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# 1

# Current trends and threats to biodiversity in Europe

## BIODIVERSITY IS DECLINING GLOBALLY

WWF estimates that up to 52 % of the world's biodiversity has disappeared. This decline is particularly acute in the freshwater and marine realms, where it is estimated that up to 76% and 39% of species have been lost, respectively. The loss of aquatic biodiversity is critical as aquatic ecosystems provide numerous economic and societal benefits in the form of ecosystem services. For example, they supply individuals with food, some ecosystems help to prevent floods, and they offer opportunities for recreation. Many of these valuable aquatic ecosystems and the services they provide are at risk of being irreversibly damaged by pressures caused by human activities, such as pollution, invasive species, overfishing, among others (EEA, 2015). These pressures are intensified by global challenges such as population growth, increasing competition for natural resources, and climate change.

### What is threatening aquatic biodiversity in Europe?

The AQUACROSS project has identified six major threats to Europe's aquatic biodiversity, as well as the main drivers behind these threats*:

| Threats | | Drivers |
|---|---|---|
|  | **Nutrient Pollution:** Nutrient enrichment poses a continuous major threat to the aquatic ecosystems of Europe. For example, this pressure can contribute to an increase in plant growth, changes in nutrient cycling, uncontrolled growth of algae, eutrophication, acidification, an increase of organic matter settlement, cyanobacteria blooms, oxygen depletion, and mortality of benthic fauna and fish. Most European coastal and marine waters still carry enough nitrogen to lead to eutrophication. In freshwaters, enough nitrogen and Phosphorus still remains to lead to the loss of biodiversity. | **Agriculture**<br>**Aquaculture**<br>**Energy**<br>**Transport**<br>**Waste sector**<br>**Tourism** |
|  | **Species extraction:** Signs of improvement are present. In 2007, 94% of assessed fish stocks in the EU North-East Atlantic Ocean and the Baltic Sea were fished above Maximum Sustainable Yield (MSY) rates. Promising trends have been observed since then, with the number of overfished stocks falling from 94% in 2007 to 39% in 2013 in those regional seas (EEA, 2015). However, the level of knowledge on species extraction is still very limited, especially in the Mediterranean Sea and Black Sea regions, making it impossible to assess change over time. | **Fishing** |

**Water abstraction:** Over-abstraction is especially severe in the Mediterranean region, where the threat can lead to reduced river flows, lower lake and groundwater levels, and drying up of wetlands, which can alter responses of ecosystems and their functions.

**Agriculture**
**Energy**
**Tourism**

**Invasive Alien Species (IAS):** IAS are being introduced in Europe's seas with increasing regularity, with around 1 400 IAS currently. The Mediterranean is the European sea with the largest number of IAS, with over a fifth (21%) of all threatened and near threatened freshwater fish species currently being threatened by IAS. Additionally, even though species extraction is on a positive trend, fishing in the marine environment has had severe repercussions and has in some instances led to species endangerment beyond recovery.

**Aquaculture**
**Transport**
**Tourism**

**Alterations to morphology:** Historically, European rivers have undergone significant modifications through land improvements, damming and increased water abstraction associated with the expansion and intensification of agriculture, industrial revolutions, and more recently the post-war economic growth. While the rate of morphological alterations has likely reduced, it is not established whether trends have reversed or will in the future. With the risk of extreme events growing, additional flood protection may be put in place.

**Agriculture**
**Energy**
**Transport**
**Tourism**

**Plastic waste:** The amount of plastic waste generated dramatically increased during the 20th century and is now pervasive in all water realms. Packaging waste represents the major source of plastic pollution in Europe. It is important to note that, although recycling and recovery rates may be improving, the actual amount of plastic waste producedhas remained roughly the same over the last 10 years. There is little information on the amounts, rates or impacts of plastic waste in freshwater environments.A major effort is underway to quantify those in coastal and marine areas.

**Fishing**
**Aquaculture**
**Transport**
**Waste sector**
**Tourism**

* Other relevant threats also threaten biodiversity, for example, in freshwater, micropollutants (e.g. pesticides), changes in temperature and hydrological changes due to climate change.

## THE POLICY RESPONSE

At the level of the European Union, the **EU Biodiversity Strategy to 2020** transposes the Convention on Biological Diversity's Aichi targets into EU policy. The Strategy aims to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. A 2015 mid-term review of the Strategy by the EU Commission concluded that the loss of biodiversity and the degradation of ecosystem services have not been halted by the Strategy.

The review indicated that biodiversity loss would continue throughout the EU and globally, with potential significant implications for the capacity of biodiversity to meet human needs in the future. For more on the EU policy response, read the brief "What's the problem with current policies and management practices for aquatic biodiversity?".


| | www.aquacross.eu/results | Go to Brief #2: Current biodiversity management: Issues → |
|---|---|---|


**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- AQUACROSS leaflet
- Gómez et al. (2016) The AQUACROSS Innovative Concept. Deliverable 3.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Piet et al. (2017) Making ecosystem-based management operational. Deliverable 8.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- O'Higgins, T. 2016. You Can't Eat Biodiversity: Agency and Irrational Norms in European Aquatic Environmental Law. Challenges in Sustainability 5(1): 43-51. DOI: 10.12924/cis2017.05010043
- AQUACROSS Policy Brief: Managing biodiversity from local to global: an EU perspective.



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# 2

# What's the problem with current policies and management practices for aquatic biodiversity?

## EU POLICY RESPONSE

To address the challenges of biodiversity protection, the EU adopted the Biodiversity Strategy in 2011, with the aims to halt biodiversity and ecosystem services loss across Europe by 2020. However, the 2015 Mid-Term Review of the Strategy concluded that biodiversity protection is deficient and that, at current trends, the EU will fail to achieve its goal of halting the negative effects of anthropogenic activities on ecosystems by 2020. These negative trends are especially apparent for aquatic biodiversity in the EU's freshwater, coastal and marine realms, which have suffered as a result of economic activities over the last decades.


Inner and outer core of considered policies relevant for the achievement of the targets of EU Biodiversity Strategy to 2020.

The EU Biodiversity Strategy largely relies on other EU policies to achieve its objectives for aquatic ecosystems (see Figure above):

- The Birds and Habitats Directives (also called Nature Directives), the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) directly contribute to reducing pressures on aquatic ecosystems and on biodiversity;
- Many other (environmental and sectoral) policies also deliver positive synergies with the EU Biodiversity Strategy, whileothersare in competition with it and affect outcomes for the six main threats imposed on aquatic ecosystem in Europe (see table below).

# EU POLICIES RELEVANT TO THE IDENTIFIED KEY THREATS ON AQUATIC ECOSYSTEMS – 2 EXAMPLES

**Nutrient Pollution:** The Urban Waste Water Treatment Directive and Nitrates Directive set target values for the eutrophic state of freshwater and coastal waters, and promote measures to reduce nitrogen emissions from the domestic and industrial sector, and the agricultural sector, respectively. Other relevant policies include the Drinking Water Directive,the Bathing Water Directive and the Groundwater Directive. The WFD integrates all these objectives in its status assessment and the establishment of River Basin Management Plans and Programmes of Measures, while the MSFD mostly relies on freshwater and land related policies, such as the WFD and the Common Agricultural Policy, to reduce nitrogen emissions. The nitrogen threat is also tackled through legislation on air quality protection, with the National Emission Ceilings Directive, the Directive on Industrial Emissions concerning Integrated Pollution Prevention and Control, and the Ambient Air Quality Directive.

There are also policies that may increase the threatof nutrient pollution in aquatic ecosystems. These include policies such as the Common Fisheries Policythat promotes aquaculture and others that promote the expansion of agriculture, such as the Common Agricultural Policy and the Directive on the promotion of theuse of energy from renewable resources, which encourages the cultivation of crops to be used as biofuels.

**Species extraction:** In terms of species extraction, the Common Fisheries Policy mainly promotes measures to reduce pressures from fishing activities, for example by increasing selectivity and reducing unwanted catches. Furthermore, it should leadto the adoption of multi-species plans, as are in place for the Baltic, that contain conservation measures with quantifiable targets to restore and maintain fish stocks at levels capable of producing Maximum Sustainable Yield and to control the capacity of the fishing fleet. Some of these measures are financially supported by the Regulation on the European Maritime and Fisheries Fund and reinforced by the MSFD.

The majority of regulations and policies related to species extraction include commercial fishing as its main driver. Some also mention aquaculture, but for the most part regulations fail to consider blue biotechnology. Only the CBD Aichi Targets address the need to minimise genetic erosion and safeguard the genetic diversity of species. In addition to addressing drivers, policies consider the state of biodiversity through implementation of protected areas and strive towards good environmental status. While the policies in place aim to reduce species extraction, the socio-economic aspects of the threat are not addressed adequately yet and economic growth is even promoted in some. The Common Fisheries Policypromotes small-scale coastal fishing and sustainable aquacultureto contribute to food security and supplies, growth and unemployment, which could lead to an increase in activity. The same is true for the Blue Economy Strategy thatpromotes the growth of the aquaculture and marine biotechnology sector. Additionally, aquaculture is one of the pillars for the EU's Blue Growth Strategy, and its development can contribute to the Europe 2020 Strategy. For CFP in relation to biodiversity it is important to note that even if commercial fish species are exploited at maximum sustainable yield several sensitive non-target fish species (e.g. certain rays and sharks) are still potentially at risk.

## MAIN MESSAGES FROM POLICY ANALYSIS

- Many policy mechanisms, their articles and specific objectives exist for supporting synergies between the EU Biodiversity Strategy and all other environmental protection policies. In practice, however, the opportunities for policy coherence offered by the existing policy framework are not adequate and efforts for environmental improvement remain within existing silos;
- Although WFD and the MSFD are expected to support the achievement of the EU Biodiversity Strategy, their contributions to the EU Biodiversity Strategy are rarely made explicit, as both directives focus on assessments, measure selections or stakeholder processes to their specific (narrower) issues and objectives. As a result, opportunities for delivering the EU biodiversity objectives are unlikely to be fully captured;
- Sectoral policies, which primarily aim to support economic growth, directly or indirectly produce threats and put pressures on aquatic biodiversity. As long as these pressures are significantly supported through policy, the recovery of aquatic ecosystems is unlikely;
- The lack of success of EU environmental policy is the result of amongst other things, an insufficient coordination of EU policies and their fragmented implementation.


| ← Go to Brief #1: Europe biodiversity trends/threat | www.aquacross.eu/results | Go to Brief #3: Introducing EBM → |
|---|---|---|


**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Rouillard et al. (2016) Synergies and Differences between Biodiversity, Nature, Water and Marine Environment EU Policies. Deliverable 2.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Rouillard, J., Lago, M., Abhold, K. et al. (2017) Protecting aquatic biodiversity in Europe: How much do EU environmental policies support ecosystem-based management? Ambio. DOI: 10.1007/s13280-017-0928-4
- Rouillard, J., Lago, M., Abhold, K. et al. (2018)Protecting and Restoring Biodiversity across the Freshwater, Coastal and Marine Realms: Is the existing EU policy framework fit for purpose? Environmental Policy and Governance 28: 114-128. DOI: 10.1002/eet.1793
- Röschel, L. (2018). AQUACROSS Final Conference presentation: AQUACROSS Policy Review, Lessons learnt from top down and bottom up analysis.



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# 3

# Introducing Ecosystem-based Management

## WHAT MAKES EBM SO RELEVANT FOR THE PROTECTION OF AQUATIC BIODIVERSITY?

To support the achievement of the objectives of the EU 2020 Biodiversity Strategy for aquatic ecosystems, strong policy integration in terms of objectives, knowledge base, methods and tools, and engagement and exchange, is essential. The integrative nature of EBM is perfect for supporting such an integration exercise.

## ECOSYSTEM-BASED MANAGEMENT OF AQUATIC ECOSYSTEMS

### What is ecosystem-based management?

Any management or policy options intended to restore, enhance or protect the resilience of the ecosystem

### Ecosystem-based management helps to

protect aquatic biodiversity and the benefits that people receive from aquatic ecosystems. It involves tackling the threats facing aquatic ecosystems in an integrated way throughout the entire water system from source to sea.

### Ecosystem-based management

tackles many threats to aquatic ecosystems from source to sea

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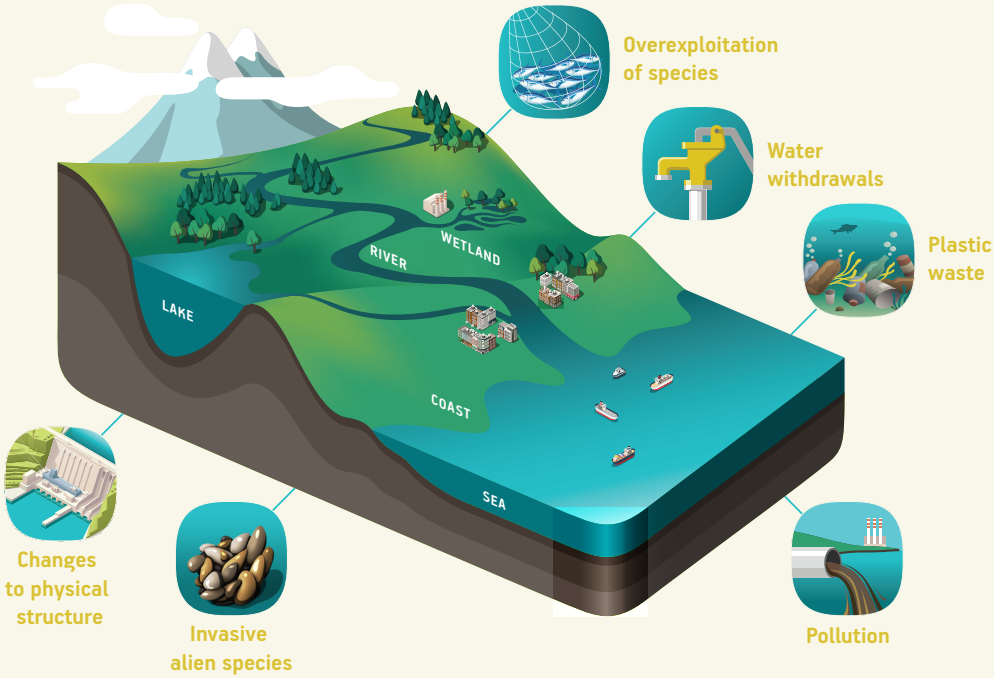



### Benefits of ecosystem-based management

- Increased benefits for human wellbeing from ecosystems
- Improved ability of ecosystems to stay within environmental limits
- Increased ability to adapt to change
- Improved management of uncertainty
- Increased ability to meet multiple policy objectives

## WHAT MAKES EBM DIFFERENT TO OTHER APPROACHES?

Ecosystem-based Management builds on six components that reach far beyond traditional management approaches (see table).

| | |
|---|---|
| **1 EBM considers ecological integrity, biodiversity, resilience and ecosystem services** | • joint value of all ecosystem services<br>• protects the integrity of the ecosystem as a means to preserve ecosystem services and biodiversity<br>• focus on multiple benefits or ecosystem services |
| **2 EMB is carried out at appropriate spatial scales** | • taking into account ecosystem boundaries |
| **3 EBM develops and uses multi-disciplinary knowledge** | • understanding of the ecological and social systems to be managed |
| **4 EBM builds on social-ecological interactions, stakeholder participation and transparency** | • balance ecological and social concerns<br>• prominence to transparent and inclusive descisiion making<br>• advance collective action by building consensus on a shared vision for the future (e.g. the array of ecosystem services to be preserved) |
| **5 EBM supports policy coordination** | • break silos and create new opportunities of pursuing different policy objectives simultaneously |
| **6 EBM incorporates adaptive management** | • ability to respond to a range of possible future scenarios |

*Aquacross case studies*

# WHAT DOES ECOSYSTEM-BASED MANAGEMENT INVOLVE?

## It is carried out at appropriate **spatial scales**

***EXAMPLE: RIVERS OF THE SWISS PLATEAU***
Ecological assessment was extended to the catchment scale to support the identification of optimal restoration measures

***EXAMPLE: RIA DE AVEIRO, PORTUGAL***
A planning process is co-developed across the river, coastal and marine area to avoid unintended consequences of management measures

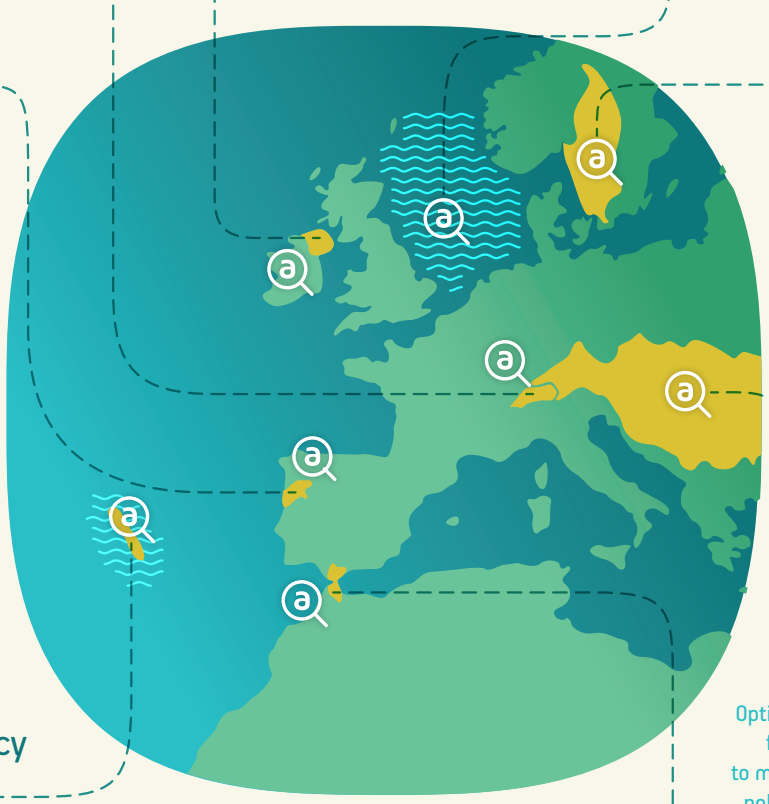
## It uses **adaptive management** to handle uncertainty in how ecosystems respond to management measures

***EXAMPLE: LOUGH ERNE, NORTHERN IRELAND***
Considers raising water levels in the lake alongside farm best management practices to manage long-term impact of invasive alien species

## It develops and uses **multi-disciplinary** knowledge

***EXAMPLE: NORTH SEA***
A risk-based approach was used to compare management measures that reduced risks to biodiversity while achieving other societal goals

***EXAMPLE: LAKE RINGSJÖN, SWEDEN***
Social and ecological dynamics were modelled to understand the lake's responses to restoration measures



## It builds on **social-ecological** interactions, stakeholder participation and transparency

***EXAMPLE: MARINE PROTECTED AREA, AZORES***
Stakeholders identified shared objectives: long-term sustainability, monitoring and compliance with legislation, participatory and holistic management

## It considers **ecological integrity**, biodiversity, resilience and ecosystem services

***EXAMPLE: INTERCONTINENTAL BIOSPHERE OF THE MEDITERRANEAN (SPAIN-MOROCCO)***
Biodiversity and ecosystem services were modelled across the region to design a network of green and blue infrastructure

## It supports **policy** coordination

***EXAMPLE: DANUBE RIVER***
Optimal sites were identified for ecological restoration to meet objectives of several policies including the Water Framework Directive and the Biodiversity Strategy

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Sources: Rouillard et al., 2017; www.aquacross.eu/casestudies

# GLOSSARY OF KEY TERMS

For a more detailed glossary see D3.1 and D3.2

| Term | Straightforward definition | More info? |
|---|---|---|
| **Biodiversity = Biological Diversity** | means the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity, article 2). Biological diversity is often understood at four levels: genetic diversity, species diversity, functional diversity, and ecosystem diversity. | **D5.1 and D5.2** |
| **Ecosystem Process** | is a physical, chemical or biological action or event that links organisms and their environment. Ecosystem processes include, among others, bioturbation, photosynthesis, nitrification, nitrogen fixation, respiration, productivity, vegetation succession. | **D5.1 and D5.2** |
| **Ecosystem Function** | the biological, geochemical and physical processes and components that take place or occur within an ecosystem. Ecosystem functions include decomposition, production, nutrient cycling, and fluxes of nutrients and energy. | **D5.1 and D5.2** |
| **Resilience** | refers to the capacity of a system to deal with changes and continue to naturally evolve. The term is related to the overall health of the ecosystem in terms of the amount of damage it can hold and still maintain the same structure and functions. In AQUACROSS, this refers to the capacity of the socialecological systems to co-produce the ecosystem services and abiotic outputs that would be demanded by society in the long term. | **D3.1 and D3.2 Case Study 6** |
| **Adaptability** | is the capacity of actors in the system to manage change so as to maintain the system within sustainability boundaries. One critical objective of policy actions within AQUACROSS consists of enhancing the robustness of the system, meaning its capacity to absorb shocks and adapt to circumstances that are not completely predictable in advance. | **D3.1 and D3.2** |
| **Transformability** | is the capacity to create a new system when, due to pressures, the current system can no longer survive. Transformability addresses active steps that can be adopted to change the system to a different, potentially more desirable, state. It includes actions to identify potential future options and pathways to get to the new state. | **D3.1 and D3.2** |
| **Pressure** | means direct and indirect transformation of the ecosystem structure. It includes, for instance, water abstractions, diversion, impoundment, pollution, land use, soil transformation, alterations of nutrient and sediment balances. | **D4.1 and D4.2** |
| **Indicator** | refers to a variable that provides aggregated information on certain phenomena, acting as a communication tool that facilitates a simplification of a complex process. It relates to the component or process responsive to changes in a system of interest, but does not possess a measurable dimension, and therefore it is not an operational tool in itself. | **D5.1 and D5.2** |

← Go to Brief #2: Current biodiversity management: Issues | www.aquacross.eu/results | Go to Brief #4: Mobilising stakeholders →

**Further information**

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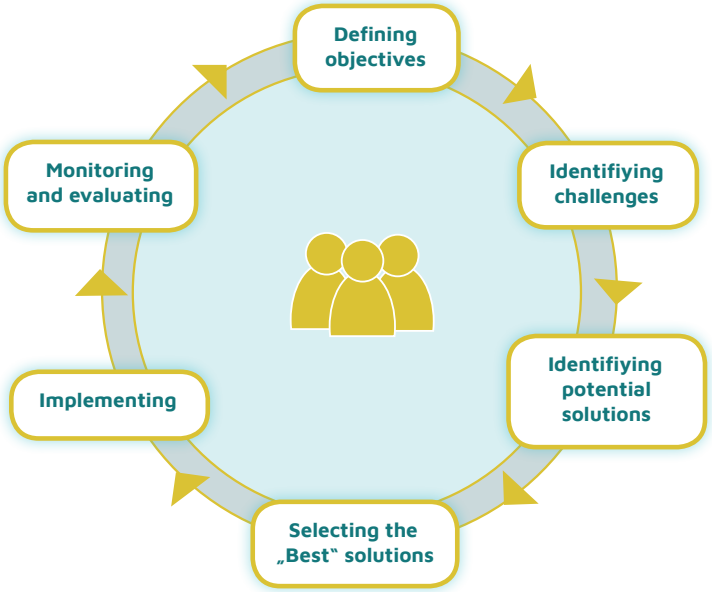
# 4

# Identifying Goals: Mobilising Stakeholders for supporting Ecosystem-based Management

## WHAT IS THE ROLE OF STAKEHOLDERS IN ECOSYSTEM-BASED MANAGEMENT – AND WHY IS IT USEFUL?

Ecosystem-based management calls for transparent management with broad stakeholder participation (see Ecosystem-based Management). Stakeholders can support management at every step of the ecosystem-based management process:

- **Objectives:** Stakeholders will help you identify societal objectives that are complementary to the ones specified in existing regulations (e.g. ensuring a given water level in a lake for supporting tourism development). They can also help you prioritise between conflicting objectives, or propose local operational targets for policy objectives that are too broadly defined (see Integrative environmental objectives).
- **Understanding the social-ecological system:** local stakeholders are (often low cost) sources of insight, data, knowledge, and subject-specific expertise essential for understanding how society and the ecosystem are interlinked.
- **Identifying and evaluating ecosystem-based management measures/policies:** With their expertise and their practical grounding, stakeholders can co-create innovative management measures, assist with implementation, as well as provide practical feedback on proposals and evaluations.
- **Monitoring, evaluation:** Stakeholders can also support effective adaptive management by providing feedback.



# GUIDANCE FOR ENGAGING STAKEHOLDERS IN ECOSYSTEM-BASED MANAGEMENT

Stakeholder mobilisation is embedded in existing environmental regulations such as the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). Simple stakeholder consultation is however the rule under the formal implementation processes of existing legislation: active participation of stakeholders for co-building priorities and selecting measures remains an exception for more local (catchment, coastal zone, marine protected area…) processes.

When dealing with ecosystem-based management, stakeholder mobilisation needs specific attention:

1 First, stakeholder involvement needs to **start as early as possible** - when defining objectives, and for helping to understand the functioning of the ecosystem under investigation in its complex relationships between drivers, activities, pressures, states and ecosystem services delivered. Indeed, some of the causal relationships between some drivers and activities (e.g. how a change in market prices can affect farming and nutrient use), or between the functioning of the ecosystem and the services it delivers (or how a change in lake water levels can affect tourism), are best known and understood by those that are "part of the system";

2 Second, because of the need to give attention to the many links between activities and ecosystems on one hand, and ecosystems, services delivered and beneficiaries on the other hand, **ecosystem-based management requires mobilising widely**: e.g. to simultaneously achieve the targets of the Biodiversity Strategy, the WFD and the MSFD, a wider range of "environmentalists" (bird specialists, wetland gurus, river renaturation experts and coastal zone NGOs) are needed. Additionally, to understand all the important activities that both put pressures on ecosystems and are impacted by/ benefit from services delivered by ecosystems, more economic sector representatives are needed. In some cases, it can be important to mobilise representatives of the value chains (retailers, food processing industry, consumers) of primary producers (e.g. fishers and farmers) as their decisions impact directly or indirectly on the practices and decisions of primary producers and thus on pressures imposed on ecosystems.

> **Example:** If a WFD expert considers multifunctional measures delivering multiple benefits such as carbon storage, flood risk mitigation, adaptation to climate change, amenities to cities…, he/ she will need to mobilise representatives from these different sectors that are not necessarily his/ her traditional "water stakeholders". These might indeed help to better capture benefits, provide financial resources to support the implementation of measures, or help monitor the impacts that the measure will deliver.

**When applying ecosystem-based management in territories where governance already exists for natural resources ....**

(e.g. water, Natura 2000 sites, or marine protected areas), it is important to build on the existing governance – but do not limit yourself to it. Indeed, existing governance mechanisms are mostly designed with a primary focus (e.g. water management) with other relevant functions and services that ecosystems can deliver not necessarily accounted for or made explicit. When ecosystem-based management requires addressing fresh and marine waters together, it is important to mobilise stakeholders and governance of both water types at the same time, as these too often remain disconnected.

