natura 2000 Network (PSRN2000) Institute for Nature Conservation and Forests (ICNF)	Outlines the water planning for the tri-basin region of Vouga, Mondego and Lis, in accordance with WFD	WFD (2000/60/EC)
National Water Plan (Decreto-Lei n.o 76/2016) Inter-ministerial Commission for Water management: APA/ARHC; ICNF; Regional Directorate for Agriculture and Fisheries (DRAP); Directorate-General for Marine Resources (DGRM)	Territorial management tool for the implementation of the national policy for the conservation of biological diversity, aiming at the safeguarding and enhancement of the sites and SPAs of the continental territory, as well as the maintenance of species and habitats in a favourable conservation status in these areas	Birds Directive (2009/147/EC); Habitats Directive (92/43/EEC)
National Strategic Plan for Tourism (PENT) Ministry of Economy and Innovation	Governmental cross-sectoral management for the next 10 years: Increase water productivity and promoting its rational use, with maximum respect for the territorial integrity of the river basins; Protection, conservation and rehabilitation of water resources and associated ecosystems; Meeting the needs of the population and the country's economic and social development; Respect for relevant national and Community legislation and satisfaction of the international commitments assumed by the Portuguese State; Access to information and participation of citizens in the management of water resources	WFD (2000/60/EC) Floods Directive (2007/60/EC) MSFD (2008/56/EC)
National Strategic Plan for Climate change adaptation (ENAC) Ministry of Environment	Serves as the basis for the implementation of a series of initiatives aimed at fostering sustained growth of national tourism over the coming 10 years, and guiding the activities of Portugal National Tourism Authority, as the key public body for the sector.	EU strategy for a smart, sustainable and inclusive growth (COM(2014) 85 final, 2014/0044)
	Sets the ground for the need for adaptation. Contains the National adaptation strategy, and the associated action plan, including reducing vulnerability and increasing the response capacity.	EU Strategy on Adaptation to Climate Change (COM (2013) 216)

Selected policy plans and programmes	Objectives	b) Link to Regional/local Policies
<p>Polis Litoral Ria de Aveiro APA/ARHC; ICNF</p> <p>Coastal Zone Management Programme Ovar – Marinha Grande (POC-OMG) APA/ARHC</p> <p>Vouga Estuary Plan (PE Vouga – not yet developed) APA/ARHC</p>	<p>Integrated Operations of Rehabilitation and Recovery of Coastal Areas. Strong collaborative work between central administration and the Ria de the Aveiro Region Inter-municipal Community (CIRA)</p> <p>Reconcile the various conflicts of uses of the coastal zone, promoting the articulation of environmental, economic and social factors related to coastal management.</p> <p>Territorial planning tool, which establish appropriate meas valorisation of water resources in the area to which their sus secure manner, linking the Public Administration and users.</p>	<p>This study addresses the regional policy instruments and contributes to the Vouga estuary management plan as well as contributes to the Regional strategy for smart specialization (RIS3 Centro)</p>

Table 2 – Identification of the main institutions and policy domains for the planning process of EBM responses in the selected Natura 2000 area.

Institution	Policy domain	Additional information
Portuguese Environmental Agency (APA, I.P.) through the Regional Hydrographic Administrations (ARH Centro)	River Basin Management Plan (WFD) and Flood Risk Management Plan (Floods Directive) for hydrographic Region 4 (RH4) that includes Vouga, Mondego and Lis Rivers, and the foreseen estuary land use and management plans.	APA / ARHCentro is responsible for: water resources management; spatial planning of water resources, uses (including the economic analysis) and demands, and law enforcement; and for the strategic and integrated planning of the coastal zone.
Institute for Nature Conservation and Forests (ICNF, I.P.)	Sectoral Plan for Natura 2000 Network (Habitats, Birds Directives; Biodiversity Strategy)	ICNF, I.P. is the national authority for nature conservation, biodiversity and forests; articulates and promotes the integration of forest policy and the conservation of nature and biodiversity in policies to combat desertification, to mitigate climate change and its effects, and to reduce the country's energy dependence.
Centro Region Department of Agriculture and Fisheries (DRAPC)	Common agricultural policy (CAP) and Common Fisheries Policy (CFP)	DRAPC is a service of the Ministry of Agriculture, Forestry and Rural Development, whose mission is to participate in the formulation and implementation of policies in the areas of agriculture, rural development and fisheries, as well as collaborate in the policies in the areas of forests, food security and plant health, in liaison with relevant central bodies and services within the framework of the efficiency of local management of resources.
Directorate general for Natural Resources, Safety and Maritime Services (DGRM)	Marine Strategy Framework Directive (MSFD) and Maritime Spatial Planning (MSP)	DGRM is a government entity of the Ministry of the Sea, a central office of direct administration of State, with administrative autonomy with the mission, under the maritime administration functions, to implement and execute policies concerning the maritime safety and the prevention of pollution by ships as well as to ensure regulation, inspection, national coordination and control of activities developed under these policies.
The Centro Regional Coordination and Development Commission (CCDR)	Promote an integrated and sustainable development of Portugal's Centro region (NUT II)	CCDR is tasked with coordinating and promoting at the regional level governmental policies with regard to Regional Planning and Development, Environment, Land Management, Inter-Regional and Cross-Border Cooperation and also support to local government and inter-municipal associations. CCDR-C's fields of intervention also encompass the management of regional operational programmes funded by the European Union, as well as other regional development financing instruments.

2.1.1 Detailed assessment of key policies

From the above selected policy plans and programmes, three are now detailed due to their particular relevance for the implementation of the EBM response in terms of biodiversity. These are Sectoral Plan for Natura 2000 Network (PSRN2000), Vouga River Basin Management Plan (Vouga RBMP) and Vouga River Estuary Plan (POE Vouga). The three plans are now analysed considering how they impact the state of the local ecosystem, drivers, and pressures.

Sectoral Plan for Natura 2000 Network (PSRN2000)

The PSRN2000 (ICNF, undated) directly links to the implementation of BD and HD through the Natura 2000 Network in Portugal, and its overall outcome concerns the reduction of threats to ensure protection and enhancement of biodiversity.

- ▶ **State:** the instrument works to coordinate action among various administrative levels, creating links between public entities and drafting the strategic framework to achieve an appropriate level of protection of these areas at the local level through management of use and activities therein.
- ▶ **Drivers:** the existence of the network, and its promotion as a valuable Portuguese resource for tourism and recreation, may result in an increase in the consumption of outdoors and nature activities. This plan also acts on drivers through the regulation of human activities stemming from designation of nature conservation areas.
- ▶ **Pressures:** through the regulation of economic activities, this instrument contributes to the reduction of pressures on the environment, in particular those physical impacts associated with land use change.

Vouga River Basin Management Plan (Vouga RBMP)

The overall impact of Vouga RBMP (APA, 2015) instrument in terms of biodiversity protection is mixed, as it combines measures that aim to enhance, protect, and converse water resources, as well as those which ensure the viability of economic activities in the region into the future. This instrument is the ground level implementation instrument for the WFD, and acts on:

- ▶ **State:** through the establishment of environmental objectives for water bodies.
- ▶ **Drivers:** this instrument regulated water protection and uses in the CS area, and thus can result in the reduction of the threat through the regulation of those activities. However, other measures under this plan involve the construction of new infrastructures (e.g., the BVL floodbank) and measures that ensure water supply and water security, which may support further urban development.
- ▶ **Pressures:** the impact of this instrument on hydro-morphological pressures is mixed as it introduces additional pressures (e.g., the BVL flood bank, water infrastructure to reduce water scarcity, dredging and sediment transport) while regulating pre-existing pressures.

Vouga River Estuary Plan (POE Vouga)

The POE Vouga (CIRA 2010, Fidelis and Carvalho, 2015) (CIRA, 2010; Fidelis and Carvalho, 2015) has not yet been developed and thus information on implementation (and impacts thereof) is lacking. However, it is an ambitious plan that aims to conserve and enhance the estuary and promote its sustainable use of water resources, integrated management of water realms and their sediments, ensure functioning of estuarine ecosystem, and other threatened aquatic ecosystems, habitats and their species, and coordination between various territorial management instruments. This is particularly relevant as stakeholders acknowledged the lack of integrated management and communication between entities; lack of landowners' involvement; need for more information and awareness in the municipal councils; and lack of policy surveillance (Lillebø et al., VSI) (see section 2.2 for an overview of stakeholder engagement).

- ▶ **State:** The plan envisions environmental restoration of the estuary and associated ecosystems (e.g. freshwater, transitional and coastal waters).
- ▶ **Drivers:** This instrument will act upon various sectoral drivers by regulating activities and use of natural resources of the estuary, as well as increase environmental management as related to conservation and restoration activities.
- ▶ **Pressures:** the plan aims to reduce pressures on the estuary and its ecosystem by addressing regulating activities of drivers of change in the area.

Overall case study policy objectives

Accordingly and in summary, the main policy objective that we identify is to address regional policy instruments, contributing to the Vouga estuary management plan (POE Vouga) (Fidélis and Carvalho, 2015) and at the end contribute to the regional strategy for smart specialisation (RIS3 Centro). The estuary plan area is discussed in Fidélis and Carvalho (2015) and is considered as management boundary in O'Higgins et al., (2018). Furthermore, Vouga estuary management plan under the responsibility of the Portuguese Environment Agency (APA/ARHC) requires coordination with:

- i) Sectoral Plan for Natura 2000 Network (PSRN2000), under the responsibility of the ICNF, which is the territorial management tool for the implementation of the national policy for the conservation of biological diversity; and
- ii) Climate change projections and the National Strategic Plan for Climate change adaptation.

The latter contains the National adaptation strategy, and the associated action plan, including reducing vulnerability and increasing the response capacity to climate change and is particularly relevant in Aveiro region coastal area (Lillebø et al., 2015; Luís et al., 2018; Pereira and Coelho, 2013; Stefanova et al., 2015).

2.1.2 Policy synergies and gaps regarding biodiversity in water-dependent Natura 2000 sites

While the above policy analysis shows that there are synergies between the selected policies managing biodiversity in the Ria de Aveiro Natura 2000 site, here we focus on policy gaps, with the final aim to support policy coordination within the frame of the EBM principles.

Policy gap one – lack of harmonised monitoring programmes for the WFD and HD

EBM requires decision-maker to monitor policy impact. In the local case, this would include the unintended pressures resulting from the present management options. One of the main challenges concerns the use of the best available information. Although most information concerning Ria de Aveiro Natura 2000 site that is reported in frame of WFD and HD and BD is available or provided under request, data sets are not harmonised. As CS5 is a water-dependent Natura 2000 a policy gap identified is the lack of WFD and HD monitoring programmes in a harmonised and integrated approach. Although each directive has its own objectives, an integrated approach for Ria de Aveiro Natura 2000 site would support EBM.

Policy gap two – Issues of scale covering freshwater to marine continuum

The Ria de Aveiro Natura 2000 site comprises the freshwater to marine continuum of the Vouga river coastal watershed under classification of Natura 2000 network. In this context, the first identified gap links to the second one as the policy analysis also identified the need for a better coordination between policies crossing freshwater, coastal and marine environments. However, this gap is foreseen in the Vouga estuary management plan (POE Vouga), which also foresees the coordination between various territorial management instruments as well as stakeholders' sectoral activities. In this sense POE Vouga appears to be an opportunity for EBM. The development of this management plan should therefore involve

complementary expertise between and within natural and social sciences, as well as stakeholders, namely CIRA - Inter-municipal Community of the Aveiro Region.

2.2 Co-design

Stakeholders have been central to Case Study 5 work throughout the project. The Portuguese Environment Agency, through its Regional Hydrographic Administration for Portugal Centro Region (APA/ARHCentro) was engaged at a very early stage of the project, as they are part of the AQUACROSS Science-Policy-Business Think Tank (SPBTT). Other stakeholders' were engaged in the final conference of a previous project (ADAPT-MED, 2015), and have since contributed to the datasets that support the development of the scenarios (e.g., Institute for Nature Conservation and Forests (ICNF, I.P.); Regional Directorate for Agriculture and Fisheries (DRAP Centro); Hydrographic Institute (IH); Directorate-General for Marine Resources (DGRM).

