

Scenario Development

Deliverable 7.2

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List of Abbreviations

AF	AQUACROSS Assessment Framework
AoI	Area of influence
CS	Case Study
EF	Ecosystem function
ESS	Ecosystem Services
IBRM	Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco (IBRM)
GBI	Green and Blue Infrastructure
MSP	Marine Spatial Planning
NbS	Nature-based Solutions
PU	Planning Unit
SCP	Spatial Conservation Planning
WP	Work Package
SES	Social-ecological system

About AQUACROSS

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

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

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

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

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1 Introduction

With this deliverable, we review recent literature on participatory scenario development and analysis within the context of ecosystem services (ESS) and biodiversity research. Beyond direct use for AQUACROSS, this deliverable exemplifies how ecosystem-based management (EBM) in aquatic ecosystems can be supported by participatory scenarios. Following the AQUACROSS Assessment Framework (AF), this deliverable aims to pave the way for innovative means to investigate complex, social-ecological systems (SES) as we observe them across all aquatic realms.

Thereafter, an overview of the scenario development processes and methods used within AQUACROSS case studies is provided. At the same time, this deliverable supports AQUACROSS case studies in their individual scenario planning processes which are differently advanced at this stage. But all scenarios are about how the main drivers, pressures and impacts affect the biodiversity and delivery of ESS, and how decisions on different policies result in alternative outcomes. In upcoming tasks, the scenarios will be analysed and linked to model analyses (Deliverable 7.3), will feed into the assessment of EBM strategies (Deliverable 8.1 and 8.2) while the scenario assessment helps to update the AQUACROSS AF (Deliverable 3.3).

The main objective, here, is to describe and explain the scenario-building processes reflecting on different information and data sources, types of stakeholder involvement and scenario uses, rather than outcomes. The document provides guidance on how to develop scenarios, i.e. possible future trajectories of the system, by combining stakeholder processes and modelling in meaningful ways. Further, this deliverable links stakeholder interactions to different steps in scenario development processes while tackling prominent challenges therein.

The common target systems in AQUACROSS case studies are European aquatic SES, where a set of goals to improve biodiversity and management options and ESS will be evaluated by models and assessed by experts together with stakeholders. Case-specific scenarios are therefore tools to connect available inputs and knowledge about the current system state and to evaluate potential SES trajectories into the future. According to Gómez et al. (2017), baseline and policy scenarios are the connections between analysis and policy, both of which crosscut throughout the AQUACROSS AF.

Against this background, we selected relevant literature for AQUACROSS case studies to develop and analyse scenarios, but also to integrate them for planning with stakeholders. We link the scenario-building and planning process to the policy context in which AQUACROSS cases work to demonstrate different purposes related to the stages that the case studies are in.

Our aim is to reflect upon the following questions