**When applying ecosystem-based management at very large scales...**

e.g. the Danube River basin (see Case Study: Danube) or the North Sea (see Case Study: North Sea) to cite the two large scale case studies of AQAUCROSS, mobilising widely can be very challenging. Indeed, the existing governance at such large scales is driven by very formal information exchange, decision-making rules, and memberships. Thus, it can be challenging to widen the community to discuss combined issues relevant to biodiversity, the WFD, the Floods Directive, the MSFD, adaptation to climate change, etc. and identify win-win solutions going beyond the objectives of one (or two) pieces of legislation.

← Go to Brief #3: Introducing EBM | www.aquacross.eu/results | Go to Brief #5: Integrative environmental policy objectives →

**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- AQUACROSS Case studies
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)

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# 5

# Identifying Goals: Integrative environmental policy objectives

## WHAT ARE INTEGRATIVE ENVIRONMENTAL POLICY OBJECTIVES, AND WHY ARE THEY IMPORTANT FOR A LOCAL POLICY MAKER?

Clearly defined local targets for biodiversity protection are important to motivate effective action. They also enable policymakers and stakeholders to evaluate the effectiveness of potential management measures, monitor progress, and adapt as needed.

The European Commission sets numerous environmental goals, which Member States transpose into national law to be met locally. Key to the protection of aquatic biodiversity are the targets of the EU Biodiversity Strategy to 2020. However, the strategy does not provide clear environmental objectives for the purposes of managing aquatic ecosystems at different scales. At local level, objectives need to be defined to respond to a well-defined environmental challenge, which also depends on those responsible for implementation.

For the successful achievement of its targets and actions for aquatic ecosystems, the EU Biodiversity Strategy to 2020 relies on other EU environmental directives, including the Water Framework Directive, the Marine Strategy Framework Directive, as well as the Birds and Habitats Directives. EU environmental policy objectives are often formulated in terms of conservation, preservation, protection, enhancement of biodiversity, habitats, water bodies, etc. While primary environmental policy objectives mostly address the ecological system, ecosystem-based management (see Introducing Ecosystem-based Management (EBM)) goes beyond this approach, by also focusing on society and how it interacts with the ecosystem. This brief covers how to integrate multiple environmental objectives to identify and set local-level, measurable targets for policy action to protect aquatic biodiversity.

Integrative environmental objectives are more effective at protecting biodiversity. By simultaneously meeting other environmental and societal goals, they also avoid duplication and can help in the identification of appropriate responses. To complement these policy objectives, it is important to elicit stakeholders' goals (see Mobilising stakeholders for supporting EBM).

# HOW CAN INTEGRATIVE ENVIRONMENTAL POLICY OBJECTIVES BE DEVELOPED?

**1 Step 1: Understand the relevance of EU environmental policy objectives for the local scale**

To support the achievement of the EU Biodiversity Strategy targets, it is necessary to consider the implementation and achievement of other environmental directives and their respective targets. The first step is familiarising yourself with the targets and objectives of the EU environmental directives relevant to the protection of aquatic ecosystems:

**TIP!** Relevant for the management of aquatic ecosystems are the targets of the Habitats and Birds Directive – e.g. achieving favourable conservation status, status of bird populations, Water Framework Directive – e.g. Good Ecological Status and Marine Strategy Framework Directive – Good environmental status for marine waters. But beware of the many accompanying policies that help with implementation and that may also include environmental targets.

**Example:** To manage invasive species in Lough Erne, (see Case Study: Lough Erne, Ireland), many competing management objectives from a range of European directives and policies as well as sectoral activities are relevant. In terms of environmental objectives, the Upper Lough Erne is designated a Special Area of Conservation under the Habitats Directive, and as such must achieve favourable conservation status. Under the Water Framework Directive, the lakes are designated as heavily modified water bodies due to the physical alteration caused by the hydroelectric dam. Under the directive, the lakes must reach good ecological potential, but currently achieve moderate ecological potential due to eutrophication.


Figure: Policies relevant for the management and impacts of Invasive Alien Species in the Lough Erne

## 2 Step 2: Understand local environmental and societal conditions to set local targets

Specific conservation and biodiversity policy objectives at local level that are consistent with EU objectives need to take into account local ecosystem and societal conditions, i.e. how the ecosystem functions to deliver benefits to society, and how society affects the ecosystem (i.e., ecosystem services used by socio-economic systems). This requires knowledge and understanding of the main human activities placing pressures on the local ecosystem, and the drivers of those activities, which are often human demand for nature's goods and services.

**TIP!** The AQUACROSS Linkage Framework can be a useful tool to understand the system (see Linkage Framework).

**TIP!** You can find many open data and information in the national reporting related to the progress reports of EU directives. Member State assessments and reports for the different Directives can help guide the identification of relevant descriptors and are the best sources of information within a region or area in terms of drivers, pressures and status indicators (see Developing relevant indicators). This not only connects the local level to the national level, but also provides an opportunity to integrate higher-level national objectives into local-level environmental decision-making processes

## 3 Step 3: Integrating environmental objectives

Once objectives for the analysis have been identified based on the identification of local needs, there is still a further step needed across aquatic ecosystems, which is to reconcile and integrate the objectives of different Directives. This is particularly relevant for the management of those aquatic ecosystems that fall under the influence of several Directives at the same time (e.g., coastal areas). Relevant EU Directives are not easily integrated as they include different terminology for the characterisation of drivers and pressures, promote different indicators to measure status, etc. See AQUACROSS reports D4.1 and D5.1.

**TIP!** AQUACROSS promotes a framework for the integrative assessment of aquatic ecosystems, which includes integrative typologies across EU Directives. The application of the framework will assist the analyst to consider aquatic ecosystems as a whole and reconcile objectives across separate targets. Thus, facilitating the selection of those relevant indicators across Directives that are important for the achievement of integrative objectives in the local area.

**Example:** The Vouga coastal watershed 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 (see Case Study: Ria de Aveiro, Portugal). For the identification of integrative environmental policy objectives in this local case study, relevant policies were first individually identified and characterised according to their relevant drivers, pressures and state available information. This information was then brought together in the development of the AQUACROSS linkage framework to characterise the entire study area. This helped to reconcile different policy objectives into measurable indicators relevant for the management of ecosystem services in the watershed.

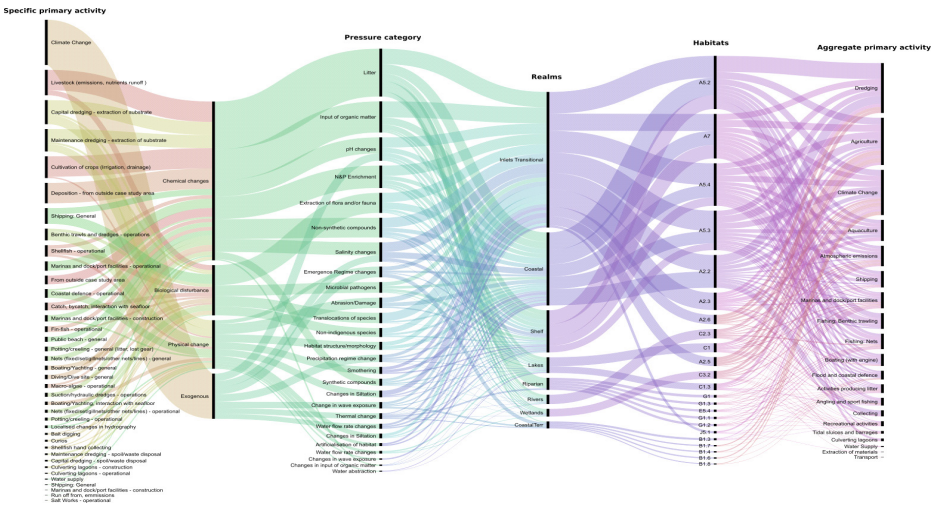


Figure: Linking drivers and pressures in the Vouga river coastal watershed

## 4 Step 4: Describing objectives

Local administrators and stakeholders can jointly develop tailored objectives to address the local-level problem previously identified. Then, to make these operational, those descriptors and indicators that are relevant for the case study area can be selected. These allow the objectives to be defined in measureable and monitorable terms.

**TIP!** Reviewing the respective national transposition of the main Directives may be one useful step to get informed about how EU objectives have been detailed at a national and local level. The step consists of specifying the general objective of the Directive by describing the characteristics used to describe targets. For instance, the MSFD describes the ecological status of a marine ecosystem by using 11 descriptors. The WFD describes the ecological status of a water body by referring to a wide array of descriptors grouped into three categories (biological, chemical and hydro-morphological status) and each one of these descriptors can be characterised by a set of indicators that can eventually be measured qualitatively or quantitatively so as to allow for the comparison of the ecological status and the characterisation of the baseline.

**Example:** In the North Sea (see Case Study: North Sea), a risk-based approach to identify the main human activities and their pressures that compromise biodiversity was undertaken. The basis of the approach was the AQUACROSS Linkage Framework (see Linkage Framework), which follows the Driver–Pressure–State–Impact–Response (DPSIR) framework consisting of single so-called impact chains of causal links. Based on the assessment, the case study was also able to identify relevant objectives. The analysis showed trawl fisheries to be among the main activities causing risk while wind energy is still mid-range in terms of its contribution to risk, but may be moving up as it further expands.

**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Rouillard et al. (2016) Synergies and Differences between Biodiversity, Nature, Water and Marine Environment EU Policies. Deliverable 2.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Rouillard, J., Lago, M., Abhold, K. et al. (2017) Protecting aquatic biodiversity in Europe: How much do EU environmental policies support ecosystem-based management? Ambio. DOI: 10.1007/s13280-017-0928-4
- Rouillard, J., Lago, M., Abhold, K. et al. (2018) Protecting and Restoring Biodiversity across the Freshwater, Coastal and Marine Realms: Is the existing EU policy framework fit for purpose? Environmental Policy and Governance 28: 114-128. DOI: 10.1002/eet.1793
- Gomez et al. (2016) Developing the AQUACROSS Assessment Framework. Deliverable 3.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Pletterbauer et al. (2016) Drivers of change and pressures on aquatic ecosystems. Deliverable 4.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Nogueira et al. (2016) Guidance on methods and tools for the assessment of causal flow indicators between biodiversity, ecosystem functions and ecosystem services in the aquatic environment. Deliverable 5.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Teixeira et al. (2018) Assessment of causalities, highlighting results from the application of meta-ecosystem analysis in the case studies. Deliverable 5.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


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# 6

# Understanding the Socio-Ecological System: Developing relevant Indicators

## WHAT ARE INDICATORS AND WHY ARE THEY USEFUL FOR MANAGING AQUATIC BIODIVERSITY?

Indicators provide consolidated information, simplifying complex issues or phenomena into something simple and easily communicable. For example, coral reefs are important indicators of marine ecosystem health. While indicators by definition are reductive, this simplification is useful for management. For example, it allows targets to be set, monitored, and evaluated – and communicated with non-expert stakeholders. As such, indicators are well-suited for informing how an ecosystem is managed and how it affects and is affected by human activities.

Indicators can be selected to describe every element of society's relationship with aquatic ecosystems. They can be used to understand human activities, while others can indicate the pressures on the ecosystem. For example, the number of fishing boats can be an indicator of fishing and of associated pressures (see Case Study: Azores). Indicators can also be used to understand the state of the different components of the ecosystem (species and habitats) – e.g. the presence of invertebrate animals can indicate river health (see Case Study: Swiss Plateau). They can also be used to understand different benefits to society of healthy ecosystems - e.g. tonnes of fish caught are an indicator for the provisioning value of an ecosystem (see Case Study: North Sea). By simplifying complex phenomena, these indicators support management decision making. By describing how these different components interrelate within the system, indicators help to understand the overall social-ecological system.

Selecting the right indicators allows evaluation of the impacts of human activities on the ecosystem, and measurement of how the ecosystem in turn provides us with valuable benefits from nature. Understanding these impacts is important to identify the causes of biodiversity loss and prioritise effective management measures and appropriate monitoring. Indicators communicate complex information in a simplified way and are therefore useful for supporting decision makers and other non-scientists.

### 1 Step 1 – Understand the linkages in the ecosystem

To choose indicators that will be helpful for understanding how human activities affect the ecosystem and its provision of ecosystem services (i.e. the benefits provided by nature), we need to identify which parts of the ecosystem and which ecosystem services are most important. To do this, we need to:

1. Know what pressures a human activity introduces to an ecosystem component (e.g. habitat, species) of interest, and how it affects that component;

2. Know which ecosystem services (i.e. benefits provided by nature) that habitat supports;

3. Know in what way this ecosystem component supplies those services.

The AQUACROSS Linkage Framework is a structured framework that can be used to identify these links between human activities and the ecological system (see Linkage Framework).

## 2 Step 2 – Consider data availability

The AQUACROSS case studies show that the availability and quality of potential indicator data varies widely among countries. If enough good-quality data is available, quantitative approaches can be used, often enabling even spatially-explicit assessment of the ecosystem. Otherwise, semi-quantitative or qualitative assessments can be used.

**Tip!** When there is not enough relevant data or it is not of good quality, involve stakeholders to verify your results (see Mobilising stakeholders for supporting EBM).

## 3 Step 3 – Select indicators

The choice of indicators is made according to the goal of the assessment and the type of data available, taking into account how human activities affect the ecosystem and provision of ecosystem services, and how these are measured. Therefore, indicator selection is specific to the context in which the ecosystem assessment is being made.

In all cases, however, several criteria should be met to ensure high-quality indicators are selected. There should be a scientific basis to the ecosystem relevance of the indicator, it should be cost-efficient, and it should be possible to set targets using the indicator.

**Tip!** From freshwaters to marine waters, AQUACROSS described the interactions between the human activities that put pressures on a specific ecosystem that supplies ecosystem services. Example lists of possible indicators that describe the possible interactions in a given ecosystem are provided. This helps to describe the overall social-ecological system being assessed (see D5.1 Annex).

**Tip!** Using expert knowledge and the wealth of scientific literature available, it is possible to make assessments without local data, albeit while making many assumptions.

**Tip!** Indicators are often chosen to assess aquatic ecosystems to meet legal reporting requirements (e.g. for EU directives or national/regional legislation). However, ecosystem-based management objectives may be different (see Integrative environmental policy objectives) and therefore may require different indicators.

**Tip!** There is often overlap between the objectives of different environmental policies, including EU policies such as the Water Framework Directive, and Birds and Habitats Directives (see Integrative environmental policy objectives). Coordinating indicators across different Directives, along with monitoring and evaluation timelines, can save money and increase knowledge (see Case Study: Ria de Aveiro, Portugal)

← Go to Brief #5: Integrative environmental policy objectives | www.aquacross.eu/results | Go to Brief #7: Developing Scenarios →

**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- O'Higgins et al. (2016) Review and analysis of policy data, information requirements and lessons learnt in the context of aquatic ecosystems. Deliverable 2.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable)
- Pletterbauer et al. (2016) Drivers of change and pressures on aquatic ecosystems. Deliverable 4.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Nogueira et al. (2016) Guidance on methods and tools for the assessment of causal flow indicators between biodiversity, ecosystem functions and ecosystem services in the aquatic environment. Deliverable 5.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


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# 7

# Understanding the socio-ecological system: Developing Scenarios

## WHAT ARE SCENARIOS AND WHY ARE THEY USEFUL FOR MANAGING AQUATIC BIODIVERSITY?

Scenarios are valuable as they consolidate diverse information into a comprehensive, actionable vision of the expected future. Scenarios compile into a coherent picture or story the impacts of current environmental and sectoral policy and management, as well as of expected external conditions (e.g. impact of climate change in the future), on an aquatic ecosystem. They identify how these will affect the environment and the society in the future. Scenarios can be based on quantitative data or can be descriptive, or some combination thereof.

A scenario that describes what will happen under business as usual conditions, including the impacts of current policy and management, is called a **baseline scenario.** The baseline scenario is important as it clearly identifies the deficits between objectives for the ecosystem and its expected future under current management.

A **management scenario** considers what will happen to society and the ecosystem under a change of management or policy. The management scenarios are important as they show the broad impact of management for aquatic ecosystems and therefore can be used as the basis for evaluating management options. They are also useful to communicate the impacts of different management options with stakeholders.

1 **Step 1 – Choose your scenario approach: Model-based vs. narrative/qualitative approaches**

The first step is to consider your aims to determine whether quantitative approaches to scenario development or more descriptive, qualitative approaches are more useful, and whether you have sufficient data and capacity for your choice. Data needs depend on the chosen indicators (see Developing relevant indicators), which are selected according to the objectives for the ecosystem (see Integrative environmental policy objectives). Quantitative scenarios can be helpful to explore consequences of potential future developments, but require data and modelling skills, and can also take longer and be more expensive (see Case Study: Swiss Plateau). Qualitative scenarios include narrative approaches, which can be collaborative exercises that use stakeholder and expert knowledge to describe a realistic outlook for the future (see Case Study: Lake Ringsjön, Sweden). Semi-quantitative methods, which sit between the two approaches (see Linkage Framework) can also be very helpful in quantitatively describing the impacts of future management without requiring extensive modelling capacity (see for example Case Study: North Sea). Combinations are also possible.

## 2 Step 2 – Describe your baseline scenario

A baseline scenario provides a shared view of the past, current and prospective trends and vulnerabilities in ecosystem services and biodiversity. As well as including environmental policies, this baseline scenario should also include future trends for sectors that affect the local environment, e.g. tourism policy targets or trends in agricultural pressures. It can be important to also think about how external factors will affect the ecosystem in the future (e.g. in the Case Study: Swiss Plateau), scenarios considered population growth and economic trends.

**TIP!** Use the information you have already gathered on policy objectives (see Integrative environmental policy objectives) and stakeholder objectives (see Mobilising stakeholders), as well as your understanding of ecosystem responses to human activities and external factors obtained from applying the Linkage Framework (see Linkage Framework) and Indicators (see Developing relevant indicators), to construct your baseline scenario.

**TIP!** Collaborate with stakeholders on scenarios – local fishers, farmers, or environmental NGOs, among others, can provide useful data, insight, expertise, and feedback to ensure realistic scenarios, such as in AQUACROSS's Swedish Case Study (see Case Study: Lake Ringsjön, Sweden). Involving stakeholders in scenario development helps to increase their sense of ownership of the process and will facilitate engaging them later in the ecosystem-based management process.

**TIP!** Business and government stakeholders at AQUACROSS's final conference reported that scenarios are useful to communicate complex issues, like environmental and societal trends, and to provide clear options (see AQUACROSS Final Conference).

## 3 Step 3 – Using scenarios to prioritise management options

Once you have a baseline scenario, you can compare the expected future it predicts to the stakeholder and policy objectives you previously identified. Any gaps between the baseline scenario and your objectives can then be used to identify the measures and policies in the next step (see Identifying EBM measures and policies: taking action). Once identified, the expected impacts of measures and policies can be formulated into management scenarios, following the process used to develop the baseline scenario (see Evaluating EBM options).

# CASE STUDY EXAMPLE – SWISS PLATEAU

AQUACROSS's Swiss Plateau case study (see Case Study: Swiss Plateau) aimed to support cost effective improvement of the ecological state of rivers by restoring ecosystems and reducing the impact of human activities. They used models to develop a baseline scenario based on the business as usual situation, including current environmental policy, the location of dams and other barriers and expected population growth. Stakeholders provided feedback and data to ensure this was realistic. They then used models to find management strategies that would improve environmental and societal outcomes without increasing cost, relative to this baseline.

## Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Martin et al. (2017) Scenario Development. Deliverable 7.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Kakouei et al. (2018) Assessing modelling approaches in selected case studies. Deliverable 7.3, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Kuemmerlen, M., Reichert, P., Siber, R., & Schuwirth, N. (2019). Ecological assessment of river networks: From reach to catchment scale. Science of The Total Environment, 650, 1613-1627. https://www.sciencedirect.com/science/article/pii/S0048969718334375 .


Revitalisation Chriesbach, Case Study Swiss Plateau © EAWAG, Peter Penicka

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# 8

# Identifying ecosystem-based management measures and policies: taking action

Once the main deficits between policy and societal objectives and the baseline scenario have been identified (see Developing Scenarios), the "best" ecosystem-based management (EBM) measures and policies can be identified. These management options together make up the management plan that is expected to effectively, efficiently and equitably address those deficits and hence contribute to the achievement of the policy objectives (see Integrative environmental policy objectives).

Often, management options are developed with the aim to mitigate a specific single threat or to achieve a specific and individual policy objective, e.g. fisheries management in the marine realm or river regulation measures for flood protection in the freshwater realm, but without any consideration of its consequences on the wider ecosystem and/or other policy objectives. Ecosystem-based management provides an approach that allows a more holistic perspective when identifying, designing and evaluating those management options and that should therefore contribute towards the achievement of multiple objectives as part of a more complete ecosystem-based management plan.

## MANAGEMENT MEASURES AND POLICY INSTRUMENTS:

Any potential responses to an environmental problem, consists of two interconnected and structured (yet well differentiated) sets of actions:

**Management measure** or **Programme of Measures.** This constitutes a single or combined set of actions that, if properly designed and implemented, contribute **to the environmental objectives** and thus to enhance and protect the ecological system.

- Prevention measures that manage the causes of the risk to the ecosystem, targeted at the human activity and/or the pressure. Examples are input controls that limit the cause of the pressure (such as scrapping schemes to reduce the capacity of the fishing fleet), output controls that prevent the pressure from entering the system (e.g. catch controls in fisheries) or spatial- and/or temporal distribution controls (e.g. marine protected areas or real-time closures).
- Mitigation measures are implemented to mitigate a pressure once it is present in the system (e.g. beach cleaning after oil spills) and or recover the ecosystem component that is impacted (e.g. habitat restoration or stocking programs).

**Policy instruments** consisting of all the arrangements or reforms that are required in the governing system (as part of the social system) to fully implement the Programme of Measures. Examples are legislative instruments (e.g. conservation laws), regulatory instruments (e.g. bans or permits), economic instruments (e.g. tariffs, taxes and charges), but also instruments involving information, awareness-raising, and public engagement such as training and qualifications (obtaining certificates or proof of qualification) related to environmental protection, public information programs, stakeholder and public participation, and innovation groups that aim to build capacity and knowledge (e.g. about a particular environmental, economic, or practical issue).

# THE FIVE STEPS OF SELECTING AN APPROPRIATE EBM RESPONSE

## 1 Step 1: Understanding your goals

Before taking any action, it is necessary to perform a policy characterisation for the definition of policy objectives and societal goals in the case study area:

- Identification of key threats compromising the achievement of policy and/or societal goals for the protection of biodiversity. A threat typically consists of a list of human activities and the pressures that impacts the ecosystem. This selection should not only reflect the most significant threats, but also their social significance and importance for local actors.
- Identification of relevant policies: Their description can include their objectives, targets, current deficits or gaps (difference between current state/status and policy targets), an inventory of existing management strategies, identification of administrative bodies in charge, scale of implementation, stakeholder groups, and funding.

(see Integrative environmental policy objectives and Mobilising stakeholders for supporting EBM)

## 2 Step 2: A tailor-made description of the socio-ecological system for management purposes

Using the knowledge developed in understanding the social ecological system (see Linkage Framework, Developing relevant indicators and Scenario development), this step describes of the current status in the case study area, and an understanding of how this will develop in the future under current management plans.

The basis of EBM planning requires a full understanding of the ecological system (including its ecological integrity and biodiversity and the human activities and their pressures which co-produce the services demanded by society) and the social system (in terms of governance and institutions relevant for the achievement of societal goals) (see AQUALINKS tool).

**TIP!** For practical reasons and to avoid the inherent complexity in understanding each connection in the system, a reduced understanding of ONLY those relevant components and their potential linkages for which adequate knowledge is available is sufficient to scan potential responses.

## 3 Step 3: Inventory existing management measures and policy instruments

This planning phase commences with an inventory of the existing management measures and policy instruments. These have the advantage that they can be assumed to be without any major issues (e.g. they are technologically feasible, financially viable or politically expedient) and are already embedded in the institutional context. To improve their environmental and social impact, these management measures can then be modified, in terms of:

- **Where** they are implemented – e.g. The Danube case study (see Case Study: Danube) is prioritizing sites for river restoration and conservation. The Intercontinental Biosphere Reserve of the Mediterranean Case Study (see Case Study: Spain/Morocco) proposed alternative zones for Green and Blue Infrastructure.
- The **degree** to which they are implemented - e.g. The North Sea case study (see Case Study: North Sea) evaluated further reducing fishing effort.
- How they can be **extended** with additional measures (e.g. restoration of saltmarshes through re-vegetation in the AQUACROSS case study in the Ria de Aveiro (see Case Study: Ria de Aveiro, Portugal)

### 4 Step 4: Screening further potential EBM measures

Alternatively there is the possibility to implement novel management options e.g. increase lake water levels in the AQUACROSS case study in Lough Erne (see Case Study: Lough Erne, Ireland), different design of offshore windfarms in the North Sea (see Case Study: North Sea) evaluated or the implementation of cross-boundary management plans (see Case Study: Lake Ringsjön, Sweden).

> **TIP!** Before identified measures can be considered for more detailed evaluation, we recommend pre-screening to determine in advance that the various issues that may prevent the management plan from being implemented are considered. Criteria for the pre-screening of measures can be found in D8.1.

### 5 Step 5: Selection of Management Strategies for further evaluation

Based on the results of the pre-screening exercise, one or several combinations of measures and policies that will be considered for further evaluation are identified and selected (see Evaluating EBM options). This includes any relevant combinations of policy instruments and measures to achieve the identified societal goals and preserve or restore the resilience and the sustainability of the system consisting of both the ecosystem components and their interactions (i.e., ecological system), but also the governing institutions and markets (i.e., social system).

## CASE STUDY EXAMPLE – NORTH SEA

The North Sea case study (see Case Study: North Sea) identified three key objectives: sustainable food supply, clean energy and a healthy marine ecosystem. Understanding of the North Sea social-ecological system was used to construct a simplified matrix of key relationships, and to look ahead and identify key gaps between the expected future (the baseline) and the societal and policy goals. The Case Study selected nine management measures for further evaluation, which included, e.g. marine protected areas, banning fishing in offshore-wind sites, allowing new fishing technology, among others.


| ← Go to Brief #7: Developing Scenarios | www.aquacross.eu/results | Go to Brief #9: Evaluating EBM → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Piet et al. (2017) Making ecosystem-based management operational. Deliverable 8.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)



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# 9

# Planning an EBM response: Evaluating ecosystem-based management options

## WHY IS IT IMPORTANT FOR AN ENVIRONMENTAL DECISION-MAKER TO EVALUATE ECOSYSTEM-BASED MANAGEMENT OPTIONS?

After identifying ecosystem-based management measures (see Identifying ecosystem-based management measures and policies: taking action), the evaluation step allows decision makers to compare the impact of different options. Here, decision makers compare new management measures and policy options to existing ones, as well as to different alternative options, according to their effectiveness, efficiency, and equity.