3 Assessing the current state of the social-ecological system

As the next step towards developing and evaluating ecosystem-based management measures and policies the AQUACROSS AF requires a clear definition of each component of D-P-S relationships and the development of comprehensive lists of all relevant elements, which can be linked in those relational chains (Gomez et al., 2017). This approach links the socio-economic and the ecological systems by making a clear distinction between:

- “i) the activities that benefit from the provision of natural goods and services for the production of final goods and services that are of direct concern for human welfare;*
- ii) the drivers of pressures affecting ecosystems, represented by the specific demands of naturally provided goods and services in the quantity, quality required at specific places and moments of time;*
- iii) the primary activities that (co-) produce goods and services provided by natural capital that are of direct concern to explain the pressures over ecosystems.”*

The assessment of Ria de Aveiro Natura 2000 site current state included the identification of the specific primary activities and the respective pressures considering the habitats identified in each water domain, i.e., freshwater, transitional and marine/coastal (please see section 3.2 for more detailed description).

3.1 Assessment of primary activities and pressures

The relevant activities within the freshwater domain are agriculture, fishing (professional and recreational), manufacturing industries, agriculture and livestock, tourism, leisure and recreational. In the transitional waters domain the main activities are fishing (commercial and recreational), aquaculture, salt production, manufacturing industries, nautical activities and sports, tourism, leisure and recreational. In the coastal/marine domain the most relevant activities are fishing (professional and recreational), tourism, leisure and recreational. Figure 2 shows the spatial distribution of the main activities within the selected Natura 2000 area, and Figure 3 shows the spatial distribution of the main activities identified at Baixo Vouga Lagunar (BVL).

Maritime trade through Aveiro Port, located in the transitional water's domain, in combination with terrestrial transport connections, is considered as one of the most important economic activities in the region. In fact, *“with an annual throughput of around 3.5 million tonnes, Aveiro is a multi-functional port which plays a crucial role in serving a wide range of industries in its hinterland, such as the ceramics, chemical,*

winemaking, metallurgic, wood and derivatives industries, as well as the agricultural food and construction sectors”³.

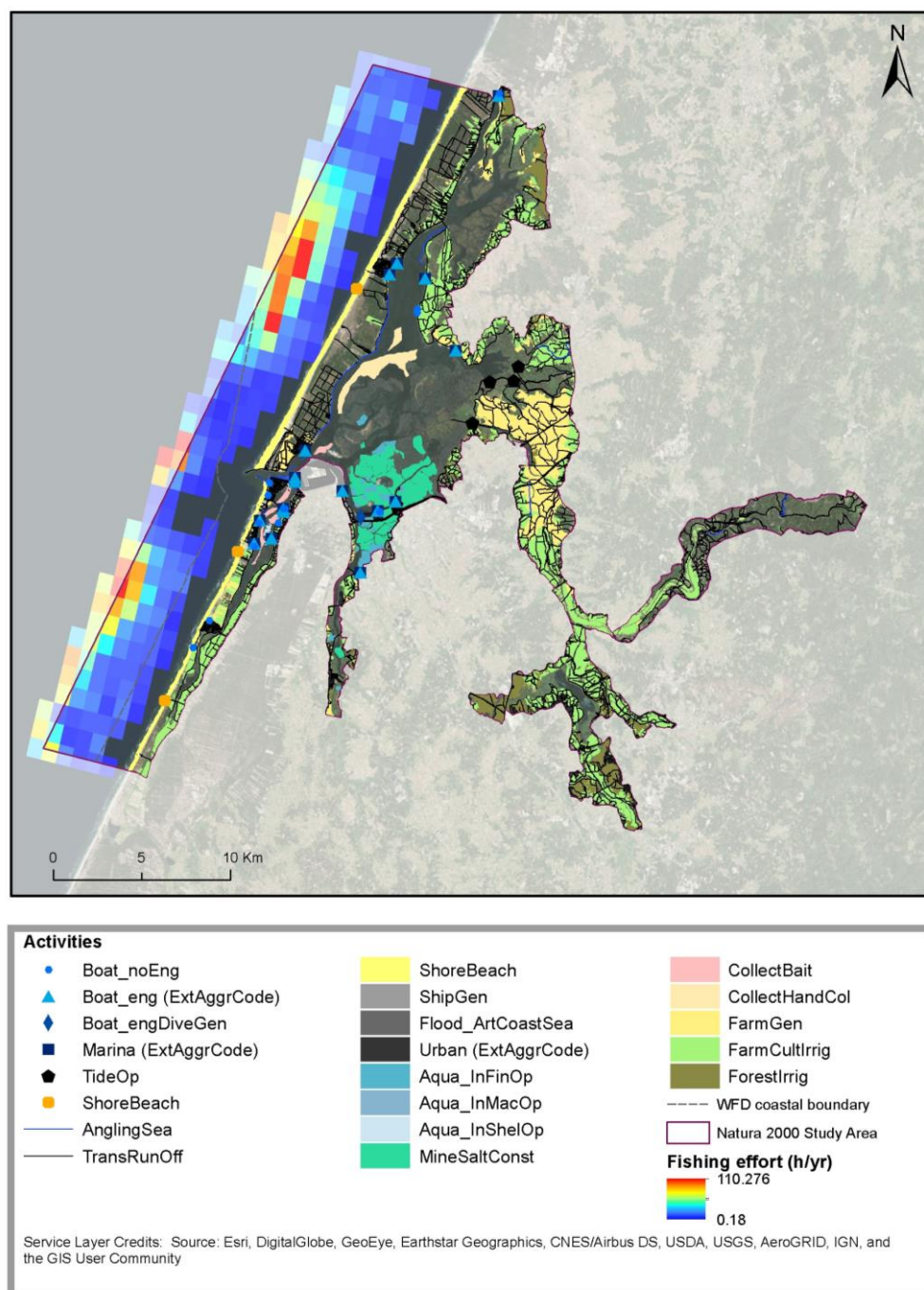


Figure 2 – The main activities identified at the Vouga river coastal watershed under classification of Natura 2000 network

³ <http://en.portodeaveiro.pt/>

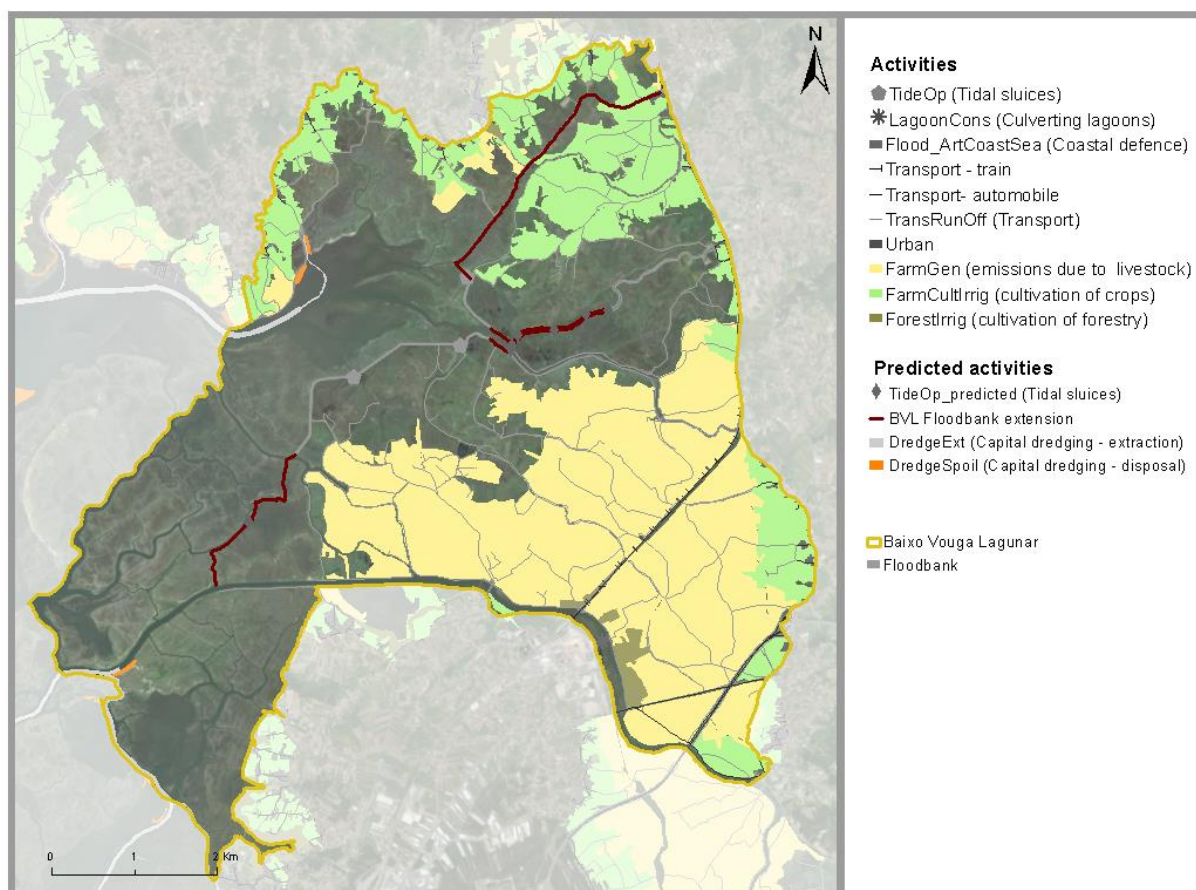


Figure 3 – The main activities identified at Baixos Vouga Lagunar (BVL).

3.2 Assessment of current Biodiversity–Ecosystem Functioning–Ecosystem Services

Following the methodology described in (Teixeira et al., SVI), the potential of a given habitat to supply ES was attained using a lookup table on the contribution of each EUNIS habitat and highly mobile biotic groups (considering their lifecycle) to a given ES provision, compiled on the basis of expert judgement involving researchers from all AQUACROSS case studies.

In brief, the lookup table for this case study considered three aquatic domains:

- ▶ Freshwater - section of the river Vouga (2769 ha); the area at the confluence of Vouga river with Ria de Aveiro coastal lagoon, the BVL (3000 ha) and the freshwater wetland Pateira de Fermentelos (262.5 ha), also designated as Ramsar site;
- ▶ Transitional - Vouga river estuary, which is part of Ria de Aveiro coastal lagoon (20 737 ha);
- ▶ Coastal/Marine - adjacent coastal and shelf waters (30642 ha).

Habitats were classified and mapped at the most detailed EUNIS levels possible, as shown in Figure 4 and Figure 5. In detail, Figure 4 shows the spatial distribution of habitats within the selected Natura 2000 area, and Figure 5 shows the main habitats identified at Baixos Vouga Lagunar (BVL).

Following the freshwater to marine continuum of Vouga river coastal watershed, under classification of Natura 2000 network, the landscape characterisation corresponds to: generally well-preserved riparian gallery; BVL landscape comprises small holdings with living edges used for agriculture, open agricultural

fields and wetlands; Pateira de Fermentelos is a natural freshwater wetland on the course of the river Cértima, an effluent of river Vouga; Ria de Aveiro is a shallow mesotidal coastal lagoon connecting Vouga River catchment area to the Atlantic Ocean with four main channels, several smaller channels, islands, intertidal sand and mudflats, *Zostera noltei* meadows and one of the largest continuous saltmarshes (e.g., *Spartina maritima*, *Juncus maritimus*) in Europe; the adjacent coastal area is separated from the lagoon by a dune system that includes the São Jacinto Dunes Natural Reserve; in the sea side it comprises extensive white sand beaches; the sea exhibits a strong seasonal upwelling, especially in summer, which is particularly relevant for pelagic fauna.

Regarding ecosystem components, the freshwater domain supports fish migratory species; mammals, birds, reptiles, and amphibians; the transitional domain supports several fish, crustacean, bivalves and worm species with economic interest; the coastal/marine domain also supports several fish species relevant for small-scale fisheries. The connectivity between the three aquatic domains is particularly important for the European eel that is a socio-economic relevant species. For a more detailed description see (Lillebø et al., VSI; Martínez-López et al., VSI); O'Higgins et al., 2018).

Concerning wildlife, BVL is important for 173 species of birds, such as the fish-hawk (*Pandion haliaetus*), the pied avocet (*Recurvirostra avosetta*), the purple heron (*Ardea purpurea*), the black kite (*Milvus migrans*), the mallard duck (*Anas platyrhynchos*) and the white stork (*Ciconia ciconia*) (ADAPT-MED, 2015). Plus it is an important habitat for mammals like the least weasel (*Mustela nivalis*), the hedgehog (*Erinaceus europaeus*) and the European otter (*Lutra lutra*), for amphibians like the common toad (*Bufo bufo*), the tree frog (*Hyla arborea*), the fire salamander (*Salamandra salamandra*), the marbled newt (*Triturus marmoratus*) and the Iberian Painted Frog (*Discoglossus galganoi*), for reptiles, namely the Iberian emerald lizard (*Lacerta schreiberi*) and the viperine water snake (*Natrix maura*), and for several fish species including the eel (*Anguilla anguilla*) and the lamprey (*Petromyzon marinus* and *Lampetra planeri*) (ADAPT-MED, 2015). According to the EU Directive 92/43/EEC some of these species are classified as "strictly protected" (e.g. the otter and the tree frog). Also for IUCN (International Union for Conservation of Nature⁴), the otter is in the "red list", classified as "Near Threatened" as well as the Iberian Emerald Lizard.