## WHICH STEPS NEED TO BE FOLLOWED WHEN CARRYING OUT AN EVALUATION?

### 1. Identifying the baseline

To realistically compare the impact of management measures, it is important to identify a clear baseline. The baseline scenario, i.e. what would happen if management stayed the same, is a shared view of the past, current and prospective trends in society and the ecosystem (see Developing Scenarios). It describes the impacts of current environmental and sectoral policy and management and expected external conditions (e.g. impact of climate change in the future) on an aquatic ecosystem. Evaluating management measures relative to a baseline scenario is preferable to evaluating immediate impact, as it by definition has a long-term focus, considers impacts on the whole system, and incorporates the influence of external factors (e.g. population growth).

### 2. Defining evaluation criteria

Within AQUACROSS, three minimum criteria are used for the evaluation: **effectiveness, efficiency**, and **equity and fairness**. Next to these basic criteria, others can be added (social acceptability, potential for funding, etc.), according to the priorities of the decision-maker.

> **Tip!** Decision makers need to reflect on what information is most interesting for them, and what data and capacities they have available. However, even though priorities may differ, all three minimum criteria identified in AQUACROSS (effectiveness, efficiency, equity and fairness) should be considered, even if different degrees of depth and detail are applied. This avoids the risk of failing to identify important weaknesses of a management measure.

### 3. Defining indicators

All criteria are assessed on the basis of indicators (see Developing relevant indicators), which specify the extent to which certain criteria are fulfilled. The choice of indicators needs to be carefully adapted to each situation, and will depend on the objectives which you aim to achieve (see Integrative environmental objectives), and the information available.

### 4. How to evaluate effectiveness?

The evaluation of effectiveness assesses the extent to which different management options reach an environmental goal. This goal might be a combination of physical and biological conditions of the ecosystem (e.g. water quality objectives, species distribution, ecological continuity, etc.). Depending on time and resources available for the evaluation and the complexity of the issues being considered, a risk assessment and/or simulation models can provide support (see Modelling approaches supporting EBM, also see Case Study: North Sea).

### 5. How to evaluate efficiency?

The evaluation of efficiency looks at the costs and benefits (i.e. the impacts on human wellbeing) of implementing environmental management options. Next to the direct costs of measures (e.g. investment costs necessary for restoring river floodplains), the evaluation of efficiency includes the identification – and ideally quantification and monetisation – of any changes (positive or negative) in ecosystem services (see Introducing EBM) that can be expected from different management choices. This can be linked for example to changes in services of water purification, recreational opportunities, biomass production, etc.

**Tip!** Ecosystem-based management evaluation requires interdisciplinary input – i.e. natural and social science. For example, to assess the economic value (i.e. social science) of the change in fish catch due to new management, you first need to understand the induced changes in the ecosystem and fish stocks, which depends on natural scientists.

### 6. How to evaluate equity and fairness?

Once you have identified the costs and benefits of different management measures, it is important to assess how these are distributed among different groups in society (e.g. stakeholders from different sectors, locations, or generations). This provides important information on the expected acceptability of proposed changes. If you find that those bearing costs (e.g. farmers which are required to change their practices) are not the ones benefitting from the changes (e.g. increased recreational potential), policy instruments (see Identifying EBM measures and policies: taking action) that balance the distribution of benefits and costs (e.g. taxes and subsidies) can increase social equity (e.g. see Case Study: Azores).

### 7. How to bring everything together?

Once you have undertaken the evaluation exercise and you know how effective, efficient and equitable the different management options you consider are, these results need to be brought together to take a final decision. This should ideally be done in collaboration with relevant stakeholders, to which results can be presented and discussed. It is very likely that different types of information will be available for different criteria – varying between quantitative, indicator-based information, monetary information, or qualitative evaluations.

**Tip!** Trade-offs will always exist. The evaluation exercise helps to render potential trade-offs transparent, but it is up to the decision-maker – ideally in cooperation with relevant stakeholders – to set priorities and to make the choice accordingly.

**Tip!** Any evaluation exercise will be subject to uncertainty, which can be linked to the choice of the method, to available data, or to the interpretations of results. Being transparent is important so that as new information becomes available, choices can be adapted.

## CASE STUDY EXAMPLE – THE DANUBE RIVER

AQUACROSS's Danube case study (see Case Study: Danube) evaluated the effectiveness and efficiency of a newly proposed allocation approach for restoration sites along the Danube River, which resulted from a spatial optimisation process. The evaluation indicated that the new sites would reach environmental and biodiversity-related objectives at lower cost than the baseline. These results can be used to help decision makers ensure efficient use of available resources for river restoration projects along the Danube.

### Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Gomez et al. (2016) Developing the AQUACROSS Assessment Framework. Deliverable 3.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Piet et al. (2017) Making ecosystem-based management operational. Deliverable 8.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Funk et al. (2018) Danube River Basin – Harmonising inland, coastal and marine ecosystem management to achieve aquatic biodiversity targets. Deliverable 9.2, Case Study 3. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)


Connected sidearm, Case Study Danube © Andrea Funk

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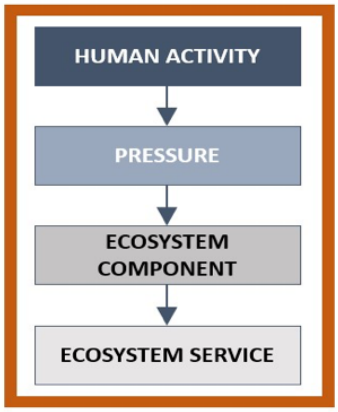
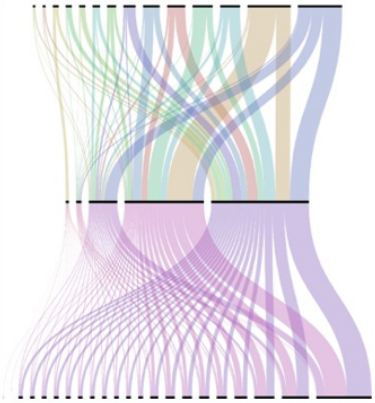
# 10

# Tools: Linkage Framework

The AQUACROSS Linkage Framework is a method to support the application of ecosystem-based management (EBM) in aquatic ecosystems. Human wellbeing relies on many different ecosystem services, such as food provision from fish, wastewater bioremediation, and cultural recreation. These services rely on different parts of the ecosystem to supply them. In turn, the services are often actively exploited by human activities.



If we want to manage ecosystem services sustainably, we need to understand how the state of the ecosystem affects their supply, and how human activities can affect the state of the ecosystem. The linkage framework, around which the AquaLinks tool was built was built (see "AQUALINKS Tool"), helps us with this by encompassing the interactions between human activities and ecosystem services. It accounts for the pressures that are being introduced by human activities and that can impact ecosystem state. Changes in ecosystem state can then affect the supply of services through altered ecosystem functioning. The Framework's integrative approach is important when it comes to considering these interactions because different activities can introduce the same pressures, and multiple ecosystem services can be supplied by the same parts of the ecosystem. Thus, by managing one activity, the key pressures are not necessarily removed, because other unmanaged activities could still be introducing these pressures. In addition, focusing on protecting one specific ecosystem service could result in the loss of multiple others.

## IMPLEMENTATION

**The steps of implementing this approach are:**

1. Identify all the relevant activities, pressures, ecosystem components and ecosystem services that are relevant for the system. The typologies developed in AQUACROSS can be a useful starting point for this (see Integrative environmental policy objectives).

2. Identify the connections between all of these elements. This requires expertise and evidence of the system you are working in. Once this has been carried out, the output is already useful as a description of the system and can be analysed

3. Identify the importance of different links (the weighting). This requires expertise and careful cross checking for consistency. The output of this will allow a prioritisation for management. This can be done for the impact risk to the ecosystem, the service supply capacity of the ecosystem and the risk to the supply of services.

# VALUE OF THE PRACTICAL APPLICATION OF THE LINKAGE FRAMEWORK TO SUPPORT EBM

The linkage framework provides valuable information for policy makers and environmental managers on how human activities and pressures affect ecosystems, their services and biodiversity, through to the capacity of aquatic ecosystems to continue providing the services society depends on.

**Visualise the system:** identifying all relevant human activities, pressures, ecosystem components and services to describe how society and nature are linked.

**Integrative perspective of the system:** a crucial element in EBM approaches is the involvement of stakeholders. In terms of communication, the linkage framework can support targeted stakeholder dialogue as it helps to conceptually describe the complex interactions of social-ecological systems, advancing from narrow single sector views or single pressure-effect approaches.

**Prioritise management:** e.g. identify the key activities to manage, or key services at risk, but also consider these in the context of the entire system, such as identifying all ecosystem services that might be affected, and all activities that might need to be managed.

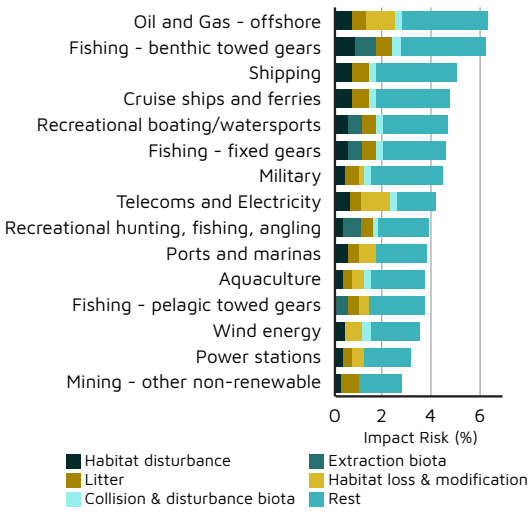
**Links to EU policy objectives:** Ecosystem components are linked to environmental objectives, e.g. Good Environmental Status of seabed habitats, or Good Ecological Status of benthic invertebrates. Activities and pressures also link to policies such as the Renewable Energy Strategy e.g. hydropower. The linkage framework can help to identify links with policies that do not directly consider aquatic biodiversity. Identifying these links can help to highlight potential synergies or trade-offs of environmental and/or economic policies.

AQUACROSS produced comprehensive guidance for transferring this work to support real assessments in aquatic ecosystems and related land-water transitional regions. Guidance available allows users to integrate and reflect the complexity of their own systems' social-ecological interactions, namely by:

- Identifying 'Activities' with associated 'Pressures' that facilitate selection of specific indicators. As additional support, in the absence of local data, an expert-based semi-quantitative characterisation of 'Activities' and 'Pressures' and their potential effects on 'Ecosystem Components' is also available for use as an alternative to data-based indicators.
- Identifying Biodiversity 'Ecosystem Components', 'Ecosystem Functions', and 'Ecosystem Services' and how to link specific indicators to the most suitable classifications. As additional support, in the absence of data-based indicators for assessing 'Ecosystem services', a Service Supply Potential for targeted ecosystem components can be used as a proxy of ecosystem services at risk.

# EXAMPLE CASE STUDY – NORTH SEA

The North Sea is heavily used by humans and many sectors lay claim to limited resources. Some of the human activities introducing pressures into this ecosystem include fishing, shipping, oil and gas extraction, and newly emerging activities such as the renewable energy sector (see Case Study: North Sea). As an example of the results from the AQUACROSS linkage framework, the figure shows the main human activities and the pressures they cause, in terms of the impact risk they introduce to the system.




Impact risk for the activities in the North Sea case study (15 most relevant activities)

## Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

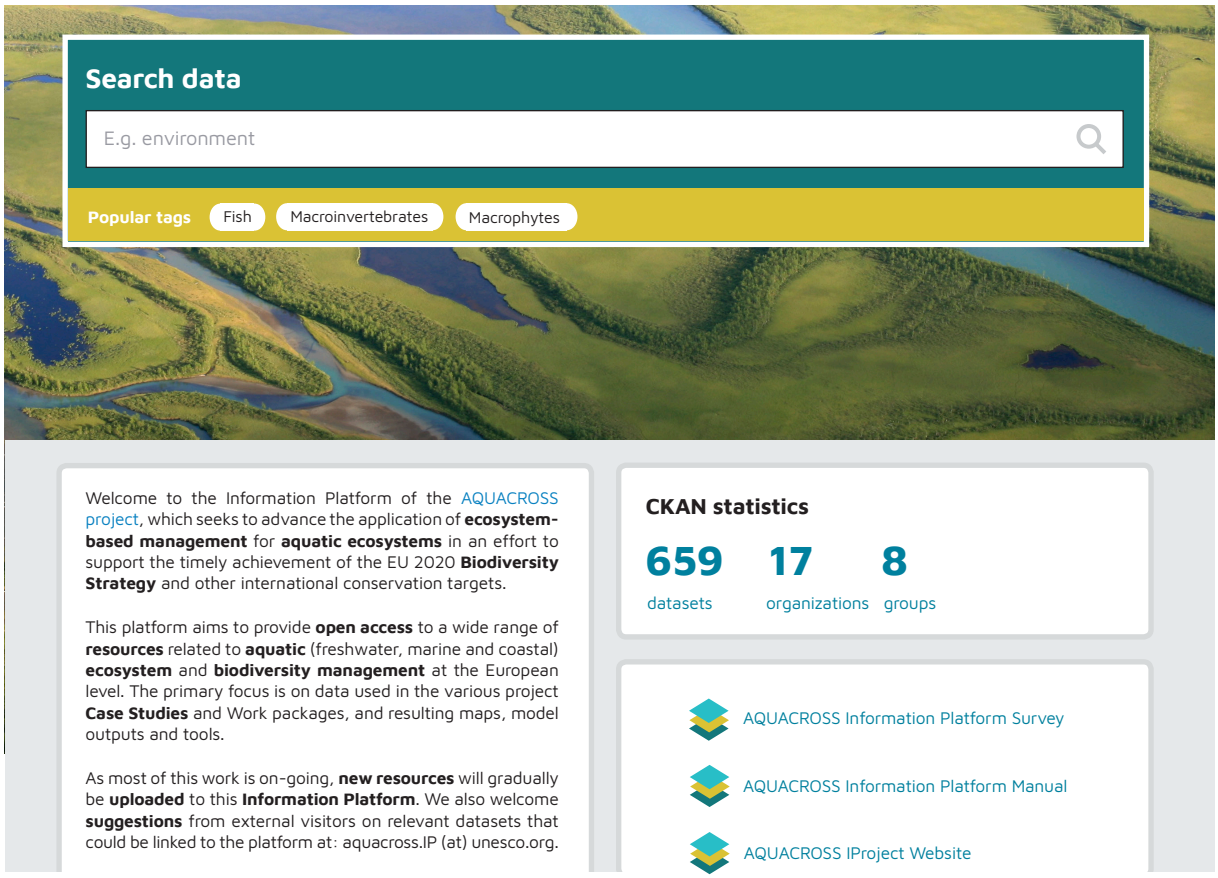

- Teixeira, H., Lillebo, A.I., Culhane, F., Robinson, L., Trauner, D., Borgwardt, F., Kummerlen, M., Barbosa, A., McDonald, H., Funk, A., O'higgins, T., Van der Wal, J.T., Piet, G., Hein, T., Arévalo-Torres, J., Iglesias-Campos, A., Barbière, J., Nogueira, A.J.A., 2019. Linking biodiversity to ecosystem services supply: Patterns across aquatic ecosystems. Science of The Total Environment 657, 517–534. doi:10.1016/j.scitotenv.2018.11.440 Culhane et al.
- Borgwardt, F., Robinson, L., Trauner, D., Teixeira, H., Nogueira, A. J. A., Lillebo, A. I., et al. (2019). Exploring variability in environmental impact risk from human activities across aquatic ecosystems. Science of the Total Environment, 652, 1396–1408. http://doi.org/10.1016/j.scitotenv.2018.10.339
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Teixeira et al. (2018) Assessment of causalities, highlighting results from the application of meta-ecosystem analysis in the case studies. Deliverable 5.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317.(Deliverable and Executive Summary)


Case Study North Sea © RBINS

AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# 11

# Tools: Information Platform




The open access online AQUACROSS Information Platform (IP) is a collaborative effort aimed at supporting more effective European environmental policy and management. It provides scientists, environmental managers and policy-makers with integrated datasets on aquatic systems across Europe at a variety of scales at local, regional, national and transboundary levels in the international context.

## THE AQUACROSS INFORMATION PLATFORM: A TOOL FOR EBM PRACTITIONERS

In the Information Platform, water managers and policy makers will find clear and detailed information about the key water-related ecosystems in the EU, the pressures exerted over them, the way they adapt, their current status and their capacity to continue providing valuable services to society as well as about the ecosystem-based management solutions proposed to improve their health based on the AQUACROSS Case Studies.

The Information Platform offers a consolidated data portal for continuously improving collaboration between scientists, environmental managers and policy makers by building common knowledge and sharing data between organisations, project partners and stakeholders. More than 650 different datasets are easily available free of charge in the platform.

The Information Platform provides clear and traceable pieces of information relevant for decision making. This includes global, European and regional reference layers used as inputs for the AQUACROSS case studies as well as the outcomes of these case studies including models that can be easily replicated with the information and tools made available in the Platform.

## THE AQUACROSS INFORMATION PLATFORM: MEANINGFUL INFORMATION FOR IMPROVED POLICY RESPONSES

In the Intercontinental Biosphere Reserve of the Mediterranean (see Case Study: Spain/Morocco) the Information Platform played a key role in integrating datasets at different spatial scale and with different statistical definitions. The Information Platform allowed for: i) the combination of international databases, ii) the elaboration of an integrated database, iii) a harmonised mapping of the relevant variables. This exercise was the basis for developing an integrated ecosystem-based management plan for the entire Intercontinental Biosphere Reserve.

In AQUACROSS's Ria de Aveiro policy analysis (see Case Study: Ria de Aveiro, Portugal) identified that local implementation of the Water Framework Directive and Habitats Directive have complementary aims, but out-of-sync monitoring and indicators. AQUACROSS researchers, in close cooperation with policy makers and stakeholders, were able to demonstrate that integrated data may help joint monitoring and would decrease costs, increase knowledge, and support more effective biodiversity protection.


| ← Go to Brief #10: Linkage Framework | www.aquacross.eu/results | Go to Brief #12: AQUALINKS Tool → |
|---|---|---|


**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

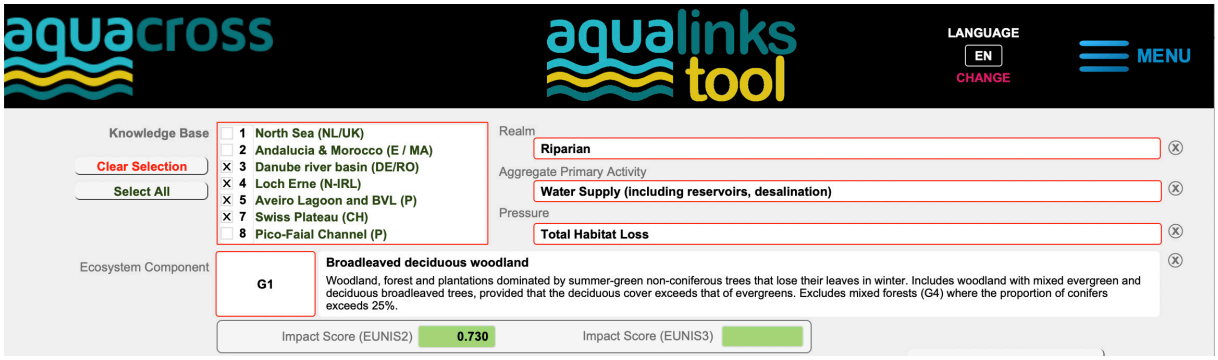

- Arévalo-Torres et al. (2016) AQUACROSS Data Management Plan. Deliverable 6.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable)
- Barbosa et al. (2018) The International Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco – Deliverable 9.2, Case Study 2. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)
- Lillebo et al. ( 2018) Improving integrated management of Natura 2000 sites in the Ria de Aveiro Natura 2000 site, from catchment to coast, Portugal – Deliverable 9.2, Case Study 5 Report. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)



AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# 12

# Tools: AQUALINKS Tool




AQUALINKS tool screenshot

Human wellbeing relies on many different ecosystem services, such as food provision from fish, waste-water bioremediation, and cultural recreation. These services rely on different parts of the ecosystem to supply them, which are threatened by human activities.

The AquaLinks tool implements linkage chains (see Linkage Framework) relating human activities, the associated pressures, the ecosystems components on which they act and the services and functions that they provide. The links between the different components are based on information produced by the eight case studies using expert judgement within the AQUACROSS project. The database underlying the different linkage chains is quite comprehensive, capturing a wide diversity of spatial scales, ecosystem components, geographic contexts and social contexts at European level.

The AquaLinks tool provides valuable information for policy makers and environmental managers on how human activities and pressures affect ecosystems, their services and biodiversity, through to the capacity of aquatic ecosystems to continue providing the services society depends on.

The use of the tool follows the logical flow along which the user selects the elements they want within the information available in the database. At each step, the information presented for the next step depends on all the conditions previously set. The report generated using the tool provides insight on the linkage chains more likely to be vulnerable and helps decide which management measures are likely to reduce vulnerability of specific parts of the ecosystem. These measures might involve the management of activities and associated pressures or increasing the coverage/representativeness of the vulnerable components.


← Go to Brief #11: Information Platform | www.aquacross.eu/results | Go to Brief #13: EBM: Modelling approaches →


**The Aqualinks tool is available:**

- The CESAM webpage
- ZENODO repository: dataset (DOI:10.5281/zenodo.1101161) and tool (DOI:10.5281/zenodo.1101161).

# 13

# Tools: Modelling approaches supporting Ecosystem-Based Management

Modelling approaches are essential to assess the status quo of the interplay between biodiversity, ecological function and ecosystem services, and to subsequently generate scenario projections of alternative management actions or environmental changes. Key causal links between biodiversity and ecosystem services can be considered in order to forecast potential future changes allowing for their linkages and interactions (Figure 1). By assessing trade-offs between ecosystem services and biodiversity conservation goals, management decisions regarding different – even potentially conflicting – policy goals can be evaluated (e.g. between the EU Biodiversity Strategy to 2020, the EU Water Framework Directive, and the Renewable Energy Directive).

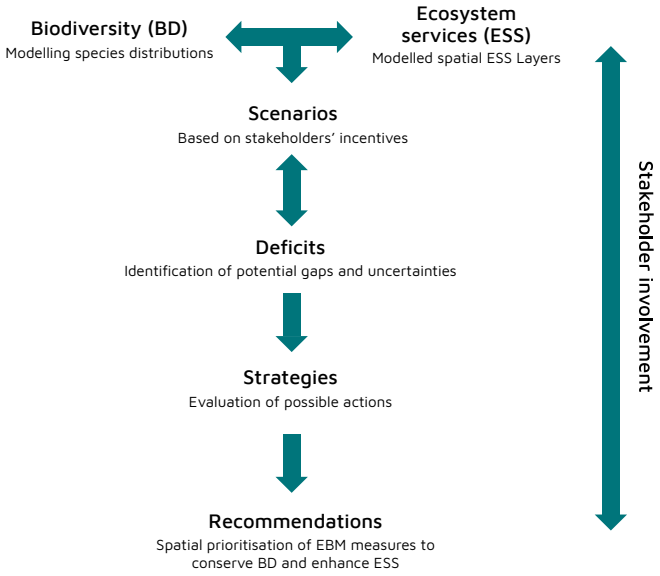



Figure 1 Simplified workflow of the spatial modelling approach in AQUACROSS. Scenarios are defined by stakeholder needs and e.g. represent alternative management scenarios or consider external scenarios such as climate or land use change.

Useful tools to approximate biodiversity and indicate possible hotspots are Species Distribution Models (SDMs) that use species geographic occurrences and environmental factors at those locations to simulate the range-wide potential habitat suitability across a study area. Ecosystem service flow as ecosystem potential on the one hand, and the service demand on the other hand can be analysed with the ARtificial Intelligence for Ecosystem Services (ARIES). The predictions of biodiversity, ecosystem service supply and demand are then used to spatially prioritise different management zones. The modelling outputs, including maps, enable stakeholders to visualise potential outcomes of scenarios, and facilitate decision-making processes to, e.g. achieve conservation goals and socio-economic targets. In agreement with the EBM principles, the outputs lead to potential identification of critical areas for particular management actions. It supports the assessment of trade-offs between protection of biodiversity and use of ecosystem services, satisfying different stakeholder demands.

Modelling in the AQUACROSS case studies tackled e.g. the EBM key issues of taking an interdisciplinary approach, considering societal choices, aiming at ecological integrity and biodiversity protection, or considering ecosystem connection:

- Within the Andalusia and Morocco case study (see Case Study: Spain/Morocco), the modelling approach allowed **a separate view of freshwater, coastal and marine areas.** A higher probability of conflicts between conservation and exploitation goals was identified in freshwater areas, while fewer conflicts were expected in the marine and coastal areas.
- Within the Danube case study (see Case Study: Danube), strategic planning including **spatial prioritisation** of river-floodplain segments for conservation and restoration considered aspects of multi-functionality, availability of remaining semi-natural areas, and reversibility of human activities (e.g., flood protection, hydropower and navigation).
- The Aveiro case study (see Case Study: Ria de Aveiro, Portugal) relied on substantial **stakeholder involvement** for framing the baseline condition, formulating the objectives, screening of measures and instruments, formulating a narrative reflecting the foreseen management measures, the stakeholders' perception on ES valuation, and an evaluation of the proposed measures by EBM criteria regarding policies and feasibility.
- To decide on most effective river restoration locations in catchments in coordination with other management activities (e.g. improving water quality), the Swiss case study considered **ecological network properties** such as connectivity in their models.


| ← Go to Brief #12: AQUALINKS Tool | www.aquacross.eu/results | Go to Brief #14: AQUACROSS's Eight Case Studies → |
|---|---|---|


**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Domisch et al. (2017) Modelling approaches for the assessment of projected impacts of drivers of change on biodiversity, ecosystem functions and aquatic ecosystems services delivery. Deliverable 7.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Kakouei et al. (2018) Assessing modelling approaches in selected case studies. Deliverable 7.3, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- O'Higgins et al. (2016) Review and analysis of policy data, information requirements and lessons learnt in the context of aquatic ecosystems. Deliverable 2.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable)
- Barbosa et al. (2018) Cost-effective restoration and conservation planning in Green and Blue Infrastructure designs. A case study on the Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco. Science of The Total Environment 652: 1463-1473. https://doi.org/10.1016/j.scitotenv.2018.10.416
- Domisch et al. (2019) Social equity shapes zone-selection: Balancing aquatic biodiversity conservation and ecosystem services delivery in the transnational Danube River Basin. Science of the Total Environment 656:797-807. https://doi.org/10.1016/j.scitotenv.2018.11.348
- Langhans et al (2019) Combining eight research areas to foster the uptake of ecosystem-based management in fresh waters. Aquatic Conservation: Marine and Freshwater Ecosystems. doi: 10.1002/ aqc.3012



AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# # 14

# AQUACROSS's Eight Case Studies – practical local examples of ecosystem-based management

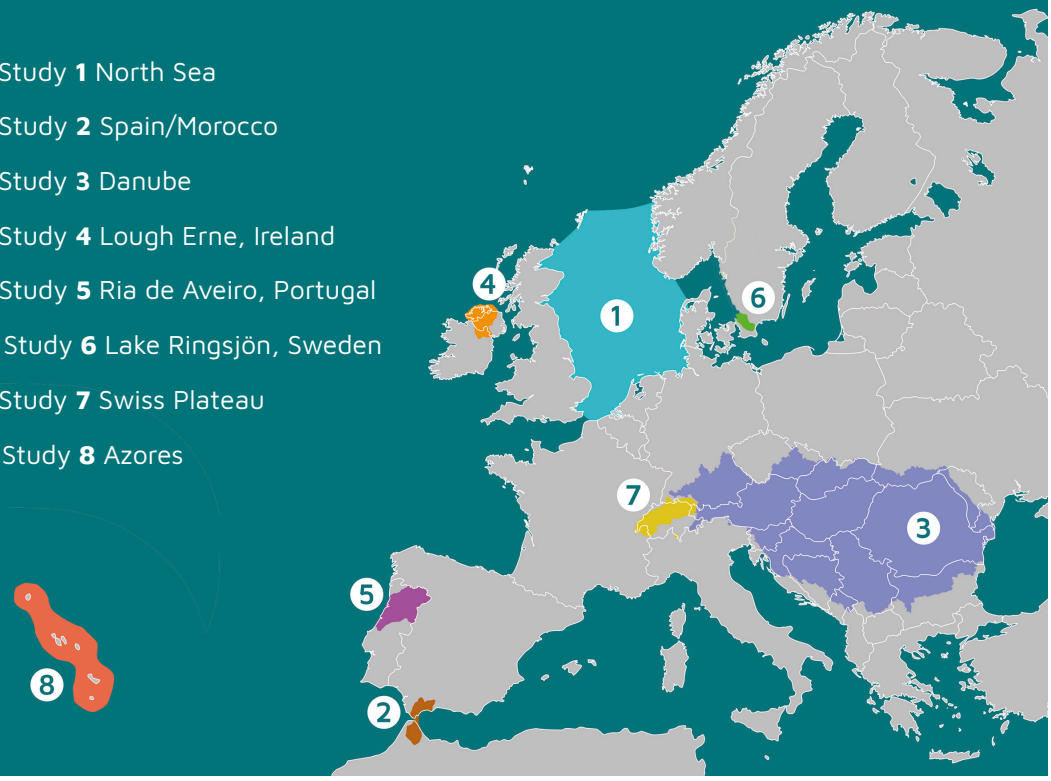
The AQUACROSS Case Studies provide eight real-world examples of applying ecosystem-based management in Europe's inland, transitional, and marine waters to protect local biodiversity from diverse threats. Each case study followed the steps laid out the AQUACROSS Ecosystem-Based Management Cookbook, and therefore offer useful examples of the approach in practice.

Each case study worked closely with local policy-makers and environmental managers, as well as diverse stakeholders (including fishers, farmers, tourism operators, and environmental groups) to apply and test ecosystem-based management on the ground. The wide range of threats, realms, key sectors, and strengths mean that these eight case studies offer diverse specific examples and practical insight into how and when ecosystem-based management can be used. For practitioners, this diversity means that – whatever your local conditions – one or more of the case studies should offer a relatable example of how ecosystem-based management can incrementally improve biodiversity protection so that ecosystems can continue to deliver valuable services that support human well-being.

**More information**

The table on the next page introduces the unique elements of each case study. To find out more, see the introductory briefs on each case study.

- #15 Case Study **1** North Sea
- #16 Case Study **2** Spain/Morocco
- #17 Case Study **3** Danube
- #18 Case Study **4** Lough Erne, Ireland
- #19 Case Study **5** Ria de Aveiro, Portugal
- #20 Case Study **6** Lake Ringsjön, Sweden
- #21 Case Study **7** Swiss Plateau
- #22 Case Study **8** Azores



| | Case Study | Realm | Biodiversity Threat | Key stakeholders/ sectors | Highlights/strenghts |
|---|---|---|---|---|---|
| **1** | Trade-offs in ecosystem-based management in the **North Sea** aimed at achieving Biodiversity Strategy targets | Coast, Marine | Fishing; Changes to morphology | Fishing, renewable energy, environment | Identifying EBM responses: risk assessment; Qualitative and quantitative evaluation; Linkage framework |
| **2** | Analysis of transboundary water ecosystems, Green and Blue Infrastructures in the **Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain): Morocco** | Freshwater, Coast, Marine | Water abstraction; Change to morphology | Environment, agriculture, fishing, tourism | Ecosystem-service maps; Indicators; Information Platform; Modeling |
| **3** | **Danube River Basin** - harmonising inland, coastal and marine ecosystem management to achieve aquatic biodiversity targets | Freshwater | Nutrient pollution; Water abstraction; Change to morphology | Environment, fishing, transport, renewable energy, agriculture | Integrative policy objectives; Modelling; Evaluation; Scenarios |
| **4** | Management and impact of Invasive Alien Species (IAS) in **Lough Erne, Ireland** | Freshwater | Nutrient pollution; Invasive Species; Change to morphology | Agriculture, tourism, fishing, renewable energy | Stakeholders; Identifying EBM responses; Evaluation |
| **5** | Improving integrated management of Natura 2000 sites in the **Ria de Aveiro**, from catchment to coast, **Portugal** | Freshwater, Coast, Marine | Change to morphology | Environment, tourism, shipping, agriculture | Linkage framework; Stakeholders; Modelling; AquaLinks tool |
| **6** | Understanding eutrophication processes and restoring good water quality in **Lake Ringsjön - Rönne å Catchment, Sweden** | Freshwater | Nutrient pollution | Agriculture, fishing, tourism | Stakeholder goals; Integrative policy objectives; Modelling |
| **7** | Biodiversity management for rivers of the **Swiss Plateau** | Freshwater | Nutrient pollution; Change to morphology, chemical pollution | Renewable energy, environment, agriculture | Integrative policy objectives; Modelling; Developing relevant indicators |
| **8** | Ecosystem-based solutions to solve sectoral conflicts on the path to sustainable development in the **Azores** | Coast, Marine | Fishing | Fishing, tourism, environment | Stakeholder processes; Integrative policy objectives; Identifying EBM responses; Monitoring |

**Realm:** Marine, Coast | **Biodiversity threat:** Fisheries, Offshore wind | **Stakeholders/ sectors:** Fisheries, renewable energy, maritime spatial planning | **Highlights:** Identifying EBM responses: risk assessment; Qualitative and quantitative evaluation; Linkage framework




# Case Study 1 Trade-offs in ecosystem-based management in the North Sea aimed at achieving Biodiversity Strategy targets

## Balancing fish, wind power, and biodiversity:

There is a need for a more integrated perspective for managing the many activities in the North Sea that impact biodiversity and hence compromise the achievement of societal goals. Management decisions are often taken without adequate knowledge of the associated risks. Our aim: to determine what scientific knowledge is needed in the North Sea to guide decision-making toward the (balanced) achievement of societal goals, whilst involving important societal actors, including (national) government, fishing industry, the offshore wind energy sector, and Non-Governmental Organisations.

## Where and what are the challenges?

The North Sea is one of the busiest seas with many (often growing or newly emerging) sectors laying claim to a limited amount of space. The main human activities include fishing, shipping, oil and gas extraction, and newly emerging activities such as the renewable energy sector. These combined human activities and their associated pressures on the environment and biodiversity have hindered the achievement of the environmental goals for the North Sea. Management of often multiple competing interests is complex and requires novel, more integrated approaches such as Maritime Spatial Planning or Ecosystem-based Management, which come with additional requirements for the scientific knowledge base.

## What was done?

In collaboration with stakeholders,

- we assessed the current state of the North Sea ecosystem using a risk-based approach and the AQUACROSS linkage framework;
- to provide further guidance to decision-makers, we developed an integrated risk-based approach that linked the impacts on biodiversity to the supply of ecosystem services;
- we identified a number of likely ecosystem-based management measures for the North Sea;
- we evaluated the effectiveness of these EBM measures to contribute to the conservation of biodiversity, i.e. achievement of the "healthy marine ecosystem" societal goal, while also considering potential management initiatives toward achieving other societal goals, i.e. a "sustainable food supply" and "clean energy".

## Local results:

We show that integrated ecosystem-based scientific advice can provide a new and complementary perspective to the conventional science advice, which can often remain confined within institutional silos. We need considerably more scientific knowledge about the North Sea to support integrated management. We show that risk-based approaches are promising for integrated assessments of cumulative effects and management of biodiversity.

## General lessons learned for managing biodiversity:

This work represents a first attempt to provide a more integrated, ecosystem-based approach that considers diverse societal goals, includes several sectors, and considers their impacts on the ecosystem and all relevant components. A risk assessment was applied to assess the effectiveness of a suite of management measures.

## Local impact:

*"What I have found really inspiring about the AQUACROSS project is the way it demonstrates how ecosystem based approaches can provide new and important insights for decision makers... (and) that ecosystem based management has moved beyond being a scientific concept to become a powerful management tool for decision makers."* - Finlay Bennet, Marine Scotland.

**Learn more about Case Study 1 at aquacross.eu or the AQUACROSS Information Platform**

**Contact: Gerjan Piet | Wageningen University & Research | gerjan.piet@wur.nl**

AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: RBINS, Koos de Visser

**Realm:** Freshwater, Coast, Marine | **Biodiversity threat:** Water abstraction; Change to morphology
**Stakeholders/sectors:** Environment, agriculture, fishing, tourism | **Highlights:** Ecosystem-service maps; Indicators; Information Platform; Modelling; Green and Blue Infrastructure



# Case Study 2

# Analysis of transboundary water ecosystems, Green and Blue Infrastructures in the Intercontinental Biosphere Reserve of the Mediterranean (IBRM): Andalusia (Spain) – Morocco

## Protecting areas to protect biodiversity:

The IBRM is home to several remarkable protected sites, high biodiversity richness and an important cultural heritage. However, pressures from human activities in the area are threatening these distinct values. Our aim is to use diverse data plus stakeholder input to understand the social and ecological system and design a multifunctional network of areas – that allow conservation, exploitation and restoration - and identify ideal sites for restoring degraded freshwater, coastal and marine ecosystems.

## Where and what are the challenges?

The case study encompasses the IBRM in Andalusia (Spain) – Morocco and its area of influence. The reserve spans over two continents, Europe and Africa, and the marine area of the Strait of Gibraltar, and includes river basins, coastal, and marine areas. Agriculture, livestock, fisheries, and tourism drive the local economy, all of which are highly dependent on terrestrial and aquatic resources. The aquatic ecosystems provide a vital range of provisioning goods (such as fish), regulation and maintenance services that sustain human well-being, as well as important cultural sites.

## What was done?

In collaboration with regional and local governments of Andalusia (Spain) and Kingdom of Morocco, we applied the AQUACROSS Assessment Framework to identify the most effective and efficient network of multi-purpose protected areas (also known as Green and Blue Infrastructure). This included:

- Using satellite and local data to analyse regional activities, pressures, ecosystem condition, biodiversity, and key aquatic ecosystem services;
- Understanding stakeholder objectives (including economic objectives) for the IBRM to identify synergies, conflicts, and opportunities for improvement;
- Using models to identify the best location for protected and semi-protected areas, i.e where biodiversity is high or can be cheaply restored, whilst still allowing human activities (such as fishing or recreations) in neighbouring or other areas;
- Co-creation: local stakeholders reviewed and contributed at two rounds of workshops held in Tarifa (Spain, northern section) and Tangier (Morocco, southern section)

## Local recommendations:

We identified priority areas that allow conserving biodiversity, maintaining ecosystem services capacity, and restoring degraded ecosystems, while minimising costs. The results suggest that using ecosystem-based management restoration measures when designing Green and Blue Infrastructure may increase protected area coverage, while improving connections between protected areas.

## General lessons learned for managing biodiversity:

Green and Blue Infrastructure combines in one single solution an ecosystem-based management outcome that balances conservation, restoration and exploitation objectives. The Green and Blue Infrastructure multi-zoning approach conserves ecosystems and biodiversity as well as human well-being, while minimising the potential conflicts between conservation and exploitation goals.

## Local impact:

Local policymakers in Andalusia (REDIAM - Environmental Information Network of Andalusia, Regional Ministry of Environment and Spatial Planning of Andalusia), Spain and in Morocco (the Regional Observatory for Environment and Sustainable Development Tangier-Tetouan-Al Hoceima) highly valued the analytical cartography, the spatial data and the storytelling tool produced in AQUACROSS. Indeed, REDIAM report that they will deploy the methodology, *"to estimate ecosystem condition of habitats and a network of multifunctional and interconnected areas (Green and Blue Infrastructure) not only in the case study area but in other areas in Andalusia"*.

**Learn more about Case Study 2 at ibrm.aquacross.eu or the AQUACROSS Information Platform**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Alejandro Iglesias-Campos

**Realm:** Freshwater | **Biodiversity threat:** Changes to hydrology; Change to morphology; Nutrient pollution
**Key stakeholders/sectors:** Environment, Transport, Renewable energy, Agriculture | **Strengths:** Integrative policy objectives; Modelling; Evaluation; Scenarios

# Case Study 3 Danube River Basin - Harmonising inland, coastal and marine ecosystem management to achieve aquatic biodiversity targets

## Restoring river-floodplains to protect biodiversity:

The Danube's river biodiversity is threatened by changes to hydrology and geomorphology (so-called hydro-morphological alterations), such as disconnection of floodplains. Multiple human activities, including the construction of hydropower plants, expansion of agriculture, and large-scale river regulation measures to increase navigation and flood protection are resulting in an ongoing loss of habitat and biodiversity. Our aim: In this Case Study, we apply the AQUACROSS Assessment Framework to identify how management of river-floodplain systems along the Danube can be supported to jointly conserve and restore biodiversity and maximise the value that these ecosystems provide to human well-being.

## What is the challenge?

Throughout the basin, hydro-morphological restoration of river-floodplain systems is important to conserve biodiversity and ensure that river stretches achieve "good status" according EU Water Framework Directive. Restoration also support other societal and policy objectives: flood protection, reducing pollution reaching the Black Sea marine environment, and climate adaptation. However, the complexity and variety of the environmental problems, lack of data, strong differences in socio-economic conditions, as well as heterogeneity in national interests along the Danube significantly hampers planning of restoration sites. Only a few countries of the Danube region have already implemented or planned restoration activities, which are due by 2021.

## What was done?

We prioritised sections of the river-floodplain systems for restoration and conservation, using a novel integrative modelling approach that considered multiple targets, including biodiversity protection as well as economic and human well-being. Unlike the current situation, where each country selects their own restoration sites based on national criteria, our method prioritizes sites along the length of the Danube independent from jurisdictional, administrative and political borders.


## Local recommendations:

We identified ideal sites for restoration along the Danube partially supporting sites already designated as with high restoration potential. Others were identified in areas where no sites are yet designated. Our evaluation suggests that our ecosystem-based management approach can be more cost-effective than the current approach. Additionally, the methodology is transparent and flexible, so can balance the different objectives related to floodplain restoration.

## General lessons learned for managing biodiversity:

Systematically linking social and ecological data and knowledge within one analysis helps decision-makers to pursue different objectives simultaneously, enabling "integrated planning". Independently considering the whole Danube River as one ecosystem supports coordination and cooperation across countries and therefore has potential to foster consensus on a shared vision for the future.

## Local impact:

The proposed ecosystem-based management approach supports the joint selection of restoration sites including prioritisation of protected areas, and site selection for the next River Basin Management Plans or Flood Management Plans. Follow-up actions of the project will focus on the take-off of the project results, with the International Commission for the Protection of the Danube River (ICPDR) inviting the case study to present potential for take-off at their 21st Ordinary Meeting.

**Find out more about Case Study 3 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Andrea Funk

**Realm:** Freshwater | **Biodiversity threat:** Nutrient pollution; Invasive Species; Change to morphology
**Stakeholders/sectors:** Agriculture, tourism, fishing, renewable energy | **Strengths:** Identifying EBM responses; Evaluation; Stakeholder processes; Semi-quantitative modelling

# Case Study 4 — Management and impact of Invasive Alien Species in Lough Erne in Ireland

### Managing Invasive Alien Species and Nutrient Pollution:

The goal of this study was to examine the implications of the regulation on Invasive Alien Species (IAS) (i.e. non-native plants and animals harming the local ecosystem) for practical management in Lough Erne, Northern Ireland, in the context of existing environmental commitments under EU legislation.

### Where and what are the challenges?

Lough Erne sustains multiple competing activities, each with different demands from the system in terms of ecosystem services and physical resources. Lough Erne is a heavily modified water body, containing a range of non-native species following a long history of introducing new fish and other plants and animals. In recent times there has been an invasion and proliferation of the Nutall's Pond Weed (Elodea nutalli), which is listed as an Invasive Alien Species of Union Concern. This new arrival is able to colonise deeper areas of the Lough and has clogged many areas of the lake, interfering with popular recreational activities, in particular boating. Managing Elodea while meeting the needs of competing users requires consensus on ecosystem boundaries and effective cross border cooperation.

### What was done?

The case study brought together a range of stakeholders from public service and NGOs, both north and south of the Northern Irish/Republic of Ireland border in a series of workshops. Mental models called "Fuzzy Cognitive Maps" of the Erne system were developed based on stakeholder inputs and were used to infer how the social and ecological systems behave. The models predict a likely decline in future water quality related to agricultural activities in the catchment. Models were used to map the impacts of altering lake levels on agricultural production in areas adjacent to the lake.

### Local recommendations:

Stakeholder views, combined with model outputs were used to identify a range of possible management options. One set of measures involved altering the lake levels to enable recreational boating, but also leading to a potential loss to agriculture in terms of inundated land, which we evaluated and costed. Agricultural nutrient management measures to reduce proliferation of the weed were also evaluated. The potential costs of conducting these measures were assessed and presented to stakeholders for feedback and comparison.

### General lessons learned for managing biodiversity:

The case study revealed the importance of considering the interconnections between policies. Potential solutions to the problem of Invasive Alien Species in Lough Erne will affect achievement of Water Framework Directive goals, as well as obligations under the regulation on Invasive Alien Species. At the same time, these goals cannot be considered in isolation from the overall driver of the Common Agricultural Policy.

### Local impact:

*"Ecosystem-based management is a valuable tool for communicating the value of water and how we all benefit from that resource"*
– Kerry Anderson, Northern Ireland Department for Agriculture, Environment and Rural Affairs. Local regulators especially valued how ecosystem-based management considered invasive alien species within the context of how agriculture and other human activities have environmental consequences for water and biodiversity.

**Find out more about Case Study 4 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Tim O'Higgins



**Realm**: Freshwater, Coast, Marine | **Biodiversity threat**: Changes to hydromorphology
**Stakeholders/sectors**: Environment, tourism, shipping, agriculture | **Strengths**: Linkage framework; Maps; Stakeholder processes; Modelling; AquaLinks tool

# Case Study 5 Improving integrated management of Natura 2000 sites in the Ria de Aveiro Natura 2000 site, from catchment to coast, Portugal

## Minimising the impacts of dredging and flood bank extension:

In 2018/2019, in the Ria de Aveiro two management interventions will have negative unintended impacts on biodiversity: 1) a dredging programme to manage water flow and navigability in Ria de Aveiro coastal lagoon, and 2) the extension of a flood bank to stop surface saltwater intruding onto local farmland. The goal of this study is to apply adaptive management and minimise foreseen but unintended management challenges in a Natura 2000 protected area, which crosses fresh and marine waters, in the context of EU water and nature-related Directives.

## Where and what are the challenges?

The Ria de Aveiro area is rich in biodiversity and supports a variety of economic, cultural and recreational activities. The region is subject to a complex variety of land and water uses and potential conflicts, and a number of human activities place pressures that affect the hydromorphological conditions of the lagoon and the adjacent freshwater section of the Vouga River, the Baixo Vouga Lagunar, such as dredging and the flood bank. 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 to protect or to enable economic activities.

## What was done?

We assessed the overarching policy plans, programmes, and objectives that manage biodiversity within the case study, as well as the key governance institutions. Stakeholders were engaged at different steps, contributing data, information, and their views so that we could understand the current and future situation, and how it might change under new management. Here, we used: i) models that assessed the risk to habitats caused by human activities; ii) stakeholder knowledge on the current state and trends of the environment and human activities in the Ria de Aveiro; and iii) the results of maps and modelling of the different ways stakeholders value the ecosystem and the goods and services it provides.

## Local recommendations:

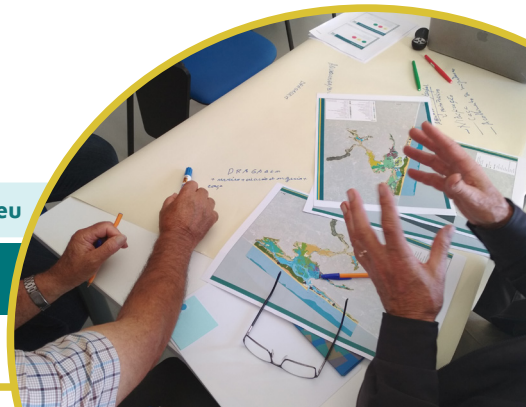
Recommendations were made for two scales, the entire Natura 2000 site and the Baixo Vouga Lagunar. We propose a plan to restore saltmarshes and seagrasses, harmonise monitoring across EU Directives, and incorporate stakeholders and integrate territorial management instruments to mitigate the expected, unintended impacts of the flood bank extension and dredging in the Ria de Aveiro Natura 2000 site. The restoration measures should be framed in the Sectoral Plan for Natura 2000 Network, which is the territorial management tool to implement Portuguese policy for conserving biological diversity.

## General lessons learned for managing biodiversity

Ecosystem-based management plans should be co-created with input from local stakeholders and policy-makers. To protect biodiversity, managers should consider climate change projections. For the successful implementation of the identified water and nature policies in places like the Ria de Aveiro Natura 2000 site, any actions need to ensure the involvement of users and landowners.

## Local impact:

The Ecosystem-based management plan is foreseen to support the development of the Vouga estuary management plan, as well as actions for a more comprehensive understanding of the social-economic implications of ecosystem services provided by these aquatic habitats. Local stakeholders were supportive of the approach, *"ecosystem-based management allows for a 'correction' of less good results"* and appreciate that it is *"concerned with beneficiaries, as well as biodiversity"*.



**Find out more about Case Study 5 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Ana I. Lillebø

**Realm:** Freshwater | **Biodiversity threat:** Nutrient pollution | **Stakeholders/sectors:** Agriculture, fishing, tourism
**Strengths:** Policy coordination, Stakeholder processes, Resilience


# Case Study 6 Understanding eutrophication processes and restoring good water quality in Lake Ringsjön – Rönne å Catchment in Kattegat, Sweden

### Nutrient pollution affecting lake biodiversity:

Due to nutrients from agriculture and household sewage, Lake Ringsjön experiences eutrophication, which has made it a target for restoration efforts by local municipalities. Situated in an agricultural landscape with a growing human population, the lakes provide multiple ecosystem services (including fish and recreational opportunities) that are valued by different stakeholders. These ecosystem services increase – along with biodiversity - when the water is clear. We investigated how the local society and ecosystems co-produce these ecosystem services. We also investigated the interactions between the social and ecological aspects of the lake system together with stakeholders to suggest how water governance might be improved.

### Where and what are the challenges?

The Rönne å catchment is located in Southern Sweden in a landscape that is witnessing a transition from an agricultural to a multi-functional landscape. The main pressures affecting freshwater quality are agricultural activities and insufficient sewage treatment. Swedish regulations are implemented at different levels: from river basin to county to municipality. Water councils, a group of stakeholders including municipalities and water users, have developed their own bottom-up solutions in the past, and are increasingly involved in the governance system through the Water Framework Directive.

### What was done?

Our research was co-designed with stakeholders, decision makers, civil servants and practitioners in three workshops and eight follow-up interviews, and complemented stylised social-ecological modelling. We used the AQUCROSS Assessment Framework alongside insights from resilience thinking to focus on the social aspects of policymaking and implementation – particularly the governance-related resilience principles and processes of change. We used these to develop future scenarios that explore two perspectives along which decision making in water governance could develop differently from the expected baseline: a) by changing the time horizon of restoration effects, and b) by changing the geographical space and institutions involved in collaboration on managing the lake.

### Local recommendations:

We qualitatively evaluated the scenarios using the resilience principles and a stylised social-ecological model that simulates social time lags and their effect on lake restoration and resulting ecosystem services. Our analysis shows: 1) consideration of the time lags between management actions and an improvement in the ecosystem can lead to stronger reinforcing feedbacks and larger improvements; and 2) an increase in the geographical and institutional scale of management allows more collaboration between water councils and across different sectors, though the final outcome would depend on which ecosystem service trade-offs are explicitly considered.

### General lessons learned for managing biodiversity:

Resilience thinking helps to identify feedback processes and interactions between society and the ecosystem that determine long-term outcomes of lake restoration. There is a need to consider time lags and different dynamics within the system, as well as how the social aspects interact with the ecological aspects. Collaboration is necessary between different levels of water governance, and across different sectors and geographical regions in order to reach the full potential for managing eutrophication in the catchment.

### Local impact:

The stakeholder process motivated an improved collaboration between practitioners and decision-makers in local freshwater management to take more ecosystem service interactions into account - *"it's about physically sitting down at a table with all these actors and discussing a common interest"* (civil servant municipality of Höör and member of Ringsjön's water council).

**Find out more about Case Study 6 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Romina Martin

**Realm:** Freshwater | **Biodiversity threat:** Nutrient pollution; Change to morphology; Chemical pollution | **Stakeholders/sectors:** Environment, agriculture, water supply, sanitation, flood protection | **Strengths:** Integrative policy objectives; Modelling; Biodiversity indicators; Maps



# Case Study 7 Biodiversity management for rivers in the Swiss Plateau

## Prioritising ecosystem restoration:

Freshwater ecosystems in the Swiss plateau are threatened by multiple stressors that deteriorate water quality and hydromorphology. This is the result of channelization, dams, wastewater, and agriculture, among other causes. To restore these ecosystems and stop the biodiversity decline, multiple management measures will be implemented over the next decades. We propose methods for prioritising the location and timing of restoration measures to maximise their effectiveness, considering many sectors and multiple societal objectives.

## Where and what were the challenges?

Case Study 7 is based in the Swiss Plateau, a relatively flat and densely populated area that facilitates agricultural production and urban development. Switzerland decided to fund the morphological restoration (i.e. river widening and removing artificial obstructions in the river) of one quarter of all morphologically degraded rivers over the next 80 years, to upgrade the 100 most important wastewater treatment plants to remove micropollutants, and to reduce pollution agriculture. Cantonal authorities were asked to provide a strategic plan for the morphological restoration of rivers over the next two decades, which will be updated every 12 years and is intended to increase the effectiveness of restoration measures

## What was done?

Using the concepts underlying the AQUACROSS Assessment Framework, we developed a procedure to prioritise restoration measures by maximising the ecological state of a catchment under a given budget constraint, while considering other societal needs and other sources of impairment:

- In close collaboration with stakeholders from federal and cantonal authorities and environmental consulting companies, we integrated procedures for chemical, physical and biological assessment at the river reach scale and proposed a spatially explicit ecological assessment at the catchment scale.
- We applied the catchment scale assessment to search for management strategies that optimise the overall ecological state of catchments, while increasing or not significantly decreasing services (e.g. recreation) demanded by society.