⁴ <https://www.iucn.org/pt>

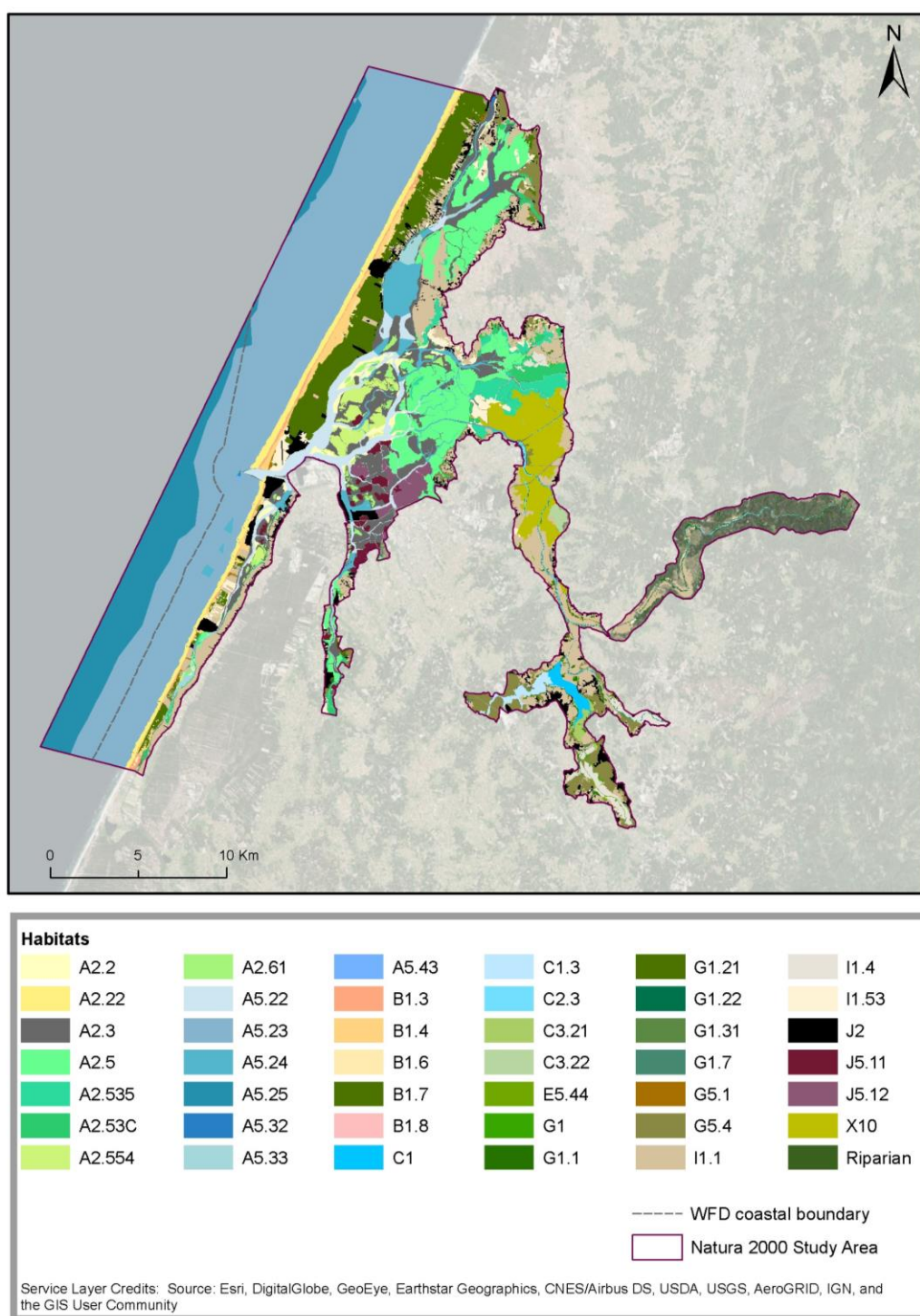


Figure 4 – The EUNIS habitats identified at the Vouga river coastal watershed under classification of Natura 2000 network

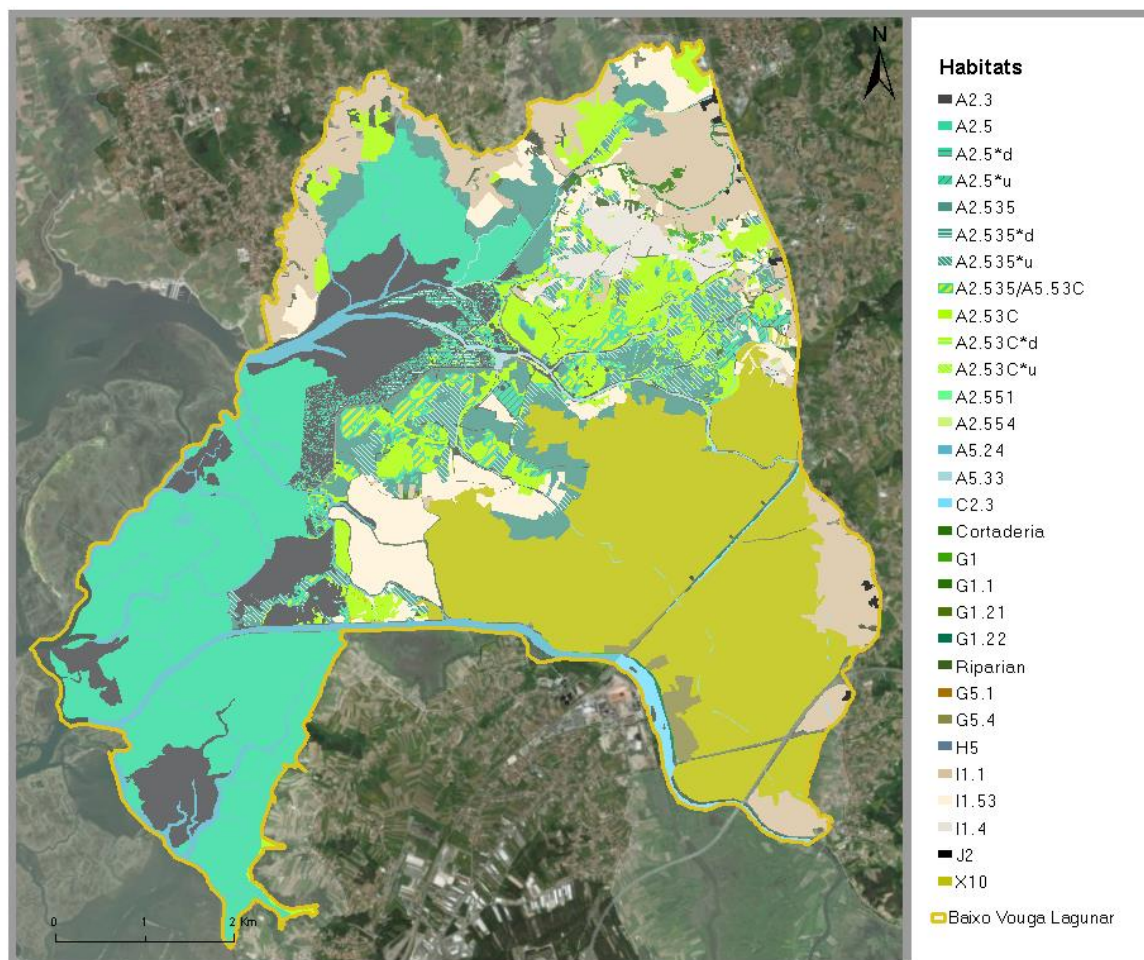


Figure 5 – The EUNIS habitats identified at Baixos Vouga Lagunar (BVL).

3.3 Assessment of current Drivers–Pressures–State

To better characterise the demand for ES, the Activities in the Case Study have been linked to the pressures they may cause in the ecosystem, based on a combination of academic and stakeholders' expertise and knowledge. These pressures have then been characterised regarding their Severity, Persistence, and potential of Dispersal of a given Activity-Pressure combination. The overlap of a given Pressure / Activity with the main ecosystem components was also described according to its Extent and Frequency. The rationale for this characterisation is fully described in (Borgwardt et al., VSI). A total number of 20 aggregate activities introducing 26 pressures were identified from literature (e.g., Dolbeth et al., 2016) and expert judgement involving AQUACROSS team. This revealed 904 interactions between an activity, pressure and an ecosystem component in Vouga river coastal watershed, excluding cases where 'No overlap' between a pressure and an ecosystem component were reported.

Figure 6 illustrates the linkage framework between the specific primary activities, the respective pressures considering the habitats identified in each realm.

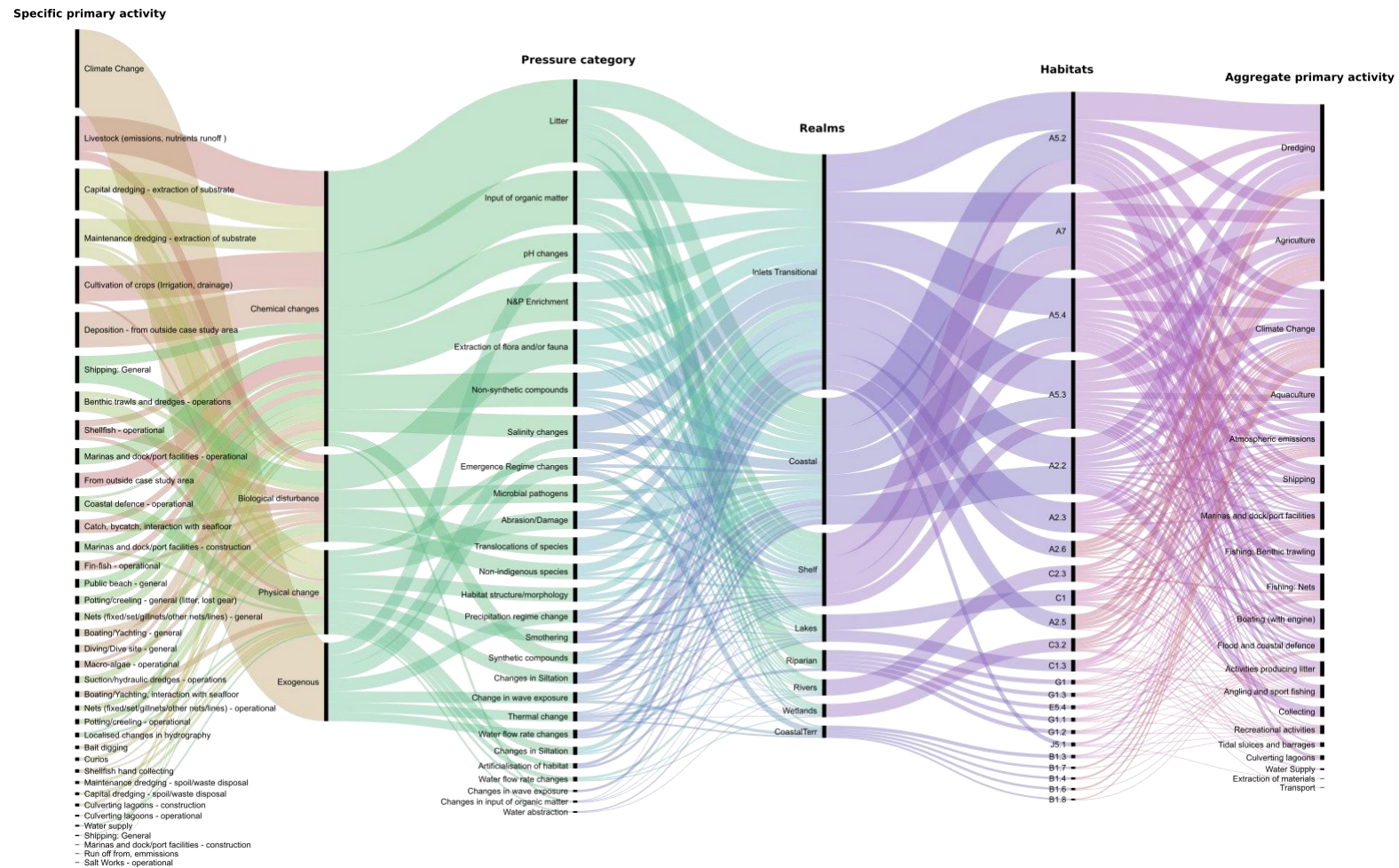


Figure 6 – Linking Drivers and Pressures in the in the Vouga river coastal watershed (plotted with Mauri et al., 2017).