## What did we find?

We developed a methodology that supports environmental managers in the integrative assessment of restoration measures at the catchment scale. This methodology is based on ecological principles, such as maximising resilience and fish migration potential and minimising fragmentation. An optimisation procedure provides a set of near-optimal combinations of measures to reach the highest ecological state for a given budget. This list of potential measures can support the development of a cantonal planning, which also requires stakeholder involvement.

## General lessons learned for managing biodiversity:

Location matters: to prioritise river restoration, managers need to consider location and also consider broad descriptors of ecosystem health. The consideration of different types of impairments, such as hydromorphological degradation and chemical pollution, is important to increase effectiveness.

## Local impact:

Given that Swiss environment policy is planned over decades, local impact will occur over time. Already, though, Yael Schindler Wildhaber and Bänz Lundsgaard-Hansen (Federal Office for the Environment Switzerland), and Irene Wittmer and Christiane Ilg (Swiss Water Association) report that they will use case study 7's models to *"adapt or develop"* indicators of specific human impacts on biodiversity. Additionally, regarding the case study's method and results for prioritising where to restore ecosystems, local policy stakeholders believe this could be useful for *"better coordination of the different management measures in a catchment"* and that it *"has potential for use for the selection of new monitoring sites"* and *"future collaboration"*.

**Find out more about Case Study 7 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Eawag, Peter Penicka, Peter Reichert

**Realm:** Coast, Marine | **Biodiversity threat:** Fishing | **Stakeholders/sectors:** Fishing, tourism, environment | **Highlights:** Stakeholder processes; Integrative policy objectives; Identifying EBM responses; Monitoring



# Case Study 8 — Ecosystem-based solutions to solve sectoral conflicts on the path to sustainable development in the Faial-Pico Channel, Azores

## Collaborating to halt declining biodiversity:

Despite designation as a Marine Protected Area, biodiversity in the Faial-Pico Channel is falling. Our aim: to collaborate with local stakeholders and policy-makers and apply the AQUACROSS Assessment Framework to understand social and ecological aspects of the Channel, and identify actions to efficiently and equitably ensure the Channel's long-run sustainability, balancing the objectives of commercial and recreational fishers, tourism operators, and other local stakeholders.

## Where and what are the challenges?

The Faial-Pico Channel is a richly biodiverse Marine Protected Area (MPA), covering 240km² of North Atlantic coast and ocean in the Azores, an EU Outermost Region. Recreational and commercial fishing place pressure on local biodiversity, while swiftly growing tourism (5.1% p.a.) fuels local economic growth but increases competition for use of the Channel, driving future pressure on biodiversity. While local commercial and recreational fishers, tourism operators, and others all value the Channel's biodiversity, they have different objectives and priorities. In 2016, local policymakers increased protection for some high biodiversity areas in the Channel, and have consulted with stakeholders on management. However, Channel management is complicated by multi-level and overlapping responsibilities, with policy development and implementation split across five institutions.

## What was done?

In close collaboration with local stakeholders and policymakers, we applied the AQUACROSS Assessment Framework to develop and evaluate ways to more efficiently and equitably manage the Channel and protect biodiversity. This included:

- Analysing local biodiversity, tourism, and fishing policies and stakeholder objectives to identify synergies, conflicts, and opportunities for improvement
- Characterising the Channel's social-ecological system to understand links between drivers, pressures, the ecosystem and its biodiversity, and ecosystem services
- Identifying and evaluating an ecosystem-based management plan for the Channel
- Co-creation with local stakeholders: throughout, we collaborated with local stakeholders, including at two day-long workshops with recreational and commercial fishers, diving operators, NGOs, scientists, and local policy representatives.

## Local recommendations:

We identified and evaluated a plan of five local policy solutions: (1) increased scientific monitoring, (2) increased stakeholder participation through a Stakeholder Advisory Group, (3) integrating and coordinating management of the Channel, (4) clearly communicating and enforcing fishing and biodiversity rules, and (5) sharing costs through a sustainability tax or diving fee. We found that, as well as protecting biodiversity, this plan supports the sustainability of the Faial-Pico Channel – increasing stakeholder engagement, knowledge, and policy coordination enables adaptive management, reduces conflict, and can improve effectiveness and efficiency.

## General lessons learned for managing biodiversity:

Stakeholder engagement and participation supports effective and equitable management of Marine Protected Areas. Stakeholders – such as recreational and commercial fishers and diving operators - can clearly identify challenges and priorities, co-create innovative solutions, provide low-cost knowledge and expertise, and support ongoing monitoring, enforcement, and evaluation.

## Local impact:

*"The AQUACROSS work is being used directly in the creation of Marine Protected Area Management for the Azores, along with other sources"* – Gilberto Carreira, Azores Regional Directorate for Sea Affairs (DRAM)

**Learn more about Case Study 8 on the AQUACROSS Information Platform and aquacross.eu**

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AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. Photos: Hugh McDonald

# Biodiversity strategy and AQUACROSS

The AQUACROSS project aimed to support the implementation of the EU Biodiversity Strategy in regards to aquatic biodiversity conservation. Methods and tools developed within the project can practically contribute to the achievement of the Biodiversity Strategy's targets. The AQUACROSS Linkage Framework investigated links between different human activities, pressures, ecosystem components and biota, and consequently ecosystem services (see Linkage Framework). This allows for a unique possibility to consider equally biodiversity conservation and the uses of aquatic ecosystems. This gives valuable information for future management decisions and the integrative approach can support better balanced policy development and decision making. The AQUACROSS project is potentially contributing to all EU Biodiversity Strategy targets below.

STRUCTURE OF THE EU 2020 BIODIVERSITY STRATEGY

| 6 TARGETS | SELECTED ACTIONS |
|---|---|
| **1. Implement nature legislation** | **1:** Complete the Natura 2000 network and ensure its good management<br>**2:** Make sure Natura 2000 sites get sufficient funding<br>**4.1:** Make the monitoring and reporting of the EU nature law more consistent, relevant and up-to-date;<br>**4.2:** provide a suitable ICT tool for Biodiversity |
| **2. Restore ecosystems and establish Green Infrastructure** | **5:** Map and assess the state and economic value of ecosystems and their services in the entire EU territory<br>**6:** Restore ecosystems, maintain their services and promote the use of green infrastructure<br>**7:** Assess the impact of EU funds on biodiversity |
| **3. Sustainable Agriculture & Forestry** | **8.3:** consider including the Water Framework in cross-compliance standards |
| **4. Sustainable Fisheries** | **14.2:** make sure the Marine Strategy Framework Directive is consistently carried out with further marine protected areas |
| **5. Combat Alien Invasive Species** | **16:** Provide a legal framework to fight invasive alien species |
| **6. Averting global biodiversity loss** | |

Below, we introduce some reflections stemming from the AQUACROSS consortium on the relevant actions for which we believe our work be of help to inform others about practical elements of implementation. We provide evidence based on case study work and links to further information.

# TARGET 1 – FULLY IMPLEMENT THE BIRDS AND HABITATS DIRECTIVE

The first target of the EU Biodiversity Strategy to 2020 aims to halt deterioration of all species and habitats covered by the EU Nature Directives as well as achieve status improvement linked to 100% more habitat assessments as well as 50% more species assessments with secure or improved status under both directives.

### AQUACROSS contribution to Target 1

- Development of a habitat-suitability-based multi-species distribution model for macroinvertebrates in freshwater ecosystems, which supports identification of the relevance of multiple stressors. This can inform decision-makers about the sensitivity of species to different stressors and can help improve the assessment and management of riverine habitats.

**Further reading:**

Modelling approaches supporting EBM
Deliverable 7.1

- Assessment of impacts risks of human activities on European aquatic ecosystems allows for the identification of habitats and species most at risk and in need of protection.

**Further reading:**

Linkage framework

### Action 1: Complete the Natura 2000 Network and ensure its good management

- The modelling approach of AQUACROSS systematicallyprioritises aquatic systems for conservation, supporting the completion and management of the Natura 2000 Network.

**Further reading:**

Modelling approaches supporting EBM
Deliverable 7.1

### Action 2: Make sure Natura 2000 sites get sufficient funding

- The modelling approach of AQUACROSS systematically prioritises aquatic systems for restoration, based on multiple criteria related to biodiversity, ecosystem services and socio-economic benefits, with an aim at optimising the restoration of ecosystems multifunctionality.

**Further reading:**

Modelling approaches supporting EBM
Deliverable 7.1

### Action 4.1: Make the monitoring and reporting of the EU nature law more consistent, relevant and up-to-date

- The AQUACROSS proposition of a catchment scale ecological assessment method helps to integrate the different aspects of the currently existing river reach-scale assessments of different ecosystem components into a spatial explicit and multifunctional assessment of the whole catchment.

**Further reading:**

Modelling approaches supporting EBM
Deliverable 7.1
Case Study: Swiss Plateau
Case Study: Danube

### Action 4.2: Provide a suitable ICT tool for biodiversity

- The AQUACROSS Information Platform helps mobilise a variety of data across aquatic eco- systems (often not yet accessible) and makes them easy to find and reusable for others.

**Further reading:**

Information Plattform
Deliverable 6.3

# TARGET 2 – MAINTAIN AND RESTORE ECOSYSTEMS AND THEIR SERVICES

The EU Biodiversity Strategy's second target aims to restore at least 15% of degraded ecosystems as well as maintain and enhance ecosystems and their services as a whole by establishing green infrastructure in the shape of the Natura 2000 Network.

### AQUACROSS contribution to Target 2

- AQUACROSS provides a method for spatial and temporal prioritisation of restoration (and conservation) strategies by optimising the ecological state of the whole catchment.

**Further reading:**

Modelling approaches supporting EBM
Deliverable 7.1

- The project evaluates changes in ecosystem services caused by management responses according to different criteria (effectiveness, efficiency and equity). The maintenance of ecosystem services and the consideration of trade-offs requires their identification and valuation.

**Further reading:**

Deliverable 8.2

Case Study: Spain/ Morocco
Case Study: Danube

- AQUACROSS investigates trade-offs between ecosystem services and biodiversity conservation. It is argued that a more differentiating policy language is needed to take into account how only specific parts of society are benefitting of ecosystem services.

**Further reading:**

Deliverable 8.2

Case Study: Spain/ Morocco

### Action 5: Map and assess the state and economic value of ecosystems and their services in the entire EU territory

- Assessing the service supply potential of aquatic ecosystems at different scales across Europe allows for the identification (and prioritisation) of areas for biodiversity protection.

**Further reading:**

Deliverable 5.2

Case Study: Spain/ Morocco

Case Study: Ria de Aveiro, Portugal

### Action 6: Restore ecosystems, maintain their services and promote the use of green infrastructure

- AQUACROSS details how the collaboration across different sectors connected to aquatic biodiversity protection can be facilitated. Thus, promoting the multiple benefits of restoration measures to broader society.

**Further reading:**

Case Study Lake Ringsjön, Sweden

- The AQUACROSS Assessment Framework allows for the semi-quantitative testing of a large suite of possible management measures to identify those, which are most likely to yield to desired outcomes (i.e. environmental risk based management – cumulative effect assessment).

**Further reading:**

Deliverable 3.2
Deliverable 8.2
Case Study: North Sea

- The modelling tools developed in AQUACROSS spatially prioritise biodiversity and ecosystem services to come up with areas or distinct management zones for biodiversity protection, also taking into account social equity and fairness to specify which countries / areas could have the "financial flexibility" to carry out the envisaged zones. The modelling framework specifies strict conservation zones without limiting ESS demand, so by protecting all species the ESS demand can still be reached.

**Further reading:**

Modelling approaches supporting EBM

Deliverable 7.1

Case Study: Spain/ Morocco

**Action 7: Assess the impact of EU funds on biodiversity**

- Within AQUACROSS, EU funding schemes were assessed in terms of their effect on EU and local level biodiversity protection. The project offers guidance towards making funding more effective in the future.

**Further reading:**

Deliverable 2.1
Deliverable 2.3
Rouillard et al. (2017)

## TARGET 3 – INCREASE THE CONTRIBUTION OF AGRICULTURE AND FORESTRY TO MAINTAINING AND ENHANCING BIODIVERSITY

The EU Biodiversity Strategy's third target is split between the sectors agriculture and forestry, aiming to increase sustainability within each. Agricultural activities especially may have negative effects on aquatic biodiversity through nutrient pollution (see Current trends and threats to biodiversity in Europe).

**AQUACROSS contribution to Target 3**

**Action 8.3: Consider including the Water Framework in cross-compliance standards**

- The Water Framework Directive is of central importance to the freshwater and coastal case studies of AQUACROSS. The project has considered cross-compliance requirements in several of these case studies.

**Further reading:**

Case Study: Danube

Case Study: Lough Erne, Ireland

Case Study: Ria de Aveiro, Portugal

## TARGET 4 – MAKE FISHING MORE SUSTAINABLE AND SEAS HEALTHIER

The fourth target of the EU Biodiversity Strategy to 2020 aims to ensure that the management plans of the Common Fisheries Policy are based on scientific advice and sustainability principles to restore and maintain fish stocks to sustainable levels, to reduce the impact of fisheries by gradually getting rid of discards and avoiding by-catch. In addition it aims for the consistent implementation of marine protected areas under the Marine Strategy Framework Directive and that fishing activities are adapted and that the fishing sector gets involved in alternative activities such as eco-tourism, the monitoring of marine biodiversity, and the fight against marine litter.

**AQUACROSS contribution to Target 4**

**Action 14.2: Make sure the Maine Strategy Framework Directive is consistently carried out with further marine protected areas**

- By including coastal and marine realms in its assessment and focussing in some cases on fisheries management, the AQUACROSS project can contribute to support sustainable fisheries and hence healthier seas in the future. Conventional fisheries management should develop into more ecosystem-based fisheries management which also considers the fishing impacts on the wider ecosystem, e.g. bycatch, disturbance of the seafloor.

**Further reading:**

How is the linkage framework useful for the Strategy Framework Directive (MSFD)

AQUACROSS Recommendations for fisheries in relation to aquatic ecosystem management

- The North Sea and Azores Case Studies particularly addressed fisheries management and proposed EBM plans with sustainable fisheries measures.

**Further reading:**

Case Study: North Sea
Case Study: Azores

- Marine protected areas are seen as a key tool for healthier seas in the future. The interaction between MPAs and fisheries management was addressed in the North Sea and Azores Case Studies. In the North Sea Case Study, we studied how fisheries management and MPAs can help to improve the integrity of seabed habitats and the ecosystem functions they supply.

**Further reading:**

Case Study: North Sea
Case Study: Azores

## TARGET 5 – COMBAT INVASIVE ALIEN SPECIES

The fifth target of the EU Biodiversity Strategy to 2020 aims to ensure that the EU Plant and Animal Health legislation includes a greater concern for biodiversity and to provide a legal framework to fight invasive alien species.

**AQUACROSS contribution to Target 5 (action 16)**

- The AQUACROSS assessment framework considers invasive alien species as one of the main pressures to aquatic biodiversity. Therefore, the assessment framework can help environmental managers and policy makers to develop management decisions for invasive, alien species management.

**Further reading:**

Currend trends and threats to biodiversity in Europe

Deliverable 3.2

- The Case Study 4 of AQUACROSS, located in Lough Erne, Ireland focused primarily on the pressure of invasive alien species. The case study reviewed material, which is relevant for the management of invasive species. The analytical process and stakeholder input for this case study has supported regional authorities to develop new management measures to tackle invasive alien species locally.

**Further reading:**

Case Study: Lough Erne, Ireland

- Even though AQUACROSS did not provided the legal framework for invasive alien species, the project assessed the existing policy framework and identified issues, which could be a vital first step towards developing a comprehensive legal framework.

**Further reading:**

Implementing EU Policy at the local level: lessons and challenges

Deliverable 2.3

# TARGET 6 – HELP STOP THE LOSS OF GLOBAL BIO-DIVERSITY

The sixth target of the EU Biodiversity Strategy to 2020 aims to reduce the impacts of EU consumption patterns on biodiversity and make sure that the EU initiative on resource efficiency, our trade negotiations and market signals all reflect this objective. In addition, it targets more EU funding towards global biodiversity and make this funding more effective. It aims to systematically screen EU action for development cooperation to reduce any negative impacts on biodiversity and to ensure that the benefits of nature's genetic resources are shared fairly and equitably.

### AQUACROSS contribution to Target 6

- The project's EBM Assessment Framework, including the proposed Linkage Framework, allow for different management options to be tested in eight case studies through translation into scenarios to be used in models. The framework can in principle be transferred and applied at any scale and could thus support general aims to stop loss of biodiversity globally. The Intercontinental Biosphere of the Mediterranean case study demonstrates how international cooperation between the EU and other countries (here, Morocco), can result in effective biodiversity management.
- The Azores case study demonstrates how stakeholder and ecosystem-based management support effective and efficient management of marine protected areas, which are a key tool for global biodiversity protection.

**Further reading:**

Linkage framework

Currend trends and threats to biodiversity in Europe

Case Study: Spain/ Morocco

Case Study: Azores


| ← Go to Brief #22: Case Study: Azores | www.aquacross.eu/results | Go to Brief #24: AQUACROSS Linkage Framework: Freshwater → |
|---|---|---|


**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project.


AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# How is the linkage framework useful for the Water Framework Directive?

## WHAT IS THE AQUACROSS LINKAGE FRAMEWORK?

The AQUACROSS Linkage Framework is a semi-quantitative tool designed for river basin managers to understand the links between human activities and the ecological system. It is a structured framework for understanding how human activities impact aquatic ecosystems, and how these ecosystems provide benefits to human society. It can be used at differing levels of complexity – simply to highlight priority elements or to more quantitatively assess risks and vulnerabilities within the system. It is based on the Drivers-Pressures-States-Impacts-Responses (DPSIR) to be consistent with the Water Framework Directive (WFD) approach (see Linkage Framework).

## WHY IS THE AQUACROSS LINKAGE FRAMEWORK USEFUL FOR RIVER BASIN MANAGERS?

**It helps to better understand the full picture.**

Understanding the full picture helps identify the causes of failure to achieve good ecological status, and to prioritise effective measures and appropriate monitoring. Achievement of good ecological status is affected by human activities and ecological functions throughout the river basin and beyond the borders (i.e. beyond coastal waters) considered for WFD purposes. The linkage framework helps identify all human activities (e.g. agriculture) that place pressures (e.g. nutrient pollution) on each element of aquatic ecosystems (e.g. specific habitats, macrophytes, fish). It then identifies how each element of the aquatic ecosystem delivers valuable goods and services to society (e.g. recreation, fish) and finally reveals the links and relationships between these. The Linkage Framework particularly highlights drivers of biodiversity loss and impacts on ecosystem services, which are insufficiently taken into account in the DPSIR framework.

**It helps you identify where best to act.**

The Linkage Framework can be used to identify the most central, at risk, or vulnerable parts of the system, and what they affect or are affected by. This helps to target actions to protect aquatic ecosystems (e.g. focusing on specific human activities) and achieve good ecological status, and to prioritise what to monitor (e.g. specific species or pressures).

**It incorporates aquatic biodiversity into river basin planning.**

The Linkage Framework specifically incorporates aquatic biodiversity into the understanding of the system being managed and therefore allows it to be included in river basin planning. Considering biodiversity goals in planning decisions allows multiple policy objectives to be achieved simultaneously (such as the targets of the Biodiversity Strategy or conservation status under the Habitats Directive). Furthermore, protecting and restoring aquatic biodiversity helps to achieve good ecological status. For example, improving the biodiversity of riparian wetlands reduces nutrient pollution. Considering biodiversity and water policy targets simultaneously in this way provides additional funding to biodiversity protection (through Water Framework Directive funding) and enhances value for money.

**It helps to structure socio-economic assessments (under article 5 of the WFD).**

The Linkage Framework connects economic activities to ecological functions and ecosystem services. In this way, the assessments can be targeted towards understanding economic drivers of the human activities that put pressure on freshwater ecosystems and threaten the achievement of good ecological status, and the benefits that healthy ecosystems provide society.

**The Linkage Framework can capture the broad values of multi-functional measures.**

Measures designed for improving ecological status, such as wetland restoration to reduce nutrient loading, frequently provide multiple other benefits, including carbon sequestration, recreation and others. The Linkage Framework helps identify all of the ecosystem services provided by the measures and by improved status of waterbodies. In this way, the multiple benefits of multi-functional measures can be more accurately considered in decision–making.

**It is useful for communicating the added value of the Water Framework Directive to stakeholders and financers.**

By identifying the multiple benefits of measures (in terms of ecosystem services), stakeholders and financing bodies can more easily understand the value of the measures in particular and the Water Framework Directive in particular.

## BEST PRACTICE: TIPS FOR APPLYING THE AQUACROSS LINKAGE FRAMEWORK

**TIP!** Look beyond the borders of the river basin district – human activities in the river basin district affect coastal and marine ecosystems. The Linkage Framework can support collaboration with Marine Strategy Framework Directive-focussed colleagues by showing links between freshwater, coastal and marine systems and by providing a common terminology for understanding these systems. It can also assist coordination with nature managers (e.g. of Natura 2000 sites) whose biodiversity goals affect and are affected by river basin planning.

**TIP!** Mobilise existing information – this includes identifying data and stakeholder knowledge. Involving stakeholders in the development of the Linkage Framework increases accuracy and also supports buy-in and understanding.

**TIP!** Don't get lost in the detail – while the tool captures considerable complexity, this can be paralysing and confuse communication. Focus on the key stories, elements, and links that arise. Here, working iteratively with stakeholders can help.

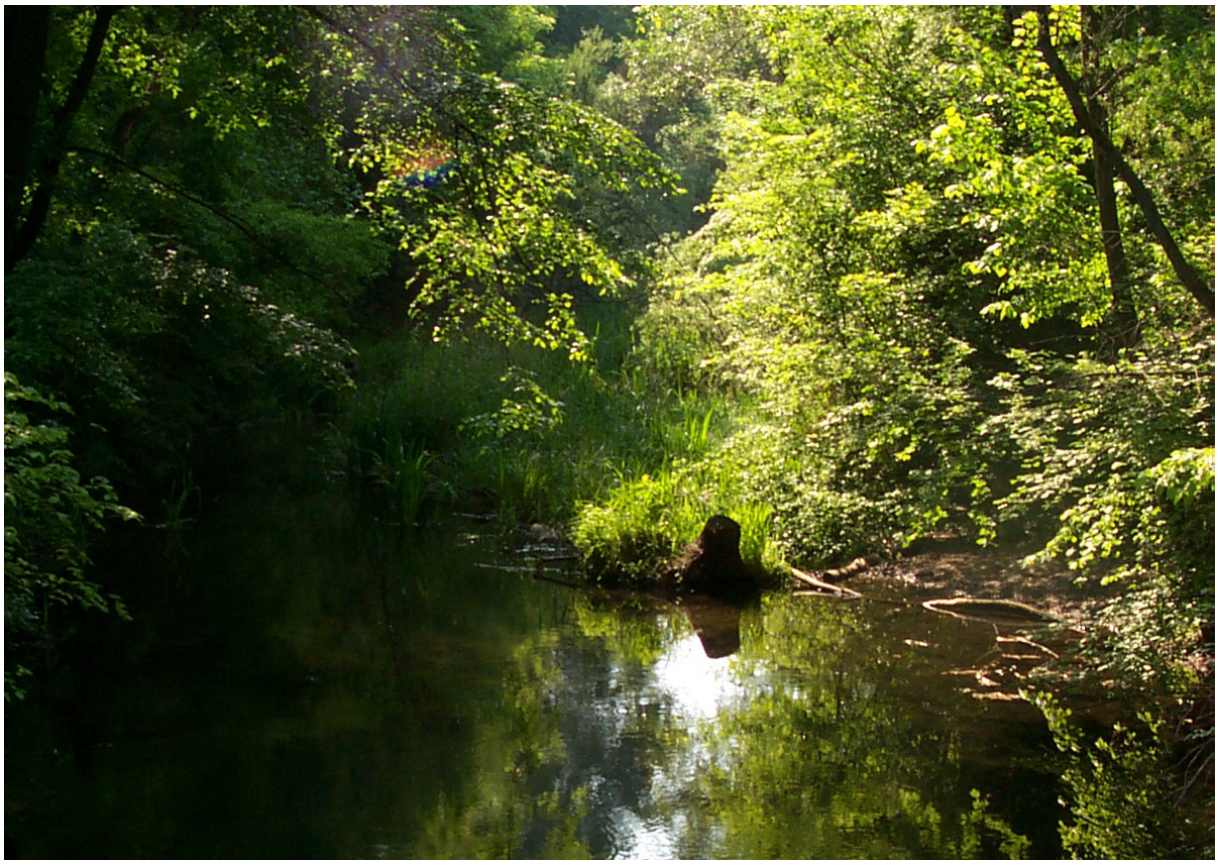
## CASE STUDY EXAMPLE – THE DANUBE RIVER

To prioritise floodplain restoration measures in the Danube River Basin, the AQUACROSS Danube case study (see Case Study: Danube) used the Linkage Framework (see Linkage Framework) to understand the complex socio-ecological system. The framework showed linkages between hydropower and navigability and alterations to hydro-morphology, as well as urbanisation and agriculture. This allowed for a greater characterisation and understanding of the whole system, relative to current management, and thus enabled new, balanced consideration of its management, which achieved multiple environmental targets at lower overall cost.

### Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- Funk et al. (2018) Danube River Basin – harmonising inland, coastal and marine ecosystem management to achieve aquatic biodiversity targets. Deliverable 9.2, Case Study 3. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Teixeira et al. (2018) Assessment of causalities, highlighting results from the application of meta-ecosystem analysis in the case studies. Deliverable 5.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317.(Deliverable and Executive Summary)



Connected sidearm, Case Study Danube © Andrea Funk

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# How is the linkage framework useful for the Marine Strategy Framework Directive (MSFD)?

## WHAT IS THE AQUACROSS LINKAGE FRAMEWORK?

The AQUACROSS Linkage Framework is a tool that may be used by marine and coastal managers and planners to understand how human activities may impact the ecosystem and the services it provides. It can be used at differing levels of complexity – as part of a risk-based approach to simply prioritise the threats that compromised the achievement of specific objectives (as emerged from the initial assessment), together with more quantitative approaches, to evaluate (parts of) the programme of measures (see Linkage Framework).

## WHY IS THE AQUACROSS LINKAGE FRAMEWORK USEFUL FOR MARINE MANAGERS AND PLANNERS?

**It helps to better understand the full picture.**

The specific ecosystem components covered by Descriptors 1,3,4 and 6 of the MSFD do not exist in isolation but lie in strong connectionwith each other. The achievement of good environmental status is affected by multiple human activities taking place at sea and on land. The Linkage Framework helps identify those human activities (e.g. fishing) that place pressures (e.g. abrasion of the seafloor) affecting specific ecosystem components (e.g. specific habitats, fish). Understanding the full picture helps understand the main causes of marine biodiversity loss and hence prioritise effective mitigation measures.

**It considers the cumulative effects of multiple pressures.**

Through its 11 Descriptors, the MSFD considers a large number of different pressures (i.e. invasive species, contaminants, marine litter, underwater noise etc.) on different marine species and habitats (i.e. birds, fish, mammals, reptiles, seabed and water column habitats). The Linkage Framework accounts for these different pressures, species and habitats and therefore allows for a holistic marine state assessment in line with the requirements of the MSFD.

**It helps you identify where best to act.**

The linkage framework can be used to identify the most important ecosystem components, and how these are impacted. This helps to focus key elements for action (e.g. specific human activities) and achieve good environmental status and locate potential knowledge gaps in order to prioritise monitor programs (e.g. specific habitats or pressures).

**It helps to structure socio-economic assessments (Article 24 of the MSFD).**

The Linkage Framework connects economic activities to ecological functions and ecosystem services. In this way, the assessments can be targeted towards understanding social and economic drivers of the human activities that put pressure on marine ecosystems, and analyse which require mitigation as required by each Member States' Programme of Measures.

**It is useful for communicating the complexity of the social-ecological system and the centrality and value of biodiversity to stakeholders and financers.**

The linkage framework provides a conceptual basis to discuss complex social-ecological systems and the centrality of sustainable ecosystems with stakeholders.

## BEST PRACTICE: TIPS FOR APPLYING THE AQUACROSS LINKAGE FRAMEWORK

**TIP!** Look beyond the borders of your managed marine area – human activities on land and at the coast affect marine biodiversity, and vice versa. The Linkage Framework can support collaboration with your Water Framework Directive and Birds and Habitats Directive-focussed colleagues, by showing links between freshwater, coastal and marine systems and by providing a common terminology for understanding these systems. It can also assist coordination with nature managers (e.g. of Natura 2000 sites) whose biodiversity goals affect and are affected by marine environmental management and spatial planning.

**TIP!** Be clever in mobilising existing information – this includes identifying data and stakeholder knowledge. Involving stakeholders in the development of the Linkage Framework increases accuracy and also supports buy-in and understanding.

**TIP!** Don't get lost in the details – while the tool may potentially capture considerable complexity, which can be paralysing and confuse communication, it can also be used to simplify the system so that it only includes the most relevant elements. Focus on the key stories, elements, and links that come out. Here, working iteratively with stakeholders can help.

## CASE STUDY EXAMPLE – THE NORTH SEA

AQUACROSS's North Sea case study (see Case Study: North Sea) used the Linkage Framework (see Linkage Framework) to understand how key sectors in the North Sea (fisheries and renewable wind energy) are affecting local biodiversity, and in turn affecting the North Sea's ability to supply specific ecosystem services such as the provisioning of seafood or regulation and maintenance ecosystem services, including climate regulation or mediation of waste. The Linkage Framework focused attention on key activities and parts of the ecosystem. The risk assessment based on the Linkage Framework allowed the researchers to estimate the contribution of the different activities and their pressures to specific parts of the ecosystem, and to assess the likely impact on food and energy provision of different management measures (such as new fishing methods or protected areas).

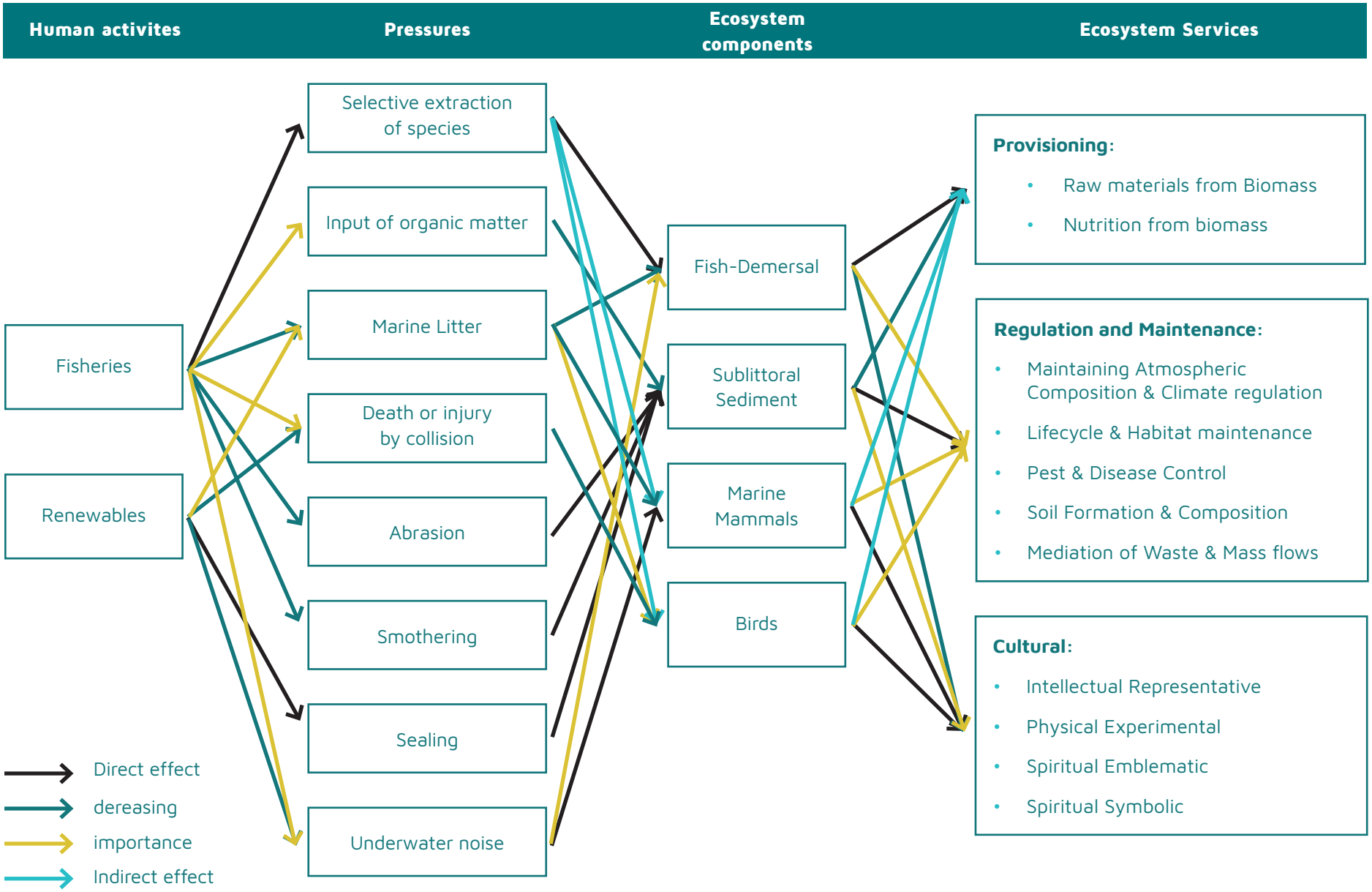


Figure 3 Simplified linkage framework for North Sea case study.

← Go to Brief #24: AQUACROSS Linkage Framework: Freshwater | www.aquacross.eu/results | Go to Brief #26: AQUACROSS Linkage Framework: Birds/Habitats →

**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Piet et al. (2018) Trade-offs in ecosystem-based fisheries management in the North Sea aimed at achieving Biodiversity Strategy targets. Deliverable 9.2, Case Study 1. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Teixeira et al. (2018) Assessment of causalities, highlighting results from the application of meta-ecosystem analysis in the case studies. Deliverable 5.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317.(Deliverable and Executive Summary)


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# How is the linkage framework useful for the Birds and Habitats Directive?

## WHAT IS THE AQUACROSS LINKAGE FRAMEWORK?

The AQUACROSS Linkage Framework is a semi-quantitative tool designed for environment managers, such as managers of Natura 2000 sites, to understand the links between human activities and the ecological system. It is a structured framework for understanding how human activities impact aquatic ecosystems, and how these ecosystems provide benefits to human society. It can be used at differing levels of complexity – simply to highlight priority elements or, more quantitatively, to assess risk and vulnerability within the system (see Linkage Framework).

## WHY IS THE AQUACROSS LINKAGE FRAMEWORK USEFUL FOR NATURE MANAGERS?

**It helps to better understand the full picture.**

A Natura 2000 site is not an island – local biodiversity is affected by external drivers, and it delivers benefits beyond its borders. The linkage framework helps identify all human activities (e.g. fishing) that place pressures (e.g. abrasion of the seafloor) on each element of aquatic ecosystems (e.g. specific habitats, fish, reptiles). It then identifies how each element of the aquatic ecosystem delivers valuable goods and services to society (e.g. fish, carbon sequestration) and finally reveals the links and relationships between these. Understanding the full picture helps understand the cause of biodiversity loss, and to prioritise effective protection measures.

**It helps you identify where best to act.**

The linkage framework can be used to identify the most central, at risk, or vulnerable parts of the system, and what they affect or are affected by. This helps to target actions to protect aquatic ecosystems (e.g. focusing on specific human activities) and prioritise what to monitor (e.g. specific habitats or pressures).

**It helps you mobilise the right stakeholders to protect biodiversity in your Natura 2000 site.**

The linkage framework identifies which sectors impact your Natura 2000 site, and who benefits from it, which is useful for gathering their support and engagement.

**It is useful for communicating the importance and value of biodiversity to stakeholders and financers.**

The linkage framework provides a conceptual basis to discuss complex social-ecological systems and illustrate the importance of sustainable aquatic ecosystems with stakeholders.

**TIP!** Seizing the opportunities of the LIFE Programme. The EU LIFE Programme aims to contribute to the implementation, updating and development of EU environmental and climate policy and legislation, through the co-financing of environmental projects that deliver value. The most recent LIFE programme (2014-2020) prioritises 'integrated projects', which support synergies between different policy objectives and sectors. This requires that socio-economic impacts on the environment are accounted for and measures are selected that provide the greatest benefits to environmental conservation to local stakeholders. The Linkage Framework can be useful for this task.

## BEST PRACTICE: TIPS FOR APPLYING THE AQUACROSS LINKAGE FRAMEWORK

**TIP!** Look beyond the borders of your Natura 2000 site – human activities beyond the boundaries of the site affect its biodiversity. The Linkage Framework can support collaboration with your Water Framework Directive and Marine Strategy Framework Directive-focussed colleagues by showing links between the parts of the system of interest for each policy.

**TIP!** Mobilise existing information – this includes identifying data and stakeholder knowledge. Involving stakeholders in the development of the Linkage Framework increases accuracy and also supports buy-in and understanding.

**TIP!** Don't get lost in the detail – while the tool captures considerable complexity, this can be paralysing and confuse communication. Focus on the key stories, elements, and links that come out. Here, working iteratively with stakeholders can help.

## CASE STUDY EXAMPLE – FAIAL-PICO CHANNEL MARINE PROTECTED AREA, AZORES

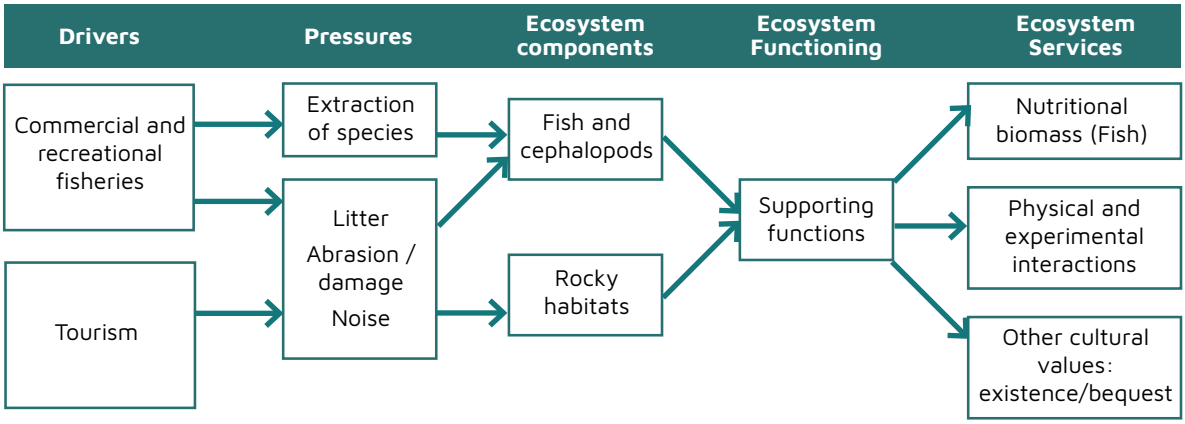


Figure 4 Simplified version of the AQUACROSS linkage framework developed for the Faial-Pico Channel MPA in the Azores case study.

The AQUACROSS Azores case study (see Case Study: Azores) applied the Linkage Framework to manage the Faial-Pico Marine Protected Area (MPA), which includes Natura 2000 sites. The Linkage Framework was focussed on a broad spatial scale that extended beyond the MPA to include the neighbouring waters and towns. While fishing has the biggest impact on biodiversity, the Linkage Framework identified that tourism also has an impact, and is an important beneficiary of biodiversity. This suggested new policies for management, including a sustainability tax and/or diving fee to fund biodiversity monitoring. It was also useful to mobilise tourism stakeholders (diving operators), who now understood the importance of biodiversity protection for their business, and wanted to contribute to policy.

### Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- McDonald et al. (2018) Ecosystem-based solutions to solve sectoral conflicts on the path to sustainable development in the Azores. Deliverable 9.2, Case Study 8. European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Report and Executive Summary)
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Teixeira et al. (2018) Assessment of causalities, highlighting results from the application of meta-ecosystem analysis in the case studies. Deliverable 5.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)

Case Study Azores © Hugh McDonald

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AQUACROSS Lessons and Recommendations

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# What are the limitations and challenges of implementing ecosystem-based management?

The implementation of ecosystem-based management (EBM) (see Introducing EBM) is a social and political challenge rather than merely a technical one. To successfully apply EBM, several barriers need to be overcome: a lack of cooperation between institutions not used to working together; the focus on recognised, traditional, technical measures; the use of models that do not consider ecosystem dynamics and future uncertainties; planning processes prone to managing crises or opportunities rather than anticipating; and piecewise approaches that hinder the effective advance towards a more integrative and holistic framework. Crucially, ecosystem-based management depends on coordination between sectors and the relevant policy institutions, which is a challenge when those policy units lack political leverage and are each responsible for complying with an individual EU Directive. These limitations of current practice and the need to adjust existing governance frameworks to the requirements of innovative EBM approaches was a challenge identified in all AQUACROSS case studies.

Implementing EBM involves applying an integrated approach. However, considering the whole social-ecological system is a complex and potentially time-consuming task, which includes **risks of inaction from overwhelming complexity.**

The possibility for carrying out an integrated assessment depends on the **availability and type of data** to be used in the analysis. **Gaps in data** availability pose challenges, for example, when making a homogenous assessment of human pressure across aquatic realms, or when evaluating the current state of an ecosystem and its deficits compared to agreed policy objectives (in the precision and resolution of indicators) (D4.2).

Evidence from the work in the AQUACROSS case studies shows that methodological limitations exist for predicting changes in the ecological system induced by the management measures. These changes, however, and the changes in the provision of ecosystem services that are linked to it, are necessary for assessing benefits and evaluating management. Mapping ecosystem services for fresh and marine water ecosystems is complex, especially in comparison to the simpler case on land.

In some AQUACROSS case studies (e.g. see Case Study: Ria de Aveiro, Portugal, and Case Study: Azores), data availability did not allow for clear-cut statements on the expected performance of EBM approaches compared to currently applied and planned management approaches. However, even in these cases, reflecting on potential consequences of measures, bringing in more (even if imperfect) information, clearly identifying uncertainties, etc. still turned out to be very useful in the process of improving management, as it allows stakeholders to take more informed decisions.

Accounting for ecosystem services is the first step for balancing costs and benefits between different societal groups. The costs of new management measures often fall disproportionately on those imposing the pressures today, whereas other groups of the population would benefit from the improvements in the environment. A key focus of the Azores case study (see Case Study: Azores) has been to decrease conflicts between different stakeholders, by involving them in the process of elaborating the EBM plan. The question of who will finance conservation measures has been identified as a main issue with regards to equity and fairness.

The AQUACROSS Linkage Framework (see Linkage Framework) identifies potential impacts on ecosystem services, but does not enable the quantification of these potential impacts. Also, modelling did not allow predicting how all ecosystem services are affected by the introduction of measures. While estimates can be made more easily for provisioning ecosystem services (e.g. water, food, raw materials), which are often traded in markets and for which extracted quantities are usually known, making reliable assumptions for regulating or maintenance services, for example, is much more difficult. In fact, there are major information gaps regarding ecosystem services that are not traded in markets, particularly regulating, cultural, and supporting services (Millennium Ecosystem Assessment, 2005). However, it is this change in ESS provision – together with estimates of the financial costs of measures – which is the basis for a proper evaluation of efficiency. These methodological limits explain why evaluations linked to impacts on ecosystem service provision remain qualitative in the AQUACROSS case studies – or are addressed together with stakeholders (see for example Case Study: Lough Erne or Case Study: Ria de Aveiro, Portugal) (D8.2) .

The results of the work undertaken within AQUACROSS case studies seem to highlight that the failure to meet the Biodiversity Strategy objectives is to a great extent due to the lack of knowledge and limitations around assessment tools employed to inform policy choices on ecosystem restoration options. There is a real need for change in the way policy decisions are informed and institutions organised to make these changes happen. To inform biodiversity protection choices we need to understand how ecological systems work and interact with humans. Only from the understanding of how nature organises itself, will we be able to design effective policy/restoration action that will bring real ecological benefits. In a second step, if public policy really seeks to achieve efficiency across the board, the right analytical instruments need to be developed in order to come up with reliable advice (D8.2). Ecosystem-based management provides an integrated decision-making framework that, despite the limitations identified, enables changes in the way policy decisions are made to better protect aquatic biodiversity.


| ← Go to Brief #26: AQUACROSS Linkage Framework: Birds/Habitats | www.aquacross.eu/results | Go to Brief #28: EBM: Added value → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- Identifying ecosystem-based management measures and policies: taking action, Introducing EBM, Evaluating ecosystem-based management options, Pre-conditions for "making EBM happen
- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- DeFries, Ruth, and Harini Nagendra. 2017. Ecosystem management as a wicked problem. Science 356: 265-270.
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


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# The added value of Ecosystem-Based Management

AQUACROSS results show that ecosystem-based management (see Introducing Ecosystem-based Management (EBM)) is worth the effort. The identified management options are more effective in reaching environmental targets, in particular when supporting the EU Biodiversity Strategy (see Biodiversity Strategy and AQUACROSS). The more holistic perspective which is taken in ecosystem-based management allows trade-offs between ecosystem services to be considered, and takes several societal goals into account. Ecosystem-based management approaches promote the most efficient allocation of financial resources, while contributing to the sustainability of the whole social-ecological system. This comprehensive approach has the potential to unveil win-win situations.

## WHICH INSIGHTS ON THE ADDED VALUE OF ECOSYSTEM-BASED MANAGEMENT THROUGH AQUACROSS?

**Applying ecosystem-based management changes the perspective of the existing situation and the way it is analysed, and leads to innovative responses to complex environmental challenges**

Applying ecosystem-based management starts with an in-depth analysis of the current situation. This analysis takes a wider range of issues into account than many other approaches do (in terms of the elements that define the environmental state, threats to biodiversity, benefits to society, etc.). This more comprehensive approach reveals different types of opportunities for reaching societal goals

- In the AQUACROSS case study of the Swiss Plateau (see Case Study: Swiss Plateau), for example, it is the combined consideration of morphological challenges and water quality that leads to a selection of measures that show increased ecological effectiveness.
- In Lough Erne (see Case Study: Lough Erne), the application of ecosystem-based management led to a radical change in the understanding of the system and of solutions considered for managing invasive alien species. Instead of their physical removal, which is costly and does not address the causes of the issue, the more holistic ecosystem-based management approach switched attention to conditions which promote their proliferation (in particular agricultural nutrient inputs to the lake), and opened a wider scope of measures that can be considered for their management (in particular the increase of lake water levels).

**Applying ecosystem-based management leads to the proposition of alternative, multi-purpose management options with positive outcomes across multiple policy areas**

In the context of ecosystem-based management, standardised, commonly-applicable solutions are not appropriate. Any situation is analysed case by case, and tailored approaches are developed. This requires decision-makers to be open minded: EBM can promote different types of measures and different policy instruments (see Identifying ecosystem-based management measures and policies: taking action), as well as the same measures or policy instruments which are currently applied, but with a different design.

- In the AQUACROSS case studies of the Danube (see Case Study: Danube) and the Intercontinental Biosphere Reserve of the Mediterranean (see Case Study: Spain/Morocco), for example, a spatial optimisation analysis within an ecosystem-based management context led to a different spatial allocation of river restoration sites, which achieved biodiversity targets at lower cost.
- The case study targeting the Intercontinental Biosphere Reserve of the Mediterranean (see Case Study: Spain/Morocco) exploited the benefits of multipurpose management solutions (Green and Blue Infrastructures) as well as co-creation with local stakeholders. To implement the resulting spatially prioritised restoration areas, local managers will now face the challenge of transboundary coordination and planning across freshwater, coastal, and marine realms.

Proposed ecosystem-based management options are in general multi-functional solutions, able to deliver benefits in many relevant areas. This is the case for example of natural water retention measures, which – depending on their design – can mitigate floods, increase carbon storage, promote biodiversity, buffer pollutants, etc. This is in contrast to solutions primarily designed to cope with single purpose problems (such as wastewater plants, fishing gears, etc.).

**Ecosystem-based management is an incremental, piecemeal process, promoting continuous adaptation and improvement**

Admittedly, ecosystem-based management comes across as a complex endeavour. Comprehensively analysing the current situation and identifying the most suitable approaches is a challenging task, and can result in choices that have high uncertainty. This is why ecosystem-based management is a cyclical approach, where the principles (see Introducing Ecosystem-based Management (EBM)) are integrated in the management practice in an incremental process. Each ecosystem-based management cycle further shapes the management of aquatic ecosystems based on the lessons learnt of the previous cycle, allowing for flexibility and continuous improvements to optimise ecological effectiveness and the achievement of other societal goals.

- The Ria de Aveiro (see Case Study: Ria de Aveiro, Portugal) presents complex challenges linked to managing the freshwater-marine continuum. These include the understanding and modelling of causal links and risks within the ecosystem, stakeholders' perceptions and spatial multicriteria analysis through valuation of ecosystem services. Modelling and stakeholder processes are useful steps for incrementally increasing stakeholder and decision-maker knowledge, supporting ongoing adaptive management.
- Within the Danube (see Case Study: Danube), ecosystem-based management has been approached through an integrative modelling exercise of multiple benefits linked to restoration measures. Restoration sites have been prioritised, taking into account the whole system, instead of country-specific target sites. However, complexity and heterogeneity of the environmental problems, lack of data, strong differences in socio- economic conditions, as well as inconsistencies in targets along the Danube significantly hampers ecosystem-based management planning that will require an incremental approach.

**Ecosystem-based management allows optimising trade-offs between ecosystem services in a transparent way**

Considering a wide range of ecosystem services (including provisioning services that are, for example, the basis for agricultural production) tends to lead to restoration of sites that are already closer to a near natural state. This approach implicitly considers trade-offs between ecosystem services that are compatible with nature conservation objectives (e.g. recreation, or partially flood protection) versus extractive / provisioning ecosystem services, which are rather incompatible, as they intervene with the ecosystem. Taking these trade-offs into account reduces costs imposed on those that currently benefit from provisioning services, which increases efficiency for the society as a whole.

- The AQUACROSS North Sea case study (see Case Study: North Sea) followed a risk-based approach that linked the impacts on biodiversity to the supply of ecosystem services, and evaluated the effectiveness of identified ecosystem-based management measures to achieve a healthy marine ecosystem. Solving trade-offs with other societal goals (sustainable food suply or clean energy) are still a challenge, but measures targeting fisheries or offshore wind farms- may result in comparable, if not bigger, reductions in total impact risk over biodiversity than those targeting biodiversity conservation (in particular marine protected areas).

**Consideration of trade-offs between ecosystem services strengthens reflections on equity and fairness**

Identifying ecosystem services and its beneficiaries, as part of the EBM process, is the basis for reflections on balancing costs and benefits between different societal groups and therefore for finding way to cooperate in restoring the environment and sharing the ensuing benefits.

- The Lough Erne case study (see Case Study: Lough Erne, Ireland) developed Fuzzy Cognitive Maps based on stakeholders' inputs to analyse management options concerning invasive alien species proliferation and water quality regarding actual ecosystem services and policy, goals that cannot be considered in isolation.
- The Swedish case study (see Case Study: Lake Ringsjön, Sweden) showed, for example, that even in the absence of quantitative or monetised estimations of ecosystem service provision, the identification of trade-offs allows fairness to be improved over space, over sectors and over time (e.g. among generations).

**EBM's focus on tradeoffs supports policy coordination and simultaneous consideration of multiple policy objectives**

Ecosystem-based management is particularly adapted to support the targets of the EU Biodiversity Strategy, and linked to this, any environmental policy (Birds and Habitats Directive, Water Framework Directive, Marine Strategy Framework Directive). At the same time, while considering all social demands linked to ecosystems, the ecosystem-based management approach takes account of sectoral policies, and the dependence of economic activities on the aquatic ecosystems (e.g. hydropower, agriculture, fishing). As the comprehensive analysis done in AQUACROSS shows, it is possible to identify win-win solutions, which should be the top priority for the next phase of the biodiversity strategy.

- In the AQUACROSS Azores case study, the assesment and understanding of the system using the AQUACROSS Linkage Framework (see Linkage Framework) allowed identifying synergies and conflicts between policies. Increasing stakeholder engagement, knowledge, and policy coordination enables adaptive management, reduces conflict, and can improve effectiveness and efficiency of ecosystem-based management.

**Ecosystem-based management provides a framework for fully valuing stakeholder contributions**

Although not a unique feature of ecosystem-based management, stakeholders (see Mobilising stakeholders) play a very important role in the process. Involving stakeholders in the elicitation of integrated societal objectives, or in the identification of joint solutions, is very important to make use of additional knowledge and of different existing perspectives. It increases the acceptability of proposed approaches, helps to define indicators that are (policy/real-life) relevant and more generally ensures that produced knowledge is useful for the decision-making process. In the case of incomplete scientific information, for example on the current status of aquatic ecosystems or on the causal relationships between management measures and induced changes, stakeholders can provide information and/or legitimacy to decisions taken in situations of high uncertainty.

- In the Swedish case study (see Case Study: Lake Ringsjön, Sweden), scenarios were co-designed with stakeholders, decision makers, civil servants and practitioners, exploring measures to enhance the resilience of the system with temporal (time lags between management actions and an improvement in the ecosystem)and spatial dynamics. Trade-offs have to be acknowledged to reach the full potential for managing catchment water quality.
- The assessment for the Swedish case study (see Case Study: Swiss Plateau), was done in close collaboration with stakeholders. It resulted in an optimisation procedure that provides a set of near-optimal combinations of measures to reach the highest ecological state for a given budget at the catchment scale.