3.4 AquaLinksTool: ES provisioning risk assessment

The AquaLinksTool (see Annex 4-8.1.4), developed in the scope of AQUACROSS project, was applied to assess the causality links in the Vouga River linkage chain, relating activities, pressures and habitats/ highly mobile biotic groups and ES. This enables assessment of the vulnerability of ecosystem components regarding the provisioning of ES, as shown in

Figure 7. In this figure the inner ring stands for the case study realms, with each colour representing a different realm; the second ring stands for the habitats identified within each realm, and the outer ring stands for the habitats that were classified using AquaLinksTool at risk for ES provisioning.



Figure 7 – Vulnerability of the Vouga river coastal watershed habitats under classification of Natura 2000 network to ES provisioning defined with AquaLinksTool (plotted with Mauri et al., 2017).⁵

⁵ EUNIS habitats codes: A5.23 Infralittoral fine sand; A5.25 Circalittoral fine sand; A2.22 Barren or amphipod-dominated mobile sand shores; A5.23 Infralittoral fine sand; A5.24 Infralittoral muddy sand; A5.25 Circalittoral fine sand; A5.43 Infralittoral mixed sediments; B1.3 Shifting coastal dunes; B1.4 Coastal stable dune grassland (grey dunes); B1.6 Coastal dune scrub; B1.8 Moist and wet dune slacks; A2.2 Littoral sand and muddy sand; A2.3 Littoral mud; A2.5 Coastal saltmarshes and saline reedbeds; A2.535 *Juncus maritimus* mid-upper saltmarshes; A2.53C Marine saline beds of *Phragmites australis*; A2.554 Flat-leaved *Spartina* swards; A2.61 Seagrass beds on littoral sediments; A5 Sublittoral sediment; A7 Pelagic water column; J5.11 Saline and brackish industrial lagoons and canals; J5.12 Saltworks; C1 Surface standing waters; C1.3 Permanent eutrophic lakes ponds and pools; C3.21 Common reed (*Phragmites*) beds; C3.22 Common clubrush (*Scirpus*) beds; C2.3 Permanent non-tidal smooth flowing watercourses; G1 Broadleaved

By supporting the identification of the most vulnerable habitats regarding the provisioning of ES, AquaLinksTool can support decision-making. Specifically in this case study the habitats that were pinpointed by AquaLinksTool clearly match the environmental concerns reported by stakeholders during the first workshop (Lillebø et al., VSI), meaning that stakeholders perception matches scientific data. As this information can be mapped it supported the identification of the areas of major concern. These results were overlaid with the areas that are expected to become affected by the dredging programme and by the extension of the floodbank in order to develop the baseline scenario. The combined results showed that the transitional water realm required spatially explicit responses. The generated maps are to be discussed with stakeholders during the second workshop that will take place in the 20th of September.

AquaLinksTool is therefore a very useful tool to support spatially explicit ES risk assessment and in this way support communication. Namely, in this case study results will support the communication of AQUACROSS team with the APA/ARHCentro, responsible for the Vouga RBMP and for the future POE Vouga, and with ICNF, responsible for the implementation of the PSRN2000.

3.5 Linkage framework

As stated in AQUACROSS AF “*For an improved understanding of aquatic SES and its interconnections, the AQUACROSS architecture considers two interrelated sets of linkages between the ecological and the socio-economic parts of the system*”. Therefore, to visualise the Drivers – Pressures - Ecosystem Component - Ecosystem Function - Ecosystem Services ‘behind’ the baseline scenario considering the transitional water realm a linkage framework was plotted considering the aggregated primary activities of dredging (representing the dredging programme) and flood and coastal defence (representing the extension of the floodbank) and the transitional waters domain regarding ecosystems components, functions and services. Figure 8 illustrates the Drivers-Pressures-Ecosystem Component-Ecosystem Function and Ecosystem Services linkage framework for the transitional waters

deciduous woodland; G1.1 Riparian and gallery woodland (Alnus Betula Populus or Salix); G1.21 Riverine Fraxinus - Alnus woodland; G1.22 Mixed Quercus - Ulmus - Fraxinus woodland of great rivers; G1.31 Mediterranean riparian Populus forests

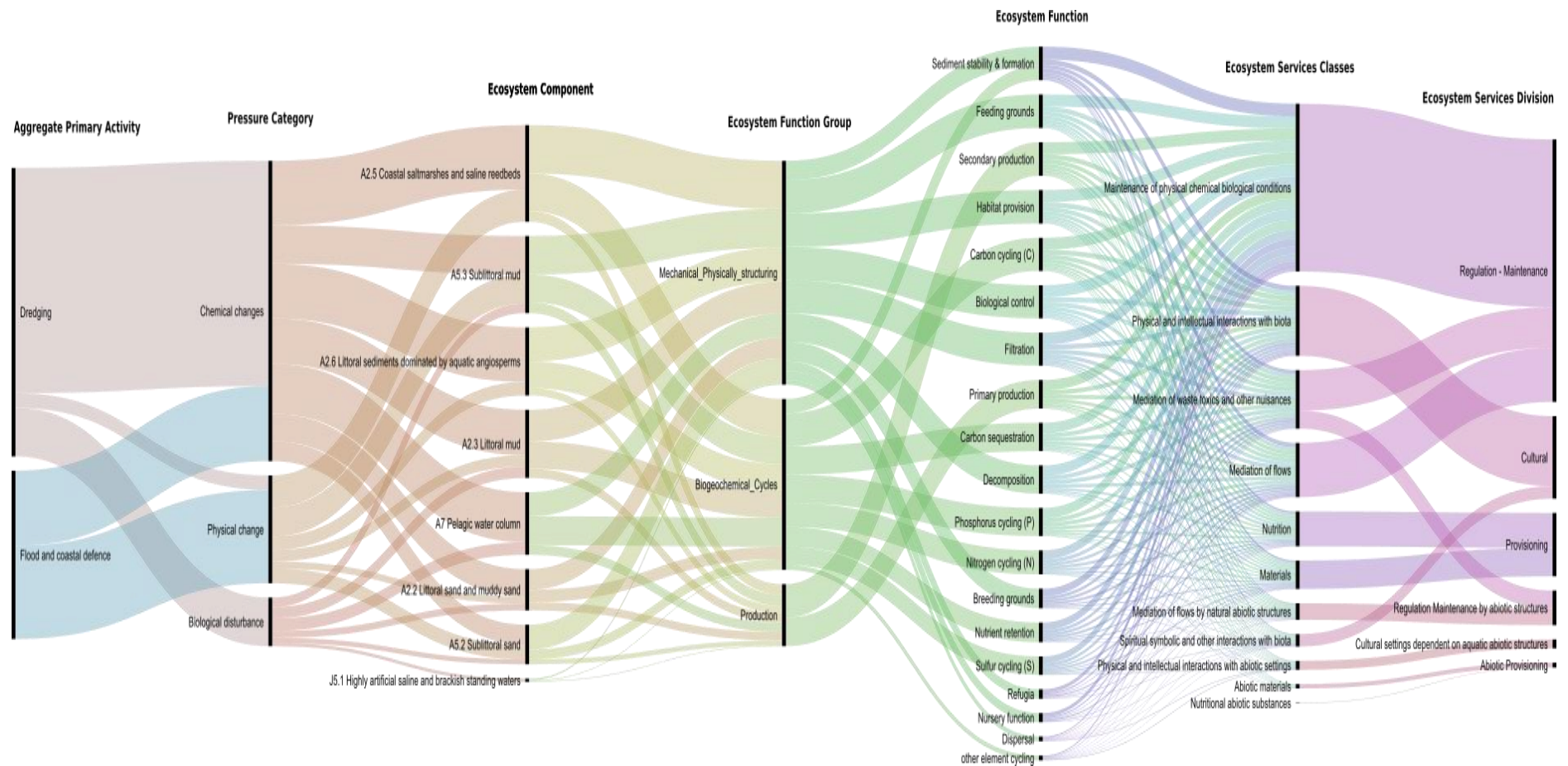


Figure 8 – Linkage framework for Drivers–Pressures–Ecosystem Component–Ecosystem Function and Ecosystem Services in the transitional waters domain of the Vouga river coastal watershed (plotted with Mauri et al., 2017).

3.6 Assessing the knowledge base of the ecological system

The following EBM principles from Rouillard et al., (2018) are especially relevant when considering assessing the knowledge base of the ecological system:

1. EBM considers ecological integrity, biodiversity, resilience and ecosystem services
2. EBM is carried out at appropriate spatial scales

We acknowledge as a major challenge the use of the best available information regarding knowledge base of Ria de Aveiro Natura 2000 site ecological system. As analysed in section 2.1.2 we identified gaps in the available data sets and will propose as part of our EBM plan an integrated approach to harmonised WFD and HD monitoring programmes in water-dependent Natura 2000 sites. This would also imply a better coordination between monitoring programmes crossing freshwater, coastal and marine environments. A shared water-continuum data base would clearly support decision-making, which is also part of our EBM plan.

3.7 Assessing the knowledge base of the social system

The following EBM principles from Rouillard et al., (2018) are especially relevant when considering assessing the knowledge base of the social system:

4. EBM builds on social–ecological interactions, stakeholder participation and transparency
5. EBM supports policy coordination

The governance of Ria de Aveiro Natura 2000 site involves a multiplicity of institutions, organisations and stakeholders, and involves the articulation of programs and plans of local, regional and national levels (e.g. Fidélis and Carvalho, 2014; Fidelis and Roebeling, 2015; Lillebø et al., 2015; Sousa et al., 2017). Relevant examples of stakeholders are included in Table 3. As mentioned in section 2.1.1 and detailed in (Lillebø et al., VSI) stakeholders still acknowledge the lack of integrated management and communication. Therefore, our EBM plan also foresees the involvement of landowners' and municipal councils in order to increase information and awareness. From the analysis carried out in section 2.1.2 the POE Vouga appears as an opportunity for EBM in Ria de Aveiro Natura 2000 site. Therefore, development of this management plan should come forward.

Table 3 – Identification of key stakeholders for the planning process of EBM responses (from (Lillebø et al., VSI))

Policy / Governance	
<i>Environment</i>	APA/ARHCentro - Portuguese Environmental Agency ICNF - Institute for Nature Conservation and Forests
<i>Fisheries and Agriculture</i>	DRAPC - Centro Region Department of Agriculture and Fisheries
<i>Marine</i>	DGRM - Directorate-general for Natural Resources, Safety and Maritime Services
Business	
<i>Industry</i>	Portucel - The Navigator Company
<i>Tourism</i>	Incrível Odisseia - Moliceiros boat rides Sterna - Solar boat tours and bird watching
<i>Agriculture</i>	ABBVL - Association of Beneficiaries of Baixo Vouga Lagunar ACRM - Association of Breeders of Marinhova Breed ALDA - Association of Agriculture of the District of Aveiro

<i>Fisheries</i>	APARA - Artisanal Fishing Association of the Region of Aveiro
<i>Aquaculture</i>	APA – Portuguese aquaculture association
<i>Services</i>	APA - Port of Aveiro Administration (APA)
Public Administration	
<i>Regional Administration</i>	CCDRC - The Centro Regional Coordination and Development Commission CIRA - Inter-municipal Community of the Aveiro Region
<i>Municipalities within the Natura 2000 classified area</i>	Águeda, Albergaria-a-Velha, Anadia, Aveiro, Estarreja, Ílhavo, Mira Murtosa, Oliveira do Bairro, Ovar and Vagos.
<i>Parish within the Natura 2000 classified area</i>	E.g., Angeja, Avanca, Beduído & Vieiros, Bunheiro, Cacia, Canelas & Fermelã, Esgueira, Espinhel, Fermentelos, Gafanha Da Boa Hora, Gafanha Da Encarnação, Gafanha Da Nazaré, Gafanha Do Carmo, Glória & Vera Cruz, Murtosa, Óis da Ribeira, Ouca, Ovar Union of parishes, Pardilhó, Requeixo, Salreu, Santo André De Vagos, São Jacinto, São Salvador, Sosa, Torreira, Vagos & Santo António De Vagos, Válega.
Other	
<i>Local associations</i>	À VELA - Sailing club ADERAV - Association for the study and protection of the Natural and Cultural Heritage of Aveiro Region CCPAV - Hunting and Fishing Club of Aveiro/Vouga
<i>Non-governmental organizations (NGO's)</i>	FAPAS - Fund for the Protection of Wild Animals GEOTA - Study Group on Spatial Planning and Environment LPN - League for the Protection of Nature SPEA - The Portuguese Society for the Study of Birds ASPEA - Portuguese Association of Environmental Education