**In the context of uncertainty, ecosystem-based management promotes the creation of a transparent, best-informed basis for decision making**

Ecosystems are complex, and it is not possible to foresee all potential consequences of management measures (both in the natural and the social system). In this context, ecosystem-based management faces difficulties that are also faced by other approaches to managing natural systems, including data limitations, uncertainty, and difficulties in estimating changes in ecosystem services. However, the holistic approach of ecosystem-based management provides the framework to prepare a basis for decision making that is as complete and transparent as possible. This is ensured for example through the comprehensive description of the current socio-ecological system, by asking for an evaluation that covers all most important criteria (e.g. effectiveness, efficiency and equity and fairness), and by involving relevant stakeholders in the discussions.

Even in situations where uncertainty remains high, information generated – even if imperfect – helps provide a critical look at different options for addressing biodiversity and water management issues. It then informs decision-making, and can be used in an adaptive management process that encompasses a learning-by-doing component and an incremental approach to move to the final solution.


| ← Go to Brief #27: EBM: Limitations / challenges | www.aquacross.eu/results | Go to Brief #29: EBM: Pre-conditions → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Gómez et al. (2016) The AQUACROSS Innovative Concept. Deliverable 3.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Gomez et al. (2016) Developing the AQUACROSS Assessment Framework. Deliverable 3.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Piet et al. (2017) Making ecosystem-based management operational. Deliverable 8.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)



AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# Pre-conditions for "making ecosystem-based management happen"

Conventional management practices (including sectoral approaches) are not necessarily well-suited for the uptake of ecosystem-based management (see Introducing Ecosystem-based Management (EBM)). Ecosystem-based management implementation is a social and political challenge rather than merely a scientific / technical one. The focus on ecosystems and ecosystem services entails a departure from traditional practice on environmental policy and natural resources management.

Successful design and effective implementation of EBM alternatives requires uptake in a policy-making environment characterised by legacy issues. Institutions, standard technological choices, well-established and commonly accepted assessment methods and criteria, and even the science-policy dialogue to date, have been shaped by an intense path dependency.

## WHAT IS NEEDED FOR ECOSYSTEM-BASED MANAGEMENT IMPLEMENTATION?

On **institutional grounds**, effective coordination mechanisms need to be built within and across relevant policy domains. For example, biodiversity concerns should be included in areas such as water, energy, spatial development, tourism and fishing, amongst others. Some of this policy integration has already been achieved, and is (partially) visible in the design of EU policy (e.g. EU Water Framework Directive, Marine Strategy Framework Directive), even if the outcomes of those processes may be disputable.

- Institutions are seen as a factor hindering the implementation of EBM. This is widely illustrated by the situation in the North Sea (see Case Study: North Sea), where despite overarching EU strategies and regulations, the scale of the ecosystem contrasts with action plans defined at national scales where responses are shared by mid-level administrative units in charge of managing activities, services, and impacts. A better coordination at both national and international scales may be the basis for a comprehensive response to the North Sea challenges (D8.2).

On **technological grounds,** seamless, comprehensive multi-purpose solutions (such as green infrastructure, river restoration, etc.) rather than individual techniques to tackle one problem at a time (such as pumps, desalination and wastewater plants, fishing gears, etc.) are required under ecosystem-based management.

On **knowledge and assessment grounds,** a meaningful body of transdisciplinary scientific knowledge must be mobilised and integrated in a way that can used and co-produced by stakeholders. This allows complex links between society and nature to be represented and collective action responses to be supported. Compelling explanations are required of how one thing leads to another (causal relationships) and of how human activities and policy choices explain the existing problems in the surrounding environment.

- The importance of the capacity to integrate knowledge on aquatic social-ecological systems in a way that can actually be taken up by stakeholders is shown in the Ria de Aveiro case study (see Case Study: Ria de Aveiro, Portugal). The need to gain social acceptance for ecosystem restoration to prevent saline intrusion, rather than extending the protected area and reducing agricultural land, is emphasised.

**Good information is needed** for carrying out an integrated assessment. Gaps in data availability pose challenges when making an assessment across aquatic realms, particularly with regards to indices and metrics for quantifying human activities and pressures, and especially for assessing the current state of an ecosystem, its deficits, and their causes (D4.2).

**Ecosystem-based management approaches are easier when there is a pre-existing agreement to jointly manage the ecosystem at hand.** If the benefits of the ecosystem's improvement are shared, the mutual interest of the different parties self-enforces the agreement. Limitations emerge when there are no suitable mechanisms in place.

- Implementing the spatial optimisation approach proposed in the Danube (see Case Study: Danube), for example, would imply that financial resources provided by one country are used for river restoration in another country. These agreements provide an institutional framework in which policy is at the level of ecosystems (the entire river basin, the biosphere reserve, or the marine protected area) (D8.2).
- The success of ecosystem-based management also depends on the ability to assess and compare the effectiveness (objectives achievement) and robustness (the degree to which the alternative courses of action would work even in the presence of potential failures) of management responses. This is relevant for example when comparing mechanical removal of alien invasive species vs. ecosystem renaturalisation through seasonally raising water levels in the Lough Erne (see Case Study: Lough Erne).

Evaluations of effectiveness show that AQUACROSS **EBM approaches are more effective in reaching biodiversity targets, in particular by more effectively choosing where to implement measures and where to invest available financial resources.** The more holistic perspective allows consideration of some trade-offs, and therefore also of other societal goals. Evidence from the case studies indicates that solutions proposed following the application of the AQUACROSS assessment framework seem also to be more efficient (although only a subsection of the costs and benefits could be considered and estimated in monetary values for the individual case studies) (D8.2).


| ← Go to Brief #28: EBM: Added value | www.aquacross.eu/results | Go to Brief #30: EU policy at the local level → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- Costea et al. (2018) Assessment of drivers and pressures in the case studies. Deliverable 4.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- Mattheiß et al. (2018) Evaluation of Ecosystem-Based Management Responses in Case Studies. Deliverable 8.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# Implementing EU policy at the local level: lessons and challenges

The AQUACROSS EU-level policy analysis identified that sectoral policies support drivers of biodiversity loss, reducing the potential effectiveness of the EU's environmental policies. A bottom-up policy analysis was subsequently conducted for the eight AQUACROSS case studies, in which we investigated whether the same is occurring at the local level. We undertook an in-depth review of relevant local policies for each case study and the linked effect on drivers of pressures to the local aquatic biodiversity, highlighting gaps and conflicts in each policy framework.

We found that, similarly to the EU level, as aquatic biodiversity declines across Europe, sectoral activities that drive biodiversity loss receive strong policy support at the local level in the shape of funding mechanisms and regulatory instruments. Our analysis suggests that local policy makers promote economic growth without sufficient environmental safeguards. Many of the drivers found in local areas are linked to emerging sectors that are key for local development: agriculture, fisheries, renewable energy or tourism. While these activities are key drivers of the increasing pressures on aquatic biodiversity in Europe, they are directly and indirectly supported by local regulations and European funds. This is one of the reasons why environmental policies in place are comprehensive on a formal level, but do not achieve their ambitious targets in practice. This conflicting policy mix results in sectoral ambitions outweighing environmental ones, thus contributing to the ongoing decline of aquatic biodiversity in Europe.

In AQUACROSS's Lough Erne case study (see Case Study: Lough Erne, Ireland), the bottom-up policy analysis showed that the pressure of invasive alien species arriving in the ecosystem through effects of tourism are coherently addressed by a number of local environmental policies (see Current biodiversity management: Issues). However, several policies and instruments supporting tourism increase the recreational activities in the Lough. For example, the Fermanagh Lakelands Tourism Area Plan aims to increase visits by 17% until 2020, with an emphasis on the need to continue partnerships to enhance water-based recreation. Environmental safeguards are missing to ensure sustainable tourism growth as well as a decline in biodiversity loss by 2020.


Figure: Local policy analysis from Lough Erne, Ireland case study

We suggest that local policy frameworks need to be restructured to simultaneously aim for biodiversity protection and sustainable economic welfare. Ecosystem-based management is proposed as a policy tool to achieve environmental mainstreaming in local policy frameworks that manage aquatic ecosystems and those that affect aquatic ecosystems (i.e. sectoral policies).

### Key findings

- **Commercial fisheries/Aquaculture:** Local legislation implementing and supporting the Common Fisheries Policy and Blue Growth Strategy will consequently support the driver of commercial fisheries and hence sustain species extraction, even if a focus lies on sustainability.
- **Agriculture:** A considerable focus on environmental goals to reduce environmental pressures such as nutrient pollution is required of the local implementation of the Common Agricultural Policy to achieve biodiversity targets. However, cross-compliance requirements within the CAP are currently not implemented sufficiently to ensure that nitrogen pressures from farming reach a sustainable level.
- **Renewable Energy:** Is managed locally as an environmental solution (to exit fossil fuel-based energy sources), even though it locally often means that new structure and infrastructure has to be built to support these renewable energies. This has the potential to cause pressures such as hydromorphological changes on the aquatic environment.
- **Tourism:** Is often supported by local policies that mainly focus on increasing economic growth with few environmental safeguards, thereby contributing to the intensification of a range of pressures (e.g., additional nutrient pollution, extraction of species, morphological alterations, invasive alien species) on aquatic ecosystems.


| ← Go to Brief #29: EBM: Pre-conditions | www.aquacross.eu/results | Go to Brief #31: EBM and Nature-Based Solutions → |
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### Further information

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:


- Rouillard et al. (2016) Synergies and Differences between Biodiversity, Nature, Water and Marine Environment EU Policies. Deliverable 2.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)
- O'Higgins et al. (2016) Review and analysis of policy data, information requirements and lessons learnt in the context of aquatic ecosystems. Deliverable 2.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable)
- Röschel, L. (2018). AQUACROSS Final Conference presentation: AQUACROSS Policy Review, Lessons learnt from top down and bottom up analysis.



AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# Ecosystem-based Management and Nature-Based Solutions

This brief explains how ecosystem-based management, as well as being a nature-based solution itself, provides a policy and decision-making framework that supports implementation of nature-based solutions to tackle societal challenges and address declining biodiversity. The AQUACROSS case studies provide eight examples of ecosystem-based management in action that demonstrate that valuation of broad benefits and costs, co-creation with stakeholders, and prioritising of resilience and sustainability supports effective, efficient, and equitable management, including implementation of nature-based solutions.

## THE CHALLENGE OF NATURE-BASED SOLUTIONS' BROAD BENEFITS

Nature-based solutions are "solutions that are inspired or supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions."

Nature-based solutions deliver broad long-term benefits to many beneficiaries and often tackle multiple societal objectives at once. A challenge for implementation of Nature-based solutions is that many of these benefits are difficult for decision and policy-makers to recognise, quantify, and take into account in decision-making.

## HOW DOES ECOSYSTEM-BASED MANAGEMENT SUPPORT IMPLEMENTATION OF NATURE-BASED SOLUTIONS?

Ecosystem-based management is any management or policy that protects, restores or maintains the resilience of the ecosystem, so that it can continue to deliver valuable ecosystem services to society and protect biodiversity (see Introducing Ecosystem-based Management (EBM)). By placing the sustainability of the ecosystem and its provision of ecosystem services at the centre of management and decision-making, it provides a framework for considering all of the benefits and costs to human welfare of management measures. As such, ecosystem-based management provides a "level playing field" that supports evaluation and implementation of nature-based solutions.

**The eight AQUACROSS case studies offer concrete examples of how ecosystem-based management supports implementation of nature-based solutions**

- Ecosystem-based management's inclusion of stakeholders at every level of decision making ensures that the priorities of diverse beneficiaries are considered. For example, the Azores case study (see Case Study: Azores) found that that the top priority of local recreational and commercial fishers, tourism operators, and other local stakeholders is the long-term sustainability of the ecosystem, and that they are all willing to collaborate and to bear costs to maintain this.
- Improved understanding of the social and ecological systems, and the impact of management measures on drivers, pressures, ecosystem state, ecosystem-functioning, and ecosystem services, ensures that the long-term, spatially-dispersed, and multiple benefits and costs associated with nature based solutions are understood. For example, the Danube case study (see Case Study: Danube) applied the AQUACROSS Linkage Framework (see Linkage Framework) and the AQUACROSS Information Platform (see Information Platform) to identify multiple ecosystem services (including recreational opportunities and pollination, among others), and long-term and dispersed spatial impacts to quantify the benefits of ecosystem restoration along the length of the Danube.
- Ecosystem-based management's deployment of ecosystem services (see Introducing Ecosystem-based Management (EBM)) ensures that these good and services delivered by nature (and nature based solutions) are valued. For example, the Ria de Aveiro case study (see Case Study: Ria de Aveiro) use stakeholder input and data to map the ecosystem services provided by the river, estuary, and coastal area, and used this information to prioritise restoration of the ecosystem.
- Ecosystem-based management's focus on the resilience and sustainability of the ecosystem and value of protecting biodiversity aligns with nature based solutions. For example, in the Intercontinental Biosphere Reserve of the Mediterranean (see Case Study: Spain/Morocco), ecosystem-based management was used to identify a network of protected areas (Green and Blue Infrastructure) that would achieve biodiversity protection targets whilst allowing sustainable use of neighbouring areas, ensuring effective restoration at lower overall cost.


| ← Go to Brief #30: EU policy at the local level | www.aquacross.eu/results | Go to Brief #32: Case Studies: Lessons → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- The AQUACROSS Case Studies


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AQUACROSS Lessons and Recommendations

# 32

# Lessons from applying ecosystem-based management in the AQUACROSS Case Studies

## OVERALL, HOW USEFUL IS ECOSYSTEM-BASED MANAGEMENT FOR PROTECTING AQUATIC BIODIVERSITY?

The eight AQUACROSS case studies are evidence that ecosystem-based management is practically doable and can be used to design more effective, efficient, and equitable management measures and policies for protecting biodiversity.

At the same time, ecosystem-based management is not revolutionary. Nevertheless, ecosystem-based management does have unique strengths. Here, we use the principles of ecosystem-based management to identify strengths of ecosystem-based management, as demonstrated by experience in the case studies.

## WHAT ARE THE BENEFITS OF ECOSYSTEM-BASED MANAGEMENT, AND HOW WERE THESE ILLUSTRATED IN THE CASE STUDIES?

### 1 EBM Principle 1: EBM considers ecological integrity, biodiversity, resilience and ecosystem services

Ecosystem-based management focuses on multiple ecosystem services and aims to maximise their joint value, whilst at the same time considering the dynamic relationships within ecosystems.

**Examples from the AQUACROSS Case Studies**

- The Intercontinental Biosphere Reserve of the Mediterranean case study (see Case Study: Spain/Morocco) considered multiple ecosystem-services (including provision of food, recreational activities, water supply, and cultural/spiritual value) to select protected area sites that delivered broader benefits than just biodiversity protection.

**Further reading:**
Deliverable 3.2

- The Swedish case study (see Case Study: Lake Ringsjön, Sweden) considered dynamic social relationships overtime to better understand how the timing of sewage discharge regulations would affect lake water quality.

**Further reading:**
Deliverable 7.2

### 2 EBM Principle 2: EBM is carried out at appropriate spatial scales

Ecosystem-based management considers ecosystem rather than jurisdictional boundaries to reach decisions and take actions at the appropriate level, and as a result can require transboundary cooperation.

**Examples from the AQUACROSS Case Studies**

- The Danube case study (see Case Study: Danube) considered the whole of the Danube river catchment to select sites for efficient and effective river restoration, rather than making choices at the national level. This may lead to better overall biodiversity outcomes at lower costs. The interdisciplinary and transboundary data generated was stored on the Information Platform (see Information Platform).

**Further reading:**

Deliverable 2.1
Deliverable 3.2
Deliverable 7.3

- The Lough Erne case study (see Case Study: Lough Erne, Ireland) considers the lake as part of linked social-ecological system that crosses the Northern Ireland/Republic of Ireland border. By considering policies and drivers and pressures from the whole system in their evaluation of potential management measures, they better identify the need for cooperation.

## 3 EBM Principle 3: EBM develops and uses multi-disciplinary knowledge

EBM emphasises the importance of understanding the social-ecological system, which requires detailed multi-disciplinary expertise, drawing on scientific as well as local and traditional knowledge.

**Examples from the AQUACROSS Case Studies**

- The North Sea case study (see Case Study: North Sea) used the AQUACROSS Linkage Framework (see Information Platform) to develop a semi-quantitative description of the social-ecological system. When combined with stakeholder input, this allowed them to identify important drivers and pressures to focus management measures on, which they then assessed in detail using data.

**Further reading:**

AQUACROSS Linkage Framework
AquaLinks tool

- The Ria de Aveiro case study (see Case Study: Ria de Aveiro, Portugal) combined stakeholder valuations of the local ecosystem with information from the AQUACROSS Linkage Framework (see Information Platform). The combined information helped identify how and where to restore seagrasses and saltmarshes to meet diverse societal goals.

**Further reading:**

Modelling approaches

- The Swiss Case Study (see Case Study: Swiss Plateau), the Intercontinental Biosphere Reserve of the Mediterranean case study (see Case Study: Spain/Morocco), and the Danube case study (see Case Study: Danube) used spatial ecological and economic data to map the most cost effective location to meet their biodiversity goals. Multi-disciplinary data and modelling support efficient and effective management of complex, cross-boundary, and integrative issues like aquatic biodiversity.

## 4 EBM Principle 4: EBM builds on social–ecological interactions, stakeholder participation and transparency

Ecosystem-based management acknowledges social–ecological interactions and considers synergies and trade-offs between benefits and beneficiaries. To balance these issues, it gives preference to transparent and inclusive decision making, seeking to build consensus on a shared vision for the future, and build in stakeholder participation at every stage of planning, evaluation, implementation, and adaptation.

**Examples from the AQUACROSS Case Studies**

- The Azores case study (see Case Study: Azores) drew on stakeholder interviews and two workshops to understand stakeholder priorities for managing the local marine protected area. Their insight, data, and feedback ensured an accurate understanding of the social-ecological system, and helped to identify consensus actions that would effectively and efficiently protect local sustainability.

**Further reading:**

Mobilising Stakeholders

- The Lough Erne case study (see Case Study: Lough Erne, Ireland) and the Ria de Aveiro case study (see Case Study: Ria de Aveiro, Portugal) developed semi-quantitative models with stakeholder input. This increased scientific knowledge and also built stakeholder understanding and consensus.

**Further reading:**

Modelling approaches

## 5 EBM Principle 5: EBM supports policy coordination

Ecosystem-based management facilitates cooperation and collective action across different stakeholder and policy domains to share the array of ecosystem services obtained. As such, a key strength is that it creates new opportunities to pursue different policy objectives simultaneously.

**Examples from the AQUACROSS Case Studies**

- The Ria de Aveiro case study (see Case Study: Ria de Aveiro, Portugal) covers a river, transitional estuary, and coastal area, and as such, had to consider freshwater, marine, and biodiversity targets. Considering these objectives together – and cooperating across policy domains – identified the opportunity of aligning biodiversity and Water Framework Directive indicator monitoring and evaluation, to save money and increase knowledge.

**Further reading:**

Developing relevant indicators
Deliverable 2.1
Deliverable 5.1

- The Azores case study (see Case Study: Azores) identified that five institutions had a role managing the local marine protected area – including two environmental directorates, the fisheries directorate, and the marine affairs directorate. At the same time, local stakeholders complained that overlapping policies were unclear. The resulting EBM plan proposed policy coordination group to align policies to increase effectiveness and ambition.

**Further reading:**

Integrative environmental objectives

## 6 EBM Principle 6: EBM incorporates adaptive management

Ecosystem-based management aims to increase adaptive capacity by restoring critical ecosystems and strengthening social capacities to respond to a range of possible future scenarios. Central is the question of weighing short-term management options against long-term benefits of alternative intervention, and monitoring impact and regularly revisiting management and policies.

**Examples from the AQUACROSS Case Studies**

- The Swiss case study (see Case Study: Swiss Plateau) and the North Sea case study (see Case Study: North Sea) developed scenarios that incorporated projections of population and economic growth. These long-term drivers increase the likely future pressures on ecosystems, and including them in management planning and evaluation makes for better informed decisions.

**Further reading:**

Developing relevant indicators
Deliverable 2.1
Deliverable 5.1

- The Swedish case study (see Case Study: Lake Ringsjön, Sweden) and the Azores case study (see Case Study: Azores) placed special focus on understanding and strengthening social capacity to adapt to uncertain futures. Both case studies concluded that participatory management with diverse stakeholders supports sustainable social and ecological systems.

## FROM A PRACTITIONER'S PERSPECTIVE, WHAT ARE THE KEY STRENGTHS AND CHALLENGES OF ECOSYSTEM-BASED MANAGEMENT?

We asked the AQUACROSS case study leads of our case studies and the local policymakers that collaborated in the case studies to identify key strengths and challenges of the ecosystem-based management approach.

**Strengths**

1. Ecosystem-based management supports **integration** of objectives and **policy coordination.**
2. Ecosystem-based management **develops** and **uses** quantitative, qualitative, and spatial **science**.
3. Ecosystem-based management places **stakeholders** at the centre of biodiversity management, recognising beneficiaries beyond biodiversity for its own sake.
4. Ecosystem-based management considers **long-term** and **transboundary** impacts.
5. Ecosystem-based management prioritises **evaluation** and ongoing **adaptive management**.

**Challenges**

1. Ecosystem-based management is **not revolutionary** - but it is useful.
2. Ecosystem-based management can **appear theoretically** difficult to practitioners and stakeholders.
3. Ecosystem-based management's requires **long-term** monitoring and evaluation.
4. Considering **transboundary** issues is a key strength of Ecosystem-based management, but is challenging in practice.


| ← Go to Brief #31: EBM and Nature-Based Solutions | www.aquacross.eu/results | Go to Brief #33: Information Platform: Lessons → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- AQUACROSS Case Studies
- Gomez et al. (2016) Developing the AQUACROSS Assessment Framework. Deliverable 3.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# Lessons learnt from the design, development and use of an Information Platform for the protection of aquatic biodiversity

Tools like the AQUACROSS Information Platform (IP) - http://dataportal.aquacross.eu/ - are meant to support not only scientists, but also EU Member States and policy makers focussed on data (in AQUACROSS related to biodiversity and ecosystem services). This brief summarises the development of the AQUACROSS Information Platform (see Information Platform) and informs interested parties about what AQUACROSS has learnt during the development of it. Recommendations included in this brief are directed to IT developers in terms of technology, scientists in terms of project planning and data publishing as well as to policy makers in terms of sustainability.

To facilitate the dissemination of research and innovation results of AQUACROSS, the project established a common and free of charge open-access information platform with focus on the eight AQUACROSS case studies. On the one hand, this platform acts as publishing tool for project partners. On the other hand, it is a central access point for data on different types of aquatic ecosystems, biodiversity and ecosystem-based management practices addressed to the entire scientific community, stakeholders and policy makers.

Building up complex infrastructures like the AQUACROSS Information Platform always includes challenges to be met and decisions to be taken. In order to present a broad spectrum of feedback for the lessons learnt, several user surveys and developer interviews were conducted and visitor statistics evaluated. AQUACROSS Information Platform development recommendations are summarised in the following paragraph with indication of the relevant audience(s) and actors:

## TECHNOLOGY → SCIENTISTS, PROJECT LEADERS, DEVELOPERS

Among a variety of technical options, the decision was made to use CKAN as technical base for the Information Platform. This turned out to be a good and practicable solution as CKAN is an excellent tool for making data and information visible and disseminating results. Technology-wise it makes datasets available for harvesting through and integration in other CKAN installations, which multiplies the potential visibility of AQUACROSS results. CKAN offers high flexibility and modularity, with a large number of available plug-ins. Technical implementation requires experienced developers, but is mostly straightforward with a very active and growing CKAN support community in the background.

## DEVELOPMENT PROCESS → DEVELOPERS

Executing development work through distributed teams, while having to reconcile differences in expectations and perspectives, is obviously challenging and requires good communication among partners. As a result of the AQUACROSS Information Platform work, a set of communication tools can be recommended to support the development process. This includes regular teleconferences and email exchanges, common programming events and participation at developer conferences as well as the use of a tracking tool to document processes and procedures (e.g., Redmine).

## DATA MOBILISATION → PROJECT LEADERS, FUNDING BODIES

An infrastructure like the AQUACROSS Information Platform can only fulfil its purpose if it presents a critical mass of relevant data. Successful data mobilisation needs extensive operational support to actively hunt for data. Therefore, sufficient resources (personnel- and budget-wise) need to be foreseen for data delivery as well as for data processing. The process of publishing (uploading) data needs to be embedded in the entire project workflow, which means that the timing of development work needs to be well aligned with the other project work. These steps should already be described in the project proposal and in the Data Management Plan.

## CHANGE OF CULTURE → SCIENTISTS

Scientists tend to be reluctant to let go of their data and to publish them open access owing to various reasons. This reluctance towards publishing and uploading data needs to be overcome. This can be done by highlighting the advantages of data publishing (such as visibility, recognition, possibility of new research collaborations, etc.) as well as by making the upload process as easy and clear as possible by providing good default options and clear guidance in the developed infrastructure.

## SUSTAINABILITY OF INFRASTRUCTURES → FUNDING BODIES

It is highly necessary to create sustainable solution options for the development and maintenance of infrastructures like the AQUACROSS Information Platform from the side of the funding body. Currently European research schemes do not foresee funding for the maintenance and further development of IT tools after the project ends and their continuation still relies on other (sometimes unrelated) sources of funding. Therefore, very often there is a risk that these developments disappear from the infrastructure landscape and considerable time and development knowledge becomes lost if alternative sources of funding are not found. AQUACROSS therefore encourages the European Union to create dedicated post-project funding schemes that allow sustainably maintaining IT infrastructures and software research tools in order to avoid duplication of work and re-inventing the wheel after each project.


| ← Go to Brief #32: Case Studies: Lessons | www.aquacross.eu/results | Go to Brief #34: EBM: Why involve stakeholders? → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- The AQUACROSS Information platform is available at: http://dataportal.aquacross.eu
- Arévalo-Torres et al. (2016) AQUACROSS Data Management Plan. Deliverable 6.1, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable)


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# Lessons learned for involving stakeholders in Ecosystem-Based Management

## WHY INVOLVE STAKEHOLDERS?

- Stakeholder engagement is required by environmental policy in Europe, and increasingly incorporated into biodiversity protection projects. While there are many interpretations of what stakeholder engagement means and how it can be made operational under specific institutional contexts, it is considered a prerequisite for the successful application of ecosystem-based management (EBM).
- Stakeholder engagement in the context of EBM is a multi-faceted and complicated process, because these projects typically promote multi-functionality for pursuing multiple objectives (ecologic, economic, and social). This requires: **(a)** mobilising wider groups of stakeholders as compared to traditional "sector-specific" stakeholder processes (see Mobilising stakeholders for supporting Ecosystem-based Management); **(b)** addressing explicitly trade-offs between different types of stakeholders (decision-makers, scientists and other actors) and between different policy objectives under conditions of complexity and uncertainty about interactions between EBM and the ecological and social systems.
- Overall, including stakeholders' supports more effective, efficient, and equitable management – stakeholders can help prioritise objective, provide low-cost information and expertise, and support implementation and ongoing adaptive management.
- In this brief, we highlight steps taken to mobilise stakeholders in the case studies and, through an example in the Azores, highlight some of the lessons learnt and applications.