3.8 Co-design

Circa seventy stakeholders were invited to participate at the workshop that took place in April 2018. From these, seventeen representing the four major groups identified in Table 3, signed an informed consent agreement form and participated at the workshop. Participants were invited to express their opinion regarding the expected beneficial effects and persistent concerns related to the current management options by affixing their answer in post-it in the wall (Lillebø et al., VSI), and to participate in the spatial multi-criteria analysis (SMCA) (Martínez-López et al., VSI) regarding ES prioritisation. The last one consisted in pairwise comparisons of ES to derive a ranking of criteria for the different stakeholder groups. At the workshop each participant filled an online Google form anonymously using his or her mobile phone, tablet or PC. To support pairwise comparisons of the ES, stakeholders were given ES cards showing examples and the spatial distribution of the ES within the Natura 2000 area (see Annex 2 - 8.1.2). Details on the SMCA methodology and modelling of results can be found in (Martínez-López et al., VSI). The final output maps (considering the two spatial scales, i.e., the entire Natura 2000 area and the area at the confluence of Vouga river with Ria de Aveiro coastal lagoon, the BVL) represent how concordant the configuration of the landscape is with an optimal landscape, based on a given stakeholder's perspective (three bottom maps in Figure 9). These maps can then be compared with the areas that will be affected by the dredging programme and the floodbank (top map in Figure 9). ES valuation by stakeholders (read colour means that higher number of stakeholders have prioritise the same ES) clearly revealed the valuation of the water domains continuum (freshwater, transitional, and coastal/marine), with special emphasis to transitional waters, i.e., to the ES provided by the lagoon ecosystem. The generated information (see section 4.1) and maps supported the narratives for EBM prospective scenarios. For a detail description of the workshop see the report available at [AQUACROSS data portal](#).

As mentioned in section 3.3, the habitats that were pinpointed by AqualinksTool, clearly match the environmental concerns reported by stakeholders. In addition, these habitats also correspond to the ones that stakeholders prioritized, plus they are also the most exposed to the unintended negative impacts (Figure 10 illustrates the linkage between Drivers-Pressures-Ecosystem Component-ES Risk assessment with AqualinksTool and the major concern identified by stakeholders during the workshop). Therefore, this is the momentum to discuss and validate with stakeholders the spatial location of the proposed mitigation measures, and the methods e.g., seagrasses transplantation; increase sediment stability and foster saltmarshes elevation through accretion. This workshop will take place on the 20th of September.

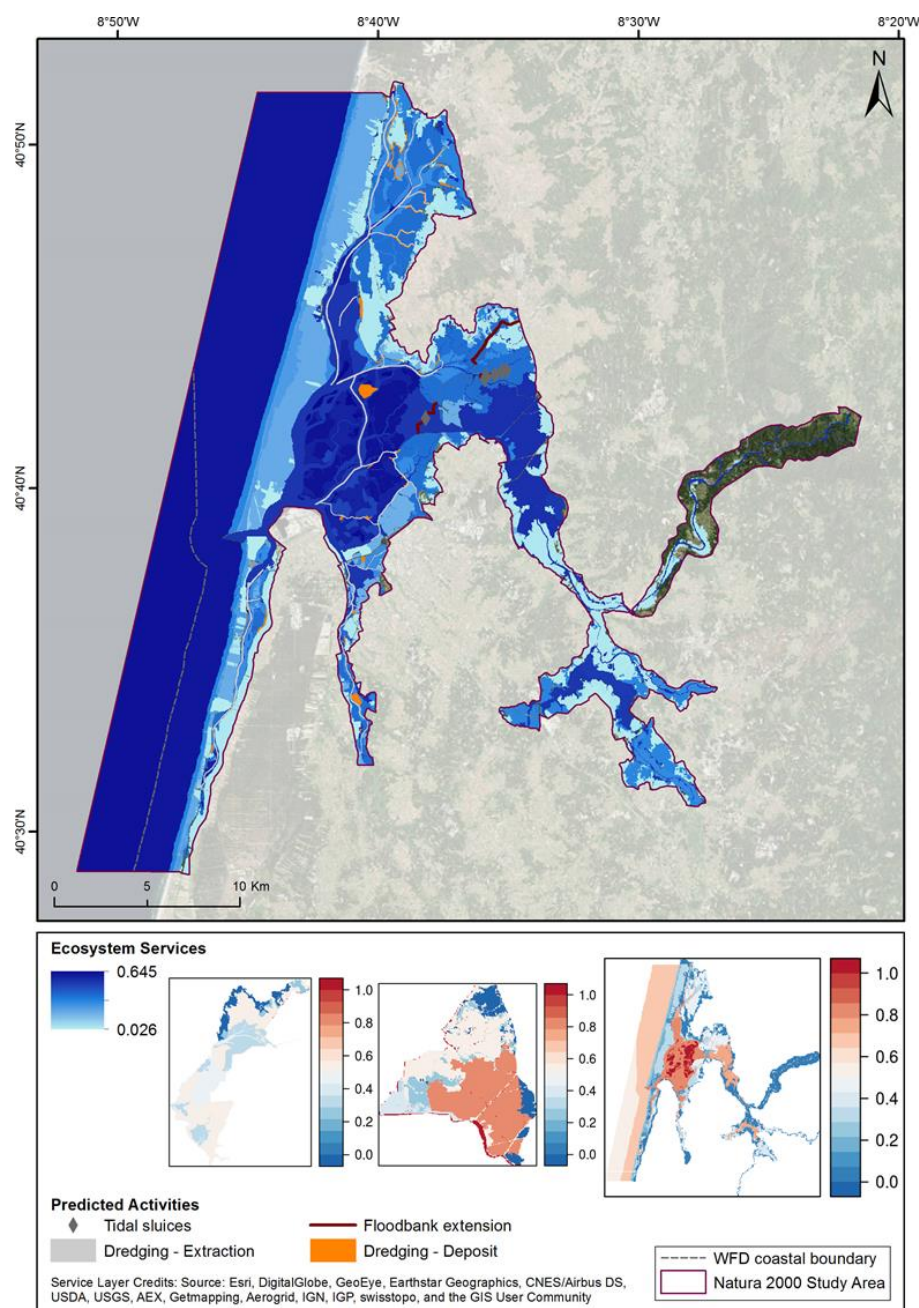


Figure 9 – Final outputs maps combined with the spatial location of the management activities (original ES maps from Lillebø et al., (VSI), Martínez-López et al., (VSI).

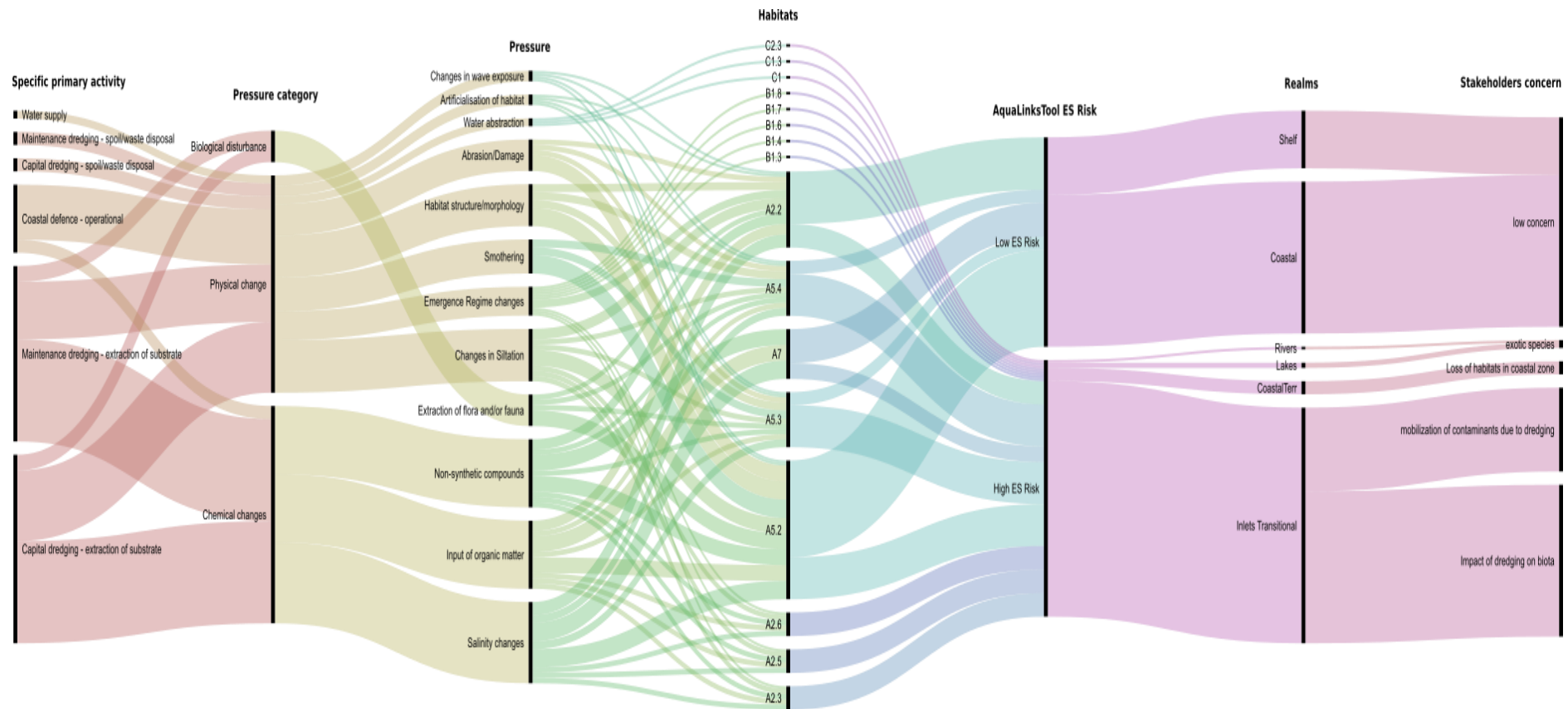


Figure 10 – Linkage between Drivers–Pressures–Ecosystem Component–ES Risk assessment with AquaLinksTool and the major concern identified by stakeholders (plotted with RAWGraphs; Mauri et al., 2017).

4 The baseline and future scenarios

4.1 Identifying gaps between baseline and objectives

For the baseline, the past and current conditions of the Vouga river coastal watershed were considered (e.g., Lillebø et al., 2015; Dolbeth et al., 2016). As mentioned, the region is vulnerable to ocean storm surges and coastal erosion, to torrential rain and flood events, meaning that it often requires human intervention for the protection or to enable economic activities, which includes the two key baseline measures that we have discussed: the dredging programme and the extension of the floodbank.

The extension of the floodbank is a continuation of historical human intervention required in the BVL. The Bocage landscape unit requires high maintenance as it gathers not only a living-hedges network but also a hydraulic grid of ditches, channels, floodgates, banks and other water barriers. The water channels supply water for crop and livestock production and also assure the drainage when there is water in excess in the fields. Some of these infrastructures were built in the 19th century in order to protect BVL from the tidal floods and its lack of maintenance is leading to draining issues and to the increase of salinity. These infrastructures, comparable to Natural Water Retention Measure (NWRM; <http://nwrn.eu/case-study/baixo-vouga-lagunar-bvl-bocage-landscape-portugal>), are not only a cultural part of the landscape but also function as a part of an integrated management system. Vegetation influences the rate and efficiency of storm-water infiltration and filtration (e.g., Runoff control, Peak-flow reduction, Water supply for farming, Water drainage to prevent freshwater floods, groundwater recharge, Soil fertilization). BVL is integrated in Ria de Aveiro Special Protection Area and is recognized as model of biodiversity and balance between man activities and wildlife. With the increase of the surface salinity intrusion, more salt tolerant species appear, like bulrushes, rushes and reeds, replacing the Open fields and Bocage landscapes vegetation (e.g., as the salinity increases, the traditional living-hedges are being replaced by the salt tolerant *Tamarix africana*).