## HOW CAN STAKEHOLDERS CONTRIBUTE TO ECOSYSTEM-BASED MANAGEMENT, AND WHAT ARE THE STEPS?

The eight AQUACROSS case studies faced unique biodiversity challenges and different contexts. Accordingly, they engaged different stakeholders, and in different ways. However, overall, the following seven steps arose as the best way to involved stakeholders in ecosystem-based management.

### 0 Step 0 – Agree on scope

Before beginning the process, it is important that decision-makers agree on their broad objectives and the scope of the EBM process, and on assigned roles of scientists, decision makers, and other stakeholders.

> **TIP!** Poorly defined goals or scope can lead to disappointed stakeholders or scientists, whose unrealistic expectations cannot be met, and frustration from all sides, due to differing expectations of commitment.

## 1 Step 1 – Map the stakeholders

Ecosystem-based management should recognise that protecting biodiversity delivers many benefits to multiple beneficiaries. Additionally, aquatic biodiversity is affected by diverse human activities and pressures (see Linkage Framework). Accordingly, consider diverse stakeholders – including sectors like agriculture and fisheries.

**TIP!** Consider multiple geographic and time scales to identify the relevant stakeholders. It is important to remember that there is no one scale that is appropriate – e.g. even though the Lough Erne case study focused on a relatively small lake, its biodiversity may is affected by catchment-wide agriculture, and country-wide tourism (see Case Study: Lough Erne, Ireland). Stakeholders from different scales needed to be considered.

## 2 Step 2 – Together, establish a shared understanding of the context

The aim of this step is to ensure that researchers, decision-makers, and stakeholders have collated as much information as possible and agree on the a general understanding of how the ecosystem is functioning, the key threats and human activities affecting aquatic biodiversity, and who benefits from aquatic biodiversity.

**TIP!** Stakeholders have knowledge and data that can help scientists understand the social-ecological system.

**TIP!** Stakeholder views and priorities are important to capture here, as well as those of managers/policy-makers. In the Swedish case study, general public and other stakeholders input on models supported understanding and consensus (see Case Study: Lake Ringsjön, Sweden).

**TIP!** The AQAUCROSS Linkage Framework (see Linkage Framework) can be developed using stakeholder input and feedback, and can produce useful visual output to support understanding.

## 3 Step 3 – Co-develop objectives

Policy objectives (see Integrative environmental objectives) are one source of societal objectives. Stakeholders are another source, and can be additionally helpful at prioritising objectives, and balancing up between competing goals.

## 4 Step 4 – Identify and evaluate possible actions

Stakeholders can support the identification of practical management measures and policies to improve aquatic biodiversity protection at the same time as meeting other goals.

**TIP!** Stakeholders are experts in their field. In the North Sea case study, fisheries stakeholders provided insight and practical knowledge to design better policies (see Case Study: North Sea). This can have the additional benefit of increasing the perception of management measures among other stakeholders, who can trust that someone representing them had a say.

## 5 Step 5 – Implement and monitor

In some cases, stakeholders will be the best people to implement new management measures and to monitor their impact.

**6 Step 6 – Evaluate and adaptive management**

After implementing new management measures, engage stakeholder to assess whether goals were met, and what can be learnt and improved. Their input is crucial for understanding the real impact of management, and for adapting it to new information.

## CASE STUDY EXAMPLE – AZORES

Through interviews, workshops, and feedback, Azorean stakeholders – including recreational and commercial fishers, diving operators, environmental NGOs, scientists, and representatives of all relevant Regional Directorates – identified issues, shared their views, and provided crucial input in the design of an ecosystem-based management plan for the Faial-Pico Channel Marine Protected Area. Stakeholders provided data and expertise that improved understanding of the system. They also communicated priorities for management missed by policy-makers, including simplifying management, increasing monitoring and enforcement, and increasing environmental ambition. The Azores case study demonstrates that local stakeholders support effective and equitable management by clearly identifying challenges and priorities, co-creating solutions, providing low-cost knowledge and expertise, and through ongoing monitoring, enforcement, and evaluation of the impact of management (see Case Study: Azores).


| ← Go to Brief #33: Information Platform: Lessons | www.aquacross.eu/results | Go to Brief #35: Recommendations: Tourism → |
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**Further information**

This is one of 38 short briefs summarising the key results of the AQUACROSS Project. For more detailed information on the topics covered in this brief, see the following:

- AQUACROSS Case Studies
- Gomez et al. (2016) Developing the AQUACROSS Assessment Framework. Deliverable 3.2, European Union's Horizon 2020 Framework Programme for Research and Innovation grant agreement No. 642317. (Deliverable and Executive Summary)


AQUACROSS has received funding from the European Union's Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317.

# Business Brief: AQUACROSS Recommendations for tourism in relation to aquatic ecosystems

## WHY IS AQUATIC BIODIVERSITY IMPORTANT FOR TOURISM OPERATORS?

Aquatic biodiversity is the range of wildlife, plants and other living organisms in seas, coasts, lakes, rivers and wetlands. Many tourism businesses depend on the protection and restoration of aquatic biodiversity - diverse wildlife, clean water and beaches, and beautiful natural environments are critical attractions for tourism in these environments and for the sector's long-term sustainability.

However, tourism activities can put aquatic biodiversity under threat, making it challenging to continue offering high-quality tourism experiences. For example, the AQUACROSS Lough Erne case study (see Case Study: Lough Erne, Ireland) identified that tourism is a source of invasive alien species introductions, which affect native species in the lake. The presence of invasive alien species, such as Nuttall's pondweed, also restricts access to the lake for recreational boating and fishing. Other tourism-related impacts on aquatic biodiversity include boat traffic, litter, pollution, water withdrawals and tourism infrastructure (e.g. hotels).

The tourism sector benefits from efforts to protect and restore aquatic ecosystems. Such efforts help to reduce risks to operations, for example from reduced recreational access, loss of the wildlife that attracts tourists, or polluted environments. Engaging in ecosystem protection also offers corporate social responsibility benefits and competitive advantages in eco- and sustainable tourism markets.

AQUACROSS identified ecosystem-based management (see Introducing Ecosystem-based Management (EBM)) as a cost-effective way of protecting aquatic biodiversity while maintaining sustainable economic activity. Ecosystem-based management involves any management or policy options intended to restore, enhance and/or protect the resilience of the ecosystem.

## AQUACROSS RECOMMENDATIONS FOR TOURISM OPERATORS

- **Tourism operators should understand both how their business depends on aquatic biodiversity and the negative impacts of their operations.**
  Tourism businesses can impact biodiversity in many ways, for example introduction of invasive species, litter and pollution, water withdrawals, and pressures on the environment from construction. Understanding this is the first way to minimise impacts. For example, the AQUACROSS case study in Lough Erne (see Case Study: Lough Erne, Ireland) found that tourism boats introduced an invasive pondweed, which then made it difficult for recreational boaters and fishers to access the lake. Local codes of conduct educate tourist boaters and recreational anglers on how to reduce such invasive alien species introductions. Relevant businesses could invest in promoting the codes with their clients.

- **Tourism operators should build coalitions with other companies and sectors, particularly those introducing risks for tourism, such as fisheries and renewable energy.**
  This can help to coordinate the institutions and regulations that govern the environment and these sectors. For example, in the AQUACROSS case study in the Azores (see Case Study: Azores) tourism operators (e.g. diving companies) collaborated with the fisheries sector and suggested increased monitoring and enforcement of biodiversity regulations. Both sectors agreed that this would better protect the biodiversity on which both sectors rely.

- **Tourism operators should participate in local policy discussions.**
  This allows their interests to be taken into account in a way that protects both aquatic biodiversity and sustainable tourism growth. For example, In the AQUACROSS case study in the Azores (see Case Study: Azores) tourism operators supported expansion of the local marine protected area to protect and promote it as a tourism destination and to maintain their own access.

- **Tourism operators reliant on a good quality environment can contribute to financing efforts to protect it.**
  For example, in the AQUACROSS case study in the Azores (see Case Study: Azores), it was estimated that a per-night tax of 0.25EUR would generate 57 500 EUR per year (excluding administrative costs), which would cover the direct costs of the proposed plan to manage the ecosystem. While this would imply some loss of income for tourism operators, it would finance other management efforts to protect biodiversity and the ecosystems in which the tourism sector operates, thus supporting the industry's longer-term sustainability.

- **Tourism operators can provide knowledge to support protection of aquatic biodiversity.**
  Some relationships between human activities, aquatic ecosystems, and the benefits they provide to human society can only be understood with knowledge from private sector tourism businesses. Providing this knowledge supports effective management.


| ← Go to Brief #34: EBM: Why involve stakeholders? | www.aquacross.eu/results | Go to Brief #36: Recommendations: Agriculture → |
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**Further information**

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- AQUACROSS Business Brief: The business benefits of engaging with the Sustainable Development Goals.


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# Business Brief: AQUACROSS Recommendations for agriculture in relation to aquatic ecosystems

## WHY IS AQUATIC BIODIVERSITY IMPORTANT FOR FARMING?

Aquatic biodiversity is the range of wildlife, plants and other living organisms in seas, coasts, lakes, rivers and wetlands. Agricultural activities affect aquatic biodiversity through water pollution (especially from fertilisers), water withdrawals for irrigation and physical damage to habitats. Higher nutrient concentrations in rivers, lakes and wetlands contribute to development of algal blooms and establishment of invasive alien species, and are a key reason that these aquatic ecosystems fail to meet European and local environmental goals.

However, taking action to reduce these agricultural impacts on aquatic ecosystems has several benefits for farmers. Efficient use of fertilisers and pesticides not only reduces the amounts that reach water bodies but also reduces input costs. Similarly, efficient irrigation reduces water costs and maintains sufficient water in rivers and lakes for biodiversity and for other users.

Maintaining riparian vegetated buffer strips and wetlands reduces the extent to which agricultural inputs (fertilisers, pesticides) reach watercourses, protecting biodiversity and helping to maintain good quality source water for irrigation and other uses. Wetlands and other floodplain ecosystems also buffer droughts, contributing to more consistent supplies of irrigation water. Many other measures to reduce water pollution from agriculture also help to improve soil quality and provide other benefits including increased carbon sequestration.

Reducing agricultural impacts on aquatic biodiversity ensures compliance with EU environmental legislation, including the Water Framework Directive, the Birds and Habitats Directives, the Nitrates Directive and cross-compliance under the Common Agricultural Policy. Improved production practices accredited through voluntary programmes and certification schemes can reduce reputational risks and increase access to new 'green' markets.

AQUACROSS identified ecosystem-based management (see Introducing Ecosystem-based Management (EBM)) as a cost-effective way of protecting aquatic biodiversity while maintaining sustainable economic activity. Ecosystem-based management involves any management or policy options intended to restore, enhance and/or protect the resilience of the ecosystem.

## AQUACROSS RECOMMENDATIONS FOR FARMERS

- **Agricultural producers should understand both how their business depends on functioning aquatic ecosystems and how their operations impact such ecosystems.**
  The AQUACROSS project shows that agriculture receives numerous benefits from healthy aquatic ecosystems, including disease prevention, clean water for livestock and more. Agriculture also places pressures on healthy ecosystems. Understanding these is particularly useful for agricultural companies interested in reporting on sustainability impacts and practices for corporate social responsibility (CSR) purposes or to obtain sustainability certification. For example, the Sustainably Grown standard requires certified food producers to effects of their agricultural production on natural ecosystem flora and fauna.

- **Reducing agricultural impacts on aquatic species and habitats is necessary to meet regulatory requirements and to comply with certification schemes.**
  By understanding their dependencies and impacts on aquatic biodiversity, farmers can target investment towards management practices that are effective in protecting aquatic biodiversity and that benefit agricultural operations. For example, in the AQUACROSS case study area of Lake Ringsjön, Sweden (see Case Study: Lake Ringsjön, Sweden), changes in use of agricultural land and more efficient nutrient use (implying lower input costs) have reduced nutrient leaching from agricultural land by 12% for nitrogen and 7% for phosphorus.

- **Best management practices that meet targets for aquatic biodiversity at the lowest cost to the farmer should be identified using cost-effectiveness analysis.**
  This analysis also identifies measures that reduce costs for the farmer. For example, in the AQUACROSS case study in Lough Erne, Ireland (see Case Study: Lough Erne, Ireland), diffuse phosphorus inputs to the lake can be considerably reduced by sequentially implementing three best management practices that involve cost savings for the farmer: **1)** integrate fertiliser and manure nutrient supply, **2)** reduce fertiliser application rates, and **3)** refrain from applying phosphorus fertilisers to high phosphorus-index soils.

- **Other benefits of measures to reduce agricultural impact on aquatic biodiversity should be identified.**
  Reducing agricultural pressures can have broad benefits for others, such as for recreation or carbon storage. Identifying these benefits mean alternative sources of funding can be used to implement the measures.

- **Farmers should collaborate with other farmers and sectors (e.g. forestry, utilities, industry) in their river catchment.**
  Working with other farmers allows small-scale projects, (e.g. installing a buffer strip) to be aggregated, which opens up financing opportunities and ensures that they deliver the desired benefits. Collaborating with other farmers and sectors also helps to reduce risks, such as poor quality or insufficient irrigation water caused by upstream activities, and ensures agricultural interests are taking into account in decision making, such as water allocations. For example, in the AQUACROSS case study in Lake Ringsjön, Sweden (see Case Study: Lake Ringsjön, Sweden), nutrient inputs from agriculture have decreased considerably, but continue from other sources. Engaging with other sectors to reduce their inputs would improve water quality in the lake and its attractiveness to tourism, thereby supporting the local economy and potentially offering opportunities for income diversification.

- **Farmers can provide knowledge to support protection of aquatic biodiversity.**
  Some relationships between human activities, aquatic ecosystems, and the benefits they provide to human society can only be understood with agricultural knowledge from the private sector. Providing this knowledge supports the identification of effective ecosystem management measures.


| ← Go to Brief #35: Recommendations: Tourism | www.aquacross.eu/results | Go to Brief #37: Recommendations: Fisheries → |
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**Further information**

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- AQUACROSS Business Brief: The business benefits of engaging with the Sustainable Development Goals.


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# Business Brief: AQUACROSS Recommendations for fisheries in relation to aquatic ecosystem management

## WHY IS MARINE BIODIVERSITY IMPORTANT FOR FISHERIES?

Marine biodiversity is the range of fish, other wildlife, plants and other living organisms in seas and coastal areas. Healthy and functioning marine ecosystems that support diverse species and resilient fish populations are critical for the long-term sustainability of the fishing industry. For example, area-based closures of fisheries help increase the size of fish populations and individuals, both of which benefit fisheries in neighbouring areas.

However, fisheries activities put a range of pressures on marine biodiversity that can also threaten the long-term sustainability of fish stocks. The AQUACROSS case studies illustrate several ways in which fisheries affect marine ecosystems. For example, the AQUACROSS case study in the North Sea (see Case Study: North Sea) identified sea bed damage from fishing as a risk to the marine ecosystem. Other pressures include extraction of species (including unintentional bycatch), marine litter (including fishing nets and gear), boat traffic and underwater noise. The pressures that arise from poorly managed fisheries increase risks to their long-term sustainability.

The fishing sector benefits from efforts to protect and restore aquatic ecosystems. Such efforts help to reduce risks to operations from insufficient fish stocks and ensure compliance with legislation such as the Common Fisheries Policy, Marine Strategy Framework Directive, and the Maritime Spatial Planning Directive, for example. Engaging in marine ecosystem protection also offers corporate social responsibility benefits and competitive advantages in 'green' markets. For example, it can assist with meeting the standards of certification schemes such as the Marine Stewardship Council's Fisheries Standard.

AQUACROSS identified ecosystem-based management as a cost-effective way of protecting aquatic biodiversity while maintaining sustainable economic activity. Ecosystem-based management (see Introducing Ecosystem-based Management (EBM)) involves any management or policy options intended to restore, enhance and/or protect the resilience of the ecosystem.

## AQUACROSS RECOMMENDATIONS FOR FISHERIES

- **Fisheries businesses should identify both how their business depends on functioning marine ecosystems and how their operations impact such ecosystems.**
  Fisheries should seek to understand the link between fisheries, the pressures it causes to the aquatic environment (e.g. sea bed disruption, marine litter), the impacts on aquatic biodiversity, and how those impacts affect fish stocks. In this way, businesses can identify effective measures that reduce the most important impacts and manage risks to fisheries. For example, the AQUACROSS case study in the North Sea (see Case Study: North Sea) considered extensions of existing fisheries management measures and some novel management approaches, such as habitat credits. The North Sea case study concluded that some measures are 'win-wins' - they minimise the impacts of fisheries and sustain landings and revenue. For example, habitat credits were identified as an opportunity to reduce impacts of bottom trawl fisheries in this case study by incentivising fishing of less sensitive habitats or using a fishing gear that causes less seabed disturbance.

- **Fisheries should collaborate with other companies and sectors in their area.**
  Engaging with other companies and sectors operating in marine environments, particularly those introducing risks for fisheries, such as renewable energy and tourism, can help ensure that policy decisions are multi-beneficial, including for fisheries. This collaborative approach can help to coordinate the institutions and regulations that govern the environment, fisheries and other relevant sectors such as tourism, thus increasing their effectiveness. For example, in the AQUACROSS Azores case study (see Case Study: Azores) fisheries activities are affected by decisions to manage tourism impacts on marine biodiversity and vice versa. Coordination between the two sectors helps to identify management measures that protect the long-term interests of both, such as increased monitoring and enforcement of regulations to protect the fish stocks and other biodiversity on which they both rely, benefitting businesses that invest in compliance.

- **It is in fisheries' interests to ensure effective biodiversity protection.**
  While environmental protection can sometimes have short-term costs for fishers, in the medium and long term, fisheries rely on the long-run health of marine ecosystems. Accordingly, while fisheries are right to be mindful of the short-term costs of protecting the environment, they should always remain attentive to the potential benefits, and should demand effective protection. In the AQUACROSS Azores case study (see Case Study: Azores), local commercial and recreational fishers supported monitoring and evaluation, to ensure that the Marine Protected Area was effectively protecting biodiversity and increasing fish stocks.

- **Fishers can provide knowledge to support protection of aquatic biodiversity.**
  Some relationships between human activities, aquatic ecosystems, and the benefits they provide to human society can only be understood with fisheries knowledge from the private sector. Providing this knowledge supports the identification of effective ecosystem management measures.


| ← Go to Brief #36: Recommendations: Agriculture | www.aquacross.eu/results | Go to Brief #38: Further research needs → |
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**Further information**

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# Further research needs

Based on AQUACROSS work and results, the AQUACROSS Consortium has identified five key areas for further related research.

## 1 Integrating biodiversity protection into sectoral policy agendas

### Background

Based on the findings of AQUACROSS, biodiversity protection has not yet been mainstreamed into sectoral policies, and therefore, sectoral policies often are in conflict with existing environmental targets. This limits the effectiveness of existing biodiversity protection measures.

### Goal

Objectives of the European Environmental Directives are truly reflected in the objectives of relevant sectoral policies. Furthermore, implementation of the EU Biodiversity Strategy should be assessed with quantifiable targets and objectives.

**Proposed research questions**

- How could the EU implement a holistic approach to biodiversity protection within their policy framework? What would be the institutional framework?
    - Explore the possibility of a 'third wave' of EU environmental policy aligned with theSustainable Development Goals, i.e. EU Directives and Regulations that consider multiple objectives in an integrative manner.
- How can sectoral policies (Common Agricultural Policy and Common Fisheries Policy) more effectively help to conserve biodiversity?
- Would it be necessary to go from overall policy objectives for biodiversity to species/habitat-specific objectives; or to develop different aims for different types of habitats/species, such as migratory, terrestrial and aquatic species?
- How can EU policy objectives be effectively transposed into local biodiversity management strategies, whilst recognising transboundary and scale challenges?
- How can short-term decision making be overcome when dealing with long-term aspects of biodiversity protection? How could policy cycles be detached from management requirements?

### Expected impacts

By continuing research on the topics above, reporting and monitoring for environmental policies could be improved. Furthermore, the implementation of the environmental policy framework could be made more effective and EU sectoral funds could be better allocated to achieve biodiversity and other environmental objectives. Sustainable economic growth could be supported while taking into account environmental boundaries.

## 2 Improving the understanding of links between biodiversity, ecosystems and ecosystem services Background

### Background

The AQUACROSS Linkage Framework (see Linkage Framework) included components such as biodiversity, ecosystems, ecosystem functioning and ecosystem services. Nevertheless, the development of local ecosystem-based management plans during the project showed that major research gaps on the links between these different components still exist.

### Goals

Links between biodiversity and ecosystem service provision are better understood and therefore measures to protect biodiversity in order to enhance or maintain a supply of ecosystem services are developed based on an improved knowledge base.

**Proposed research questions**

- What are the causal links between changes in ecosystem state and specific provision of ecosystem services? For example, investigate further the role that habitat connectivity related to the dispersal of species and transport of matter and energy plays for ecosystem services provision? How can the large scale movement of species be considered for?
- Which species and habitats are most at risk and why is this the case? What can be done to stabilise their populations? How can we identify critical habitats for species, and how can we to protect them?
- Do some aquatic species produce ecosystem functions that are irreplaceable? Can large species, which typically require large habitats, fulfil umbrella functions for other species for freshwater biodiversity in general?

### Expected impacts

Improved knowledge on the link between biodiversity and ecosystem services will support prioritisation of policy decisions on biodiversity protection. Funding for environmental protection will be applied to protect habitats/species with greatest ecosystem services provision. A focus on habitat connectivity will ensure that protection is not done in isolation but under consideration of the linkage between different ecosystems.

## 3 Further developing practical models of the social-ecological system to support effective decision making at the local level

### Background

The AQUACROSS Assessment Framework includes environmental but also socio-economic aspects and the links between these different components. However, due to a limited duration of AQUACROSS, research gaps remain. Better understanding of the social-ecological system, and translating this into practical tools to support local managers will support effective management.

### Goal

Improve tools for understanding the aquatic biodiversity and socio-ecological systems. This will improve the accuracy of respective models in the future and support the development of more holistic protection approaches.

**Proposed research questions**

- To what extent is climate change impacting biodiversity and consequently ecosystem services provision? Will climate change hinder biodiversity protection measures?
- What role does aquatic biodiversity (and healthy aquatic ecosystems) play in mitigating climate change? And adapting to climate change?
- Which spatial and temporal scales are most relevant to improve aquatic biodiversity and ecosystem service provision model results?
- Which human interactions with aquatic ecosystems positively influence its biodiversity or reinforce ecosystem functions for long-term ecosystem services provision?
- How can the baseline information for ecosystem-based management be improved (e.g. detailed spatial maps of social-ecological system)?
- How can trade-off assessments between society and the environment be improved?
- How can we extend the AQUACROSS Linkage Framework to support local managers of biodiversity e.g. include spatial data, valuation?

### Expected impacts

Further research on socio-economic modelling approaches could improve the accuracy of the results and hence the knowledge base for decision making. The consideration of climate change impacts in the development and prioritisation of protection measures will become increasingly important, especially to inform management choices under climate adaptation. The understanding of human dependence on ecosystem-services and biodiversity will be improved. Management will be improved through more practical tools and guidance.

## 4 Communicating the complex issue of biodiversity to different stakeholders (general public, policy, businesses)

### Background

A major issue in local biodiversity protection is a lack of communication with the local stakeholders, which hinders the understanding of the issue of biodiversity loss and benefits of ecosystem services, and thus consequently limits the implementation of ecosystem-based management measures. This was apparent in the AQUACROSS case studies. In addition, the increase in local acceptance that biodiversity is of value to the local economy and wellbeing will support effective biodiversity protection.

### Goal

Testing and identifying suitable tools for communicating the issue of biodiversity loss, stakeholder's role in biodiversity decrease and protection, and the benefits of ecosystem-based management.

**Proposed research questions**

- How to be strategic about the identification and involvement of relevant stakeholders?
- How can relevant businesses down the value chain be involved in the discussions (e.g. supermarkets)?
- How can local stakeholders be effectively informed, what communication techniques are necessary to reach the public?
- Can we develop stakeholder-accessible databases for economic valuation of ecosystem services?
- How can data be made available to stakeholders in a FAIR way (Findable, Accessible, Interoperable, and Re-usable)?
- How do we increase the willingness to pay for ecosystem restoration?
- Freshwater species are out of sight, often hidden below the surface - how are these species perceived in society? How can the normal public be educated to become interested and caring for biodiversity (assuming that by public interest pressure can be built up for politicians to work towards changes)?
- How can society be convinced of the value of functioning ecosystems in relation to the value of economic growth?
- How can policy language be adapted to enhance communication and understandings and to avoid lack of confidence (at local level)?

### Expected impacts

An increased public awareness of the economic benefits of pristine aquatic ecosystems and linked biodiversity with increased knowledge on how ecosystem-based management can be applied to protect aquatic biodiversity. This would result in broader public engagement when ecosystem-based management is integrated into local aquatic biodiversity management, which would increase likelihood of successfully protecting biodiversity.

## 5 Putting ecosystem-based management into practice

### Background

The AQUACROSS project identified a number of local limitations that can hinder the application of ecosystem-based management to a certain extent. These range from existing structures (i.e. regulatory, sectoral etc.) up to local participation.

### Goal

To identify how ecosystem-based management as a tool can best be made available to local practitioners linked to an endangered aquatic ecosystem or species. Further research the limitations of ecosystem-based management that hinder application in local management areas.

**Proposed research questions**

- Which of the ecosystem-based management steps/principles have the greatest impact on management decisions? How can these be structured / used to have greatest impact for stopping biodiversity loss?
- How can governance aspects be further integrated into ecosystem-based management?
- How can successful case studies be scaled up?
- What (additional) practical tools are required by local policy-makers to implement ecosystem-based management?
- What financing options are optimal? Are there sustainable and profitable public-private partnerships for the protection of aquatic biodiversity available?
- What are the long-term impacts of ecosystem-based management, for example in the AQUACROSS case studies?
- Is ecosystem-based management being implemented by the relevant decision makers/ practitioners? Why is ecosystem-based management not being implemented? What are the reasons ecosystem-based management is not being widely applied?

## Expected impacts

Ecosystem-based management will be widely applied in local aquatic management sites as it is known to deliver optimal results in efforts towards aquatic biodiversity protection. The regulatory framework for application is straight-forward and cross-sectoral. Local nature managers would be inclined to apply ecosystem-based management rather than traditional management methods that avoid a holistic approach to biodiversity protection.

← **Go to Brief #37: Recommendations: Fisheries**

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**Further information**

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