The extension of the floodbank, which represents the primary system of defence of BVL is expected to improve accessibilities, to foster agricultural and livestock activities and protect the upstream wildlife and other economic activities in the area. The base value for the cost is 700,000 euros, and the foreseen execution period is seven months (to be done in 2018/2019) (CIRA 2017). The project also includes hydraulic structures in the Rio Velho, the Canelas and Salreu channels, and the strengthening of the right bank of the Vouga River. As well as the construction of a water regulation structure (bridge pond) at Rio Novo do Principe aiming to facilitate access to the fields and regulating, through a platform system, the fresh (Vouga river) and salt (Ria de Aveiro) water bodies. The base value for the cost is 115,000 euros, and the foreseen execution period is 80 days (to be done in 2018). For the dredging programme the base value for the cost is 17.65 million euros, and the foreseen execution period is 15 months (to be done in 2018/2019) (CIRA 2017). As summarised by Azevedo et al., 2013), changes in the system hydrodynamics (water current velocity and turbidity) due to dredging has been pointed as the main cause for the loss of sub-tidal *Zostera noltei* meadows, although intertidal meadows coverage has not decreased in the last decade (Sousa et al., *unpublished*). In addition, the increase in tidal prism and shoreline erosion due to changes in the system hydrodynamics, has promoted the dieback of saltmarshes, namely of *Juncus maritimus* due to increase of the submerged period, and fragmentation of *Spartina maritima* marshes at shoreline fringes of the lagoon (LAGOONS, 2013a, 2013b).

As identified in section 3, these measures will have negative impacts on natural habitats that mean that the baseline scenario will fall short of the biodiversity related objectives identified in section 2. Having identified these gaps, in our EBM plan in section 5, we propose using PNRN2000, the Vouga RBMP, and the still-to-be-finalised POE Vouga policies to close the gap between baseline scenario and the objectives. In this sense, AQUACROSS results can clearly contribute to support the development of POE Vouga.

4.2 Scenario development

The development of the prospective scenarios for each of the two spatial scales is summarised in Figure 11. For both baseline and the foreseen management scenarios, three approaches were combined: i) model-based scenarios on causal links and habitats risk assessment; ii) a process to gather stakeholders' perceptions regarding the present status and future trends; and iii) a combination of both, i.e., modelling of the SMCA results that were attained by stakeholder's valuation of ES.

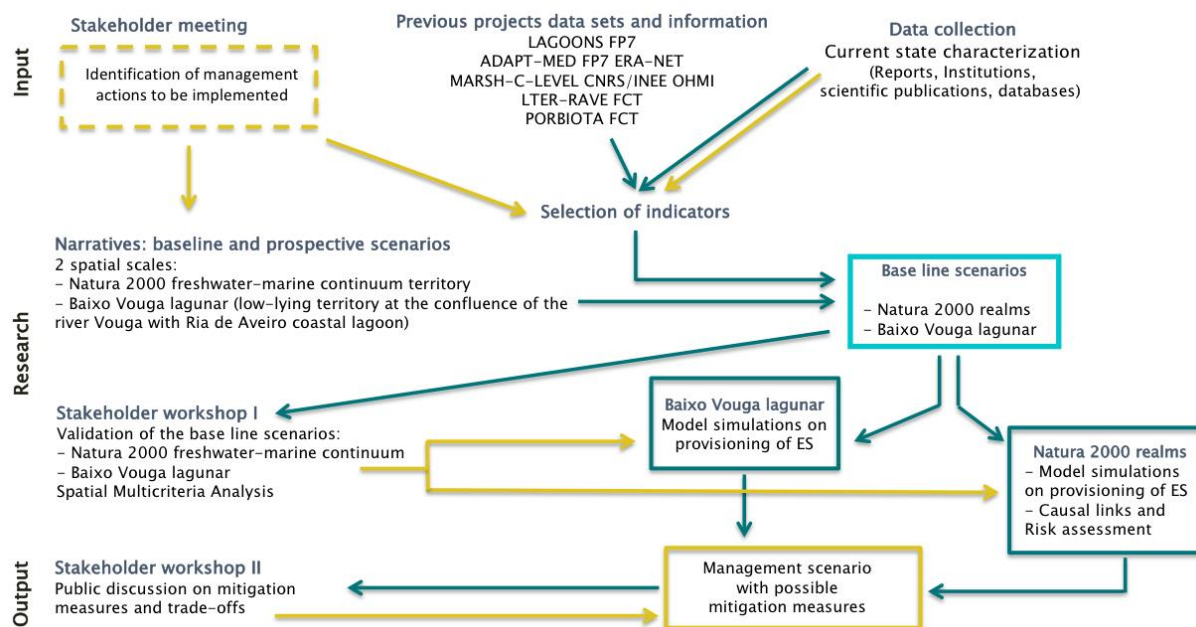


Figure 11 – The scenario development workflow for Vouga river coastal watershed under classification of Natura 2000 network. Note: the second workshop will take place in the 20th of September. Legend: yellow boxes and arrows correspond to stakeholders participatory inputs; green boxes and arrows correspond to data sets and fluxes of information for the modelling set up; blue box stands for the base line scenarios

5 Ecosystem-based management plan valuation

5.1 Detailed specification of relevant EBM solutions

This section is devoted to the proposed ecosystem-based management plan. The EBM plan was co-created with input from local stakeholders and policy-makers during the first CS5 workshop. At the following workshop taking place on the 20th of September the proposed measures will be discussed in order to establish the priority options and how they should be implemented. Some of the proposed measures directly target the environmental status of Ria de Aveiro Natura 2000 site as they intend to mitigate the response to the expected, unintended impacts from the base-line scenario Lillebø et al., (VSI).

Overall policy instruments applicable to water-dependent Natura 2000 sites

1. **Harmonised WFD and HD monitoring programmes in aquatic ecosystems:** Both WFD and BHD aim to protect aquatic ecosystems but in different ways (EC, 2011). However, an integrated approach could harmonise the monitoring programmes, maximising data sets with reduced effort and monitoring costs. In fact, some attempts have been made regarding the use of ES indicators for integration of monitoring across EU legislation and international agreements in the marine environment (Zampoukas et al., 2012) and between HD and WFD monitoring programmes in freshwater ecosystems (Bolpagni et al., 2017). The proposed harmonisation also implies a better coordination between these two policies crossing freshwater, coastal and marine/coastal environments with water continuum shared data bases; as well a better coordination with other relevant policies.

Case study specific policy plans and programmes

2. **Restoration of tidal wetlands, namely saltmarshes and seagrasses:** In June 2016 the Inter-municipal Community of the Aveiro Region (CIRA) approved the international public tender procedure for the extension of the flood bank, which represents the primary system of defence of Baixo Vouga Lagunar (BVL), which is characterised by soils of high productive capacity (DGADR, 2017). The main objective is to improve accessibility and to foster agricultural and livestock activities that due to its characteristics require low energy and water consumption. BVL represents a man-shaped landscape working in a dependent relationship between agricultural activities, wildlife and water regulation. Therefore, improvements are also expected to protect the wildlife and other economic activities in the area, namely ecotourism with bird watching tours, angling and recreational activities at the upstream area of the flood bank. However, downstream saltmarshes will be subdued due to the “coastal squeeze” effect (see Martínez-López et al., (VSI). Regarding the entire case study, the major driver of environmental changes is the dredging activities that take place periodically in order to enable hydrodynamic equilibrium and navigability in Ria de Aveiro coastal lagoon Lillebø et al., (VSI). In May 2018 the Minister of the Environment promoted the launch of the tender for the contract for the new dredging programme (APA et al., 2018). The main objectives concern the reinforcement of the banks at lower elevation zones threatened by surface saltwater intrusion, for the protection of infrastructures and goods; the use of dredge sand for beach sand replenishment; and improvement of navigability of the lagoon. Although the dredging activities are acknowledged as very important, concerns remain, as communicated in several participatory processes (e.g., Lillebø et al., (VSI); Lillebø et al., (2015); Sousa et al., (2013). Relevant examples from the latest workshop are the impact of dredging on seagrasses, saltmarshes and juvenile fauna due to changes in eco-hydrology; and regarding increase mobilization of

contaminants due to dredging (Lillebø et al., VSI). In this context, and considering the two spatial scales, two restoration measures are proposed and detailed in Table 4. The fragmentation and loss of these tidal wetlands will have implications on several other economic activities (e.g., Adam, 2002; Dewsbury et al., 2016; Mehvar et al., 2018; Newton et al., 2018).

Table 4 – Description of the proposed EBM responses considering results from the prospective scenarios. The Sectoral Plan for Natura 2000 Network and the National Strategic Plan for Climate change adaptation are considered transversal to the proposed EBM responses (data from Lillebø et al., VSI)

Transitional water domain	Saltmarshes restoration	Seagrasses meadows restoration
<i>Type of measure</i>	Mitigation measures to compensate the loss off saltmarshes due to ‘coastal squeeze’ and to the increase in tidal prism.	Mitigation measures to compensate the loss off seagrasses due to changes in water current velocity and light availability.
<i>Policy target</i>	WFD Birds Directive Habitats Directive	WFD Birds Directive Habitats Directive
<i>Policy instrument</i>	River Basin Management Plan; National Water Plan	River Basin Management Plan; National Water Plan
<i>Target area</i>	To be selected within the lagoon tidal wetland area	Currently under study
<i>Science-based knowledge requests for detailed measures</i>	Application of a GIS based modelling tool to select the potential areas considering the generate information. Attending to the site-specific characteristics of the selected areas different restoration techniques might be requested. These might be combined with supportive nature-based solutions to protect shorelines, as well as actions to promote sediment accretion.	There is an ongoing study on intertidal <i>Zostera noltei</i> modelling in Ria de Aveiro aiming for supporting restoration measures (e.g., Azevedo et al., 2013, 2016, 2017). In addition, two recently funded projects (MAR2020 BioPradaRia and Remoliço) will test under controlled laboratory conditions and in situ different restoration techniques for <i>Zostera noltei</i> meadows
<i>Detailed restoration measures</i>	i) Restoration of salt-marsh communities, namely <i>Juncus maritimus</i> , through revegetation of sheltered mudflats, considering submersion time ⁶ ii) Foster saltmarshes elevation through accretion.	iii) Protection of existing populations from fragmentation and increase resilience by enhancing sediment stability through the application of coconuts fibber mats (e.g., Sousa et al., 2017) iv) Transplantation of <i>Zostera noltei</i> plots from selected donor sites within Ria de Aveiro (e.g., Suykerbuyk et al., 2016)

3. Development of the Vouga estuary management plan (POE Vouga): Stakeholders acknowledge the need to foster integrated management and communication between entities. In this context, POE Vouga foresees the coordination between various territorial management instruments as well as stakeholders’ sectoral activities, representing an opportunity for EBM.
4. Engage local users and landowners in the restoration actions: As acknowledge by stakeholders at the 1st CS5 workshop, landowners’ need to be involved. As well, stakeholders acknowledged the lack of integrated management and the need for more information and awareness in the municipal councils (Lillebø et al., VSI). Therefore, communication with CIRA - Inter-municipal Community of the Aveiro Region should also be enhanced.
5. Promote the value of ecosystems services provided by tidal wetlands: Although stakeholders acknowledge the provided services, a more comprehensive understanding is needed regarding the quantification of the social-economic implications of ecosystem services provided by these habitats, as well as their connectivity with ecosystem services provided by adjacent habitats (e.g.,

⁶ <https://www.doc.govt.nz/Documents/science-and-technical/casn90.pdf>

in the case study area cuttlefish uses seagrass meadows in the lagoon area as nursery, but fishing activity takes place seasonally inside the lagoon and in coastal waters (O'Higgins et al., 2018). Available socio-economic data is summarized in Annex III. At the workshop, participants also acknowledge as a benefit the stimulus for ecotourism, including the marked walking trails usually in natural environments, supporting recreational activities (Lillebø et al., VSI).

5.2 Evaluation

The EBM plan was co-created with stakeholders in alignment with the six EBM principles as shown in Table 5. The evaluation of the proposed EBM measures followed (Piet et al., 2017) by applying the proposed pre-screening criteria. During the evaluation processes, special attention was given to seagrasses and saltmarshes restoration measures, as these have direct impact in the ecosystem. Attending to the pre-screening criteria, seagrasses and saltmarsh restoration seeks to recover natural ecosystems ecological processes and services, therefore it is ecologically sustainable, socially desirable, ethically defensible, and culturally inclusive. Additionally, local population acknowledges these natural habitats as important nursery areas, being fundamental for economic activities in the region (Dolbeth et al., 2016; Lillebø et al., VSI; Newton et al., 2018). Regarding financing sources for the implementation of the response measures, applications in the scope of EU funding instruments, namely LIFE environmental programme, Regional Development and/or Territorial Cooperation funds, and R&I H2020 programme could be considered (Marino et al., 2014; UE, 2016).

Both measures to restore tidal wetlands have the same policy target (i.e., WFD, Birds Directive Habitats Directive), and both legally permissible. They both are implemented using the same policy instrument (River Basin Management Plan; National Water Plan), therefore administratively achievable although it implies the articulation of several Institutions. This is also foreseen with the proposed development of the POE Vouga. It is also effectively communicable and politically expedient in articulation with the foreseen actions to promote the value of ecosystems services provided by tidal wetlands. In addition, the effective implementation of the proposed habitat restoration in the selected Natura 2000 area is consistent with the prevailing (national) political climate and have the explicit support of political leaders.

Table 5 – EBM plan alignment with EBM principles

EBM principles:	EBM Scenario
1. EBM considers ecological integrity, biodiversity, resilience and ecosystem services	The harmonised WFD and HD monitoring programmes along the water continuum will together with the proposed tidal wetlands restoration measures and stakeholder participation increase resilience and ecosystem services.
2. EBM is carried out at appropriate spatial scales	The EBM Plan considers two spatial scales, the entire Natura 2000 area and the area at the confluence of Vouga river with Ria de Aveiro coastal lagoon, the BVL, in order to better consider current and future stakeholders.
3. EBM develops and uses multi-disciplinary knowledge	The POE Vouga foresees the coordination between various territorial management instruments as well as stakeholders' sectoral activities, with the support of science-based knowledge. POE Vouga should therefore involve complementary expertise between and within natural and social sciences, in a trans-disciplinary approach.
4. EBM builds on social–ecological interactions, stakeholder participation and transparency	The EBM plan was co-created with input from local stakeholders and policy-makers, and considers their perceptions, namely their concerns regarding the unintended pressures from the base-line scenario and their valuation of ES through Spatial Multi-criteria Analysis (SMCA). The proposed plan will be presented and discussed at the second that will take place in the 20 th of September.
5. EBM supports policy coordination	The proposed EBM approach is timely to the Portuguese spatial planning and water planning systems, framed for the protection and management of

	estuarine systems, which includes the Vouga river coastal watershed. The EBM plan also proposes to harmonise WFD and HD monitoring programmes.
6. EBM incorporates adaptive management	The proposed measures, namely the habitats restoration measures, follow the principles of resilience thinking and adaptive management, by considering ecology, management of natural capital and systems analysis.

5.3 Pre-conditions for implementation of selected EBM solutions

5.3.1 Funding opportunities

The dredging programme and the extension of BVL floodbank are being implemented within the frame of the Vouga RBMP (APA, 2015). The co-financing rates associated with these programs may, as a rule, vary between 40% and 85% of the relevant applications, depending on the type of projects to be developed and the nature (public or private) of the entities responsible for their implementation. During the first management cycle (2009-2015) the majority of funding was dedicated towards base measures for the “Protection, improvement and recovery of water bodies” classified under WFD (59% of the funding for the period. For the following second management cycle (2016-2021) the majority of funding is dedicated to “supplementary measures” (88%) (APA, 2015). In addition, due to the nature of the proposed measures, applications in the scope of EU funding instruments, namely LIFE environmental programme, Regional Development and/or Territorial Cooperation funds, and R&I H2020 programme could also be considered (UE, 2016).

5.3.2 The added value of seagrasses and saltmarshes

In the case study area, stakeholders clearly recognize the intrinsic value as well as the added value of seagrasses and saltmarshes (provisioning, regulating and maintenance, and cultural services) and their support to economic activities, and acknowledge the existing scientific knowledge on habitats and species (Lillebø et al., VSI). It can be said that stakeholders acknowledge the so-called direct and indirect use values and non-use values of ecosystem services and have environmental and economic concerns.

5.3.3 Ecotourism as an opportunity

The Ministry of the Economy and Innovation developed national Strategic Plan for Tourism (PENT) aiming to affirm tourism as a contributor to the economic, social and environmental development of the country, positioning Portugal as one of the most competitive and sustainable tourist destinations in the world (e.g., INE, 2017; OECD, 2018; Turismo de Portugal, 2017). It is operationalized at regional level involving other ministries, tourism associations and companies, municipal councils, among others. In fact, in previous participatory processes stakeholders have acknowledged tourism, namely ecotourism as an opportunity for economic development of the region (Lillebø et al., VSI; Lillebø et al., 2015).

6 Discussion and Conclusions

A distinctive feature of the Natura 2000 Network of protected areas is the fact it “*is not a system of strict nature reserves from which all human activities would be excluded, but instead centres its approach on people working with nature rather than against it*”. The main challenges posed to Vouga river coastal watershed, and presented in section 1.2, are well summarised in the Natura 2000 message for Member States to ensure that these sites are “*managed in a sustainable manner, both ecologically and economically*”.

As detailed in Lillebø et al., (VSI) “*Ria de Aveiro region illustrates the challenges of an ecosystem-based management (EBM) planning process in a Natura 2000 freshwater-marine continuum territory*”. For the co-creation process, together with stakeholders, we applied the AQUACROSS AF. The process followed a stepwise approach, including assessment and analysis of policy and stakeholder objectives;

characterisation of the social-ecological system, and of the baseline scenario; and the development of an ecosystem-based management plan.

The implementation of the proposed mitigation measures to compensate the loss off saltmarshes due to 'coastal squeeze' and to the increase in tidal prism; and mitigation measures to compensate the loss of seagrasses due to changes in water current velocity and light availability (as detailed in Table 4) should be framed in the Sectoral Plan for Natura 2000 Network (PSRN2000), under the coordination of the Portuguese Nature Conservation and Forests (ICNF), which is the territorial management tool for the implementation of the national policy for the conservation of biological diversity. EBM responses should also consider climate change projections and the National Strategic Plan for Climate change adaptation.

The PSRN2000 establishes the strategic orientation and programme norms for the actions of central and local government, and the measures and guidelines provided for therein should be transposed to the municipal planning of the territory (PMOT) and special plans (PEOT). Thus, the management measures provided for in the PSRN2000 will only be binding measures when they are inserted in the PMOTs and the PEOTs. In the case of the CS area, this plan is implemented by the UNIR@RIA, which ensures articulation between the regional and municipal plans that are relevant for the Ria de Aveiro and associated protected areas.

The proposed measures fall within the key targets of PSRN2000, which are:

- i) establish guidelines for the territorial management of SPAs, SACs and LICs;
- ii) establish the system of safeguarding natural resources and protected areas ensuring the uses and management regime are compatible with the use sustainable development of the area;
- iii) represent cartographically, according to the data available, the distribution of habitats in SPAs and LICs;
- iv) establish guidelines for the zoning of areas in terms of conservation characteristics and priorities;
- v) define the measures that guarantee recovery and maintenance of habitats, the conservation status and species, as well as provide the typology of restrictions on land use, considering the distribution of the habitats to requiring protection;
- vi) provide guidance on inclusion at the municipal level or special arrangement of the territory of the and restrictions;
- vii) define the conditions, criteria and processes to be followed in the implementation of the environmental impact assessment.

The National Strategic Plan for Climate change adaptation is framed on a Territorial Management System organized within a framework of coordinated interaction at three levels (Law n°48/98, August 11th): national, regional and local. At the Vouga river coastal watershed the spatial planning regulations to consider are illustrated in Figure 12.

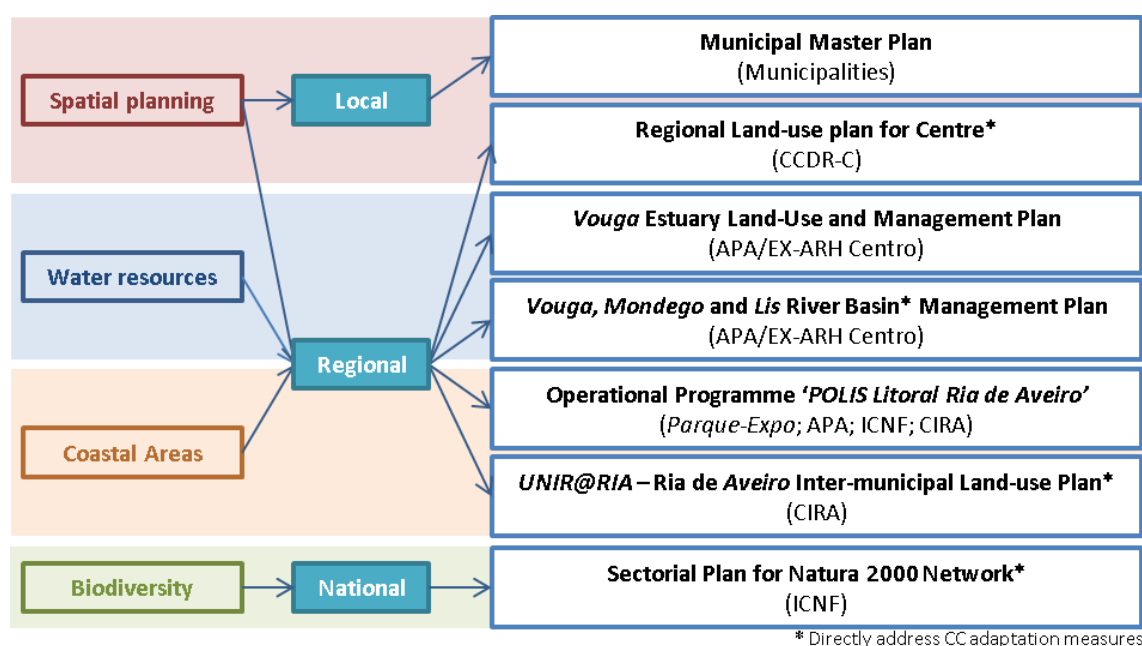


Figure 12 – Spatial planning regulations for climate change adaptation for Vouga river coastal watershed (Source: ADAPT-MED, 2015).

6.1 Conclusions

Following the EBM principles, particularly the principle of adaptive management, and scenarios co-creation with stakeholders (Gomez et al., 2016, 2017; Rouillard et al., 2018) we propose the harmonisation of WFD and HD monitoring programmes in water-dependent Natura 2000 sites. The proposed harmonisation of water and nature Directives also implies a better coordination between these two policies, crossing freshwater, coastal and marine/coastal environments with databases shared across the water continuum; as well as better coordination with other relevant policies (e.g. Floods Directive).

For the successful implementation of the identified water and nature policies at Ria de Aveiro Natura 2000 site any actions to restore tidal wetlands, namely saltmarshes and seagrasses, need to ensure the involvement of users and landowners. As fragmentation and loss of these tidal wetlands will have implications on biodiversity and on several economic activities, the restoration measures are proposed considering the entire case study area in order to consider potential trade-offs.

The EBM plan is also foreseen to support the development of the Vouga estuary management plan (POE Vouga); as well as actions for a more comprehensive understanding of the value of ecosystems services provided by tidal wetlands.

The effective implementation of the EBM response to the foreseen unintended impacts resulting from the present management options, i.e., the dredging programme (APA, 2018) and the extension of a floodbank (DGADR, 2017) still requires additional, but tangible, science based-knowledge for the selection of the most suitable areas at Ria de Aveiro (Lillebø et al., VSI). Nevertheless, the proposed EBM approach is timely for the Portuguese spatial planning and water planning, framed for the protection and management of estuarine systems, which includes the Vouga river coastal watershed, i.e., the enactment of the Legal Regime of the Estuary Land Use and Management Plans (Planos de Ordenamento de Estuário (POE) (Fidélis

and Carvalho, 2015). It has been acknowledged that “*at the level of plan content the contribution of the Portuguese Estuary Land Use and Management Plans (Planos de Ordenamento de Estuário) legislation brings strong new prospects for integration, at the level of planning process and implementation, further efforts should be undertaken*” (Fidélis and Carvalho, 2015). Furthermore, the proposed EBM response is aligned with the National strategy for smart specialization (ENEI) as well as with the regional strategy (RIS3 Centro) under the coordination of the Centro Regional Coordination Development Commission (CCDR-C). It relates to three ENEI domains: i) Water and Environment, namely on the main area of practice regarding the evaluation, monitoring and protection of ecosystems; ii) Economy of the Sea in what concerns Climate Change; and iii) Agro-alimentary domain in the topic of biodiversity. The alignment with RIS3 Centro concerns the integrated management of endogenous natural resources and ultimately might contribute to the creation of specialized jobs in the ecotourism sector.

6.2 Next steps

As stated in chapter 1.2 the main challenge in the scope of AQUACROSS and the development of an EBM planning approach for the freshwater to marine continuum of Vouga river coastal watershed, under classification of Natura 2000 network, regards the use of the best available information in a trans-disciplinary context to build prospective scenarios in order to mitigate the foreseen unintended pressures resulting from the present management options. The best available information at present allowed for quantitative modelling at the BVL level with the identification of the most vulnerable areas. For the entire Natura 2000 area quantitative data (maps on habitats, activities and risk of inundation due to changes in water level) were combined in a qualitative manner in order to identify potential areas for restoration. The produced scenarios will be presented and discussed with stakeholders in the second participatory workshop (WS II) taking place on September 20th (note: WS II was scheduled for July 5th, but had to be postponed due to several competing activities involving key stakeholders). WS II aims to discuss the opportunities and constraints regarding the implementation of the proposed EBM response taking into account the environmental perspective (maps with the potential areas for restoration), the policy perspective (namely PSRN2000, Vouga RBMP and POE Vouga) and the funding opportunities (namely Vouga RBMP, LIFE environmental programme, Regional Development and/or Territorial Cooperation funds). Final results and lessons learned from AQUACROSS will be gathered in an open-access book, targeting non-academic public, to be published in Portuguese and presented to stakeholders in a public session taking place in November 2018.

References

- Adam, P., 2002. Saltmarshes in a time of change. *Environ. Conserv.* 29, 39–61.
- ADAPT-MED, 2015. Baixo Vouga Lagunar Knowledge Database.
- APA, 2018. RECAPE da Transposição de Sedimentos para Otimização do Equilíbrio Hidrodinâmico na Ria de Aveiro – Canal de Ovar até ao Carregal, Canal de Ovar até ao Pardilhó e Canal da Murtosa Canal de Ílhavo, Canais do Lago Paraíso e Canais da Zona Central da Ria 35.
- APA (Agência Portuguesa do Ambiente), 2015. PGRH4 –Plano de Gestão das Bacias Hidrográficas do Vouga, Mondego e Lis. Part 1 – Enquadramento e aspectos gerais.
- Azevedo, A., Sousa, A.I., Lencart e Silva, J.D., Dias, J.M., Lillebø, A.I., 2013. Application of the generic DPSIR framework to seagrass communities of Ria de Aveiro: a better understanding of this coastal lagoon. *J. Coast. Res.* 65, 19–24.
- Bolpagni, R., Azzella, M.M., Agostinelli, C., Beghi, A., Bettoni, E., Brusa, G., De Molli, C., Formenti, R., Galimberti, F., Cerabolini, B.E.L., 2017. Integrating the Water Framework Directive into the Habitats Directive: Analysis of distribution patterns of lacustrine EU habitats in lakes of Lombardy (northern Italy). *J. Limnol.* 76.
- Borgwardt F., Culhane F., Trauner D., Teixeira H., Nogueira A.J.A., Lillebø A.I., Piet G., Kuemmerlen M., O’Higgins T., McDonald H., Arevalo-Torres J., Barbosa A.L., Hein T., R.L.. Exploring variability in environmental impact risk from human activities across aquatic realms (No. Science of the Total Environment (VSI)).
- CIRA – Comunidade Inter-Municipal da Região de Aveiro (Sociedade para a Requalificação e Valorização da Ria de Aveiro, 2010. Ria de Aveiro Polis Litoral, Requalificação e Valorização da Orla Costeira: Intervenção de Requalificação da Ria de Aveiro, Plano Estratégico.
- Conselho Intermunicipal (CIRA) 2017: Press release from 18th December 2017. <http://www.regiaodeaveiro.pt/>
- Curtin, C.G., Parker, J.P., 2014. Foundations of resilience thinking. *Conserv. Biol.* 28, 912–923.
- Dewsbury, B.M., Bhat, M., Fourqurean, J.W., 2016. A review of seagrass economic valuations: gaps and progress in valuation approaches. *Ecosyst. Serv.* 18, 68–77.
- DGADR – Direção Regional de Agricultura e Desenvolvimento Rural, 2017. Aproveitamento Hidroagrícola do Vouga Bloco do Baixo Vouga Lagunar. Intervenções nos Sistemas Primários de Drenagem e Defesa Contra Efeitos das Marés e Cheias a Candidatar à Operação 3.4.3 do PDR 2020.
- Dolbeth, M., Stålnacke, P., Alves, F.L., Sousa, L.P., Gooch, G.D., Khokhlov, V., Tuchkovenko, Y., Lloret, J., Bielecka, M., Różyński, G., 2016. An integrated Pan-European perspective on coastal Lagoons management through a mosaic-DPSIR approach. *Sci. Rep.* 6, 19400.
- Drakou, E.G., Kermagoret, C., Lique, C., Ruiz-Frau, A., Burkhard, K., Lillebø, A.I., van Oudenhoven, A.P.E., Ballé-Béganton, J., Rodrigues, J.G., Nieminen, E., 2017. Marine and coastal ecosystem services on the science-policy-practice nexus: challenges and opportunities from 11 European case studies. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* 13, 51–67.
- European Commission (EC) (2011): Links between the Water Framework Directive and Nature Directives. Frequently asked questions. <http://ec.europa.eu/environment/nature/natura2000/management/docs/FAQ->

WFD%20final.pdf

- Fidélis, T., Roebeling, P., 2014. Water resources and land use planning systems in Portugal—Exploring better synergies through Ria de Aveiro. *Land use policy* 39, 84–95.
- Fidélis, T., Carvalho, T., 2015. Estuary planning and management: the case of Vouga Estuary (Ria de Aveiro), Portugal. *J. Environ. Plan. Manag.* 58, 1173–1195.
- Gómez, C., Delacámara, G., Arévalo-torres, J., Barbière, J., Barbosa, A.L., Boteler, B., Culhane, F., Daam, M., Gosselin, M.-P., Hein, T., Iglesias-campos, A., Jähnig, S., Lago, M., Langhans, S., Martínez-López, J., Nogueira, A., Lillebø, A.I., O’Higgins, T., Piet, G., Schlüter, M., 2016. The AQUACROSS Innovative Concept– Deliverable 3.1.
- Gómez, C., Delacámara, G., Jähnig, S., Langhans, S.D., Domisch, S., Hermoso, V., Piet, G., Martínez-López, J.B., Lago, M., Boteler, B., Rouillard, J., Abhold, K., Reichert, P., Schuwirth, N., Hein, T., Pletterbauer, F., Funk, A., Nogueira, A., Lillebø, A.I., Daam, M., Teixeira, H., Robinson, L., Culhane, F., Schlüter, M., Martin, R., Iglesias-Campos, A., Luisa Barbosa, A., Arévalo-Torres, J., 2017. Developing the AQUACROSS Assessment Framework Deliverable 3.2.
- ICNF, RN2000 –Portugal – Resumo.
- INE (Instituto Nacional de Estatística), 2017.
- LAGOONS, 2013a. Results of the problem based science analysis: The Ria de Aveiro Lagoon 2–50.
- LAGOONS, 2013b. Ecosystem threshold response to the main environmental factors.
- Lillebø AI, Stålnacke P, Gooch, G., 2015. Coastal lagoons in Europe: Integrated water resource strategies. IWA Publishing.
- Lillebø AI, Teixeira H., Morgado M., Martínez-López J., Marhubi A., Delacámara G., Strosser P., N.A.J.A., 2018. Ecosystem-based management planning across aquatic realms at the Ria de Aveiro Natura 2000 territory. STOTEN VSI.
- Luís, S., Lima, M.L., Roseta-Palma, C., Rodrigues, N., Sousa, L.P., Freitas, F., Alves, F.L., Lillebø, A.I., Parrod, C., Jolivet, V., 2018. Psychosocial drivers for change: Understanding and promoting stakeholder engagement in local adaptation to climate change in three European Mediterranean case studies. *J. Environ. Manage.* 223, 165–174.
- Marino, D., Gaglioppa, P., Schirpke, U., Guadagno, R., Marucci, A., Palmieri, M., Pellegrino, D., Gusmerotti, N., 2014. Assessment and governance of Ecosystem Services for improving management effectiveness of Natura 2000 sites. *Bio-based Appl. Econ.* 3, 229–247.
- Martin R., Hellquist F.K., Schlüter M. Barbosa A.L., Iglesias-Campos A., Torres J.A, Barbière J. Martin B. Delacámara G., Gómez C.M., Arenas M., Domisch S., Langhans S., Martínez-López J., Villa F., Balbi S., Schuwirth N., R.J., 2018. Scenario Development 52.
- Martínez-López J. Teixeira H., Morgado M., Almagro M., Sousa A.I., Villa F., Balbi S., Genua-Olmedo A., Nogueira A.J.A., L.A.I., 2018. Participatory coastal management through elicitation of ecosystem service preferences and modelling driven by “coastal squeeze.” STOTEN VSI.
- Mauri, M., Elli, T., Caviglia, G., Ubaldi, G., Azzi, M., 2017. RAWGraphs: A Visualisation Platform to Create Open Outputs, in: *Proceedings of the 12th Biannual Conference on Italian SIGCHI Chapter*. ACM, p. 28.
- Mehvar, S., Filatova, T., Dastgheib, A., de Ruyter van Steveninck, E., Ranasinghe, R., 2018. Quantifying economic value of coastal ecosystem services: a review. *J. Mar. Sci. Eng.* 6, 5.
- Millennium Ecosystem Assessment, 2005. Ecosystem and human well-being: biodiversity

- synthesis. World Resour. Institute, Washington, DC.
- Newton, A., Brito, A.C., Icely, J.D., Derolez, V., Clara, I., Angus, S., Schernewski, G., Inácio, M., Lillebø, A.I., Sousa, A.I., 2018. Assessing, quantifying and valuing the ecosystem services of coastal lagoons.
- O'Higgins, T., Nogueira, A.A., Lillebø, A.I., 2018. A simple spatial typology for assessment of complex coastal ecosystem services across multiple scales. *Sci. Total Environ.*
- OECD, 2018. OECD Tourism Trends and Policies 2018, OECD Tourism Trends and Policies 2012.
- Pereira, C., Coelho, C., 2013. Mapping erosion risk under different scenarios of climate change for Aveiro coast, Portugal. *Nat. hazards* 69, 1033–1050.
- Piet, G., Delacámara, G., Gómez, C.M., Lago, M., Rouillard, J., Martin, R., van Duinen, R., 2017. Making ecosystem-based management operational (No. Deliverable 8.1), European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317.
- Rouillard, J., Lago, M., Abhold, K., Röschel, L., Kafyeke, T., Mattheiß, V., Klimmek, H., 2018. Protecting aquatic biodiversity in Europe: How much do EU environmental policies support ecosystem-based management? *Ambio* 47, 15–24.
- Sousa, A.I., Valdemarsen, T., Lillebø, A.I., Jørgensen, L., Flindt, M.R., 2017. A new marine measure enhancing *Zostera marina* seed germination and seedling survival. *Ecol. Eng.* 104, 131–140.
- Stefanova, A., Krysanova, V., Hesse, C., Lillebø, A.I., 2015. Climate change impact assessment on water inflow to a coastal lagoon: the Ria de Aveiro watershed, Portugal. *Hydrol. Sci. J.* 60, 929–948.
- Teixeira H., Lillebø A.I., Culhane F., Robinson L., Trauner D., Borgwardt B., Kummerlen M., Barbosa A., McDonald H., Funk A., O'Higgins T., Van der Wal J.T., Piet G., Hein T, Arévalo-Torres J., Iglesias-Campos A., Barbière J., N.J., 2018. Flow linkages from biodiversity to ecosystem services supply: integrating across aquatic ecosystems. STOTEN VSI.
- Turismo de Portugal, 2017. Estratégia 2027. *Estratégia Tur. 2027* 1–66.
- UNDP, 2015. Sustainable Development Goals, Undp.
- UE (European Union), 2016. A Starter's Guide. Overview on the main provisions of the Water Framework Directive, the Marine Strategy Framework Directive, the Birds and Habitats Directives, and the Floods Directive: similarities and differences.
- Zampoukas, N., Piha, H., Bigagli, E., Hoepffner, N., Hanke, G., Cardoso, A.C., 2012. Monitoring for the Marine Strategy Framework Directive: requirements and options. JRC Sci. Tech. Reports. Publ. Off. Eur. Union. EUR 25187.

Annex

All annexes are available on the AQUACROSS website [Case Studies](#) page.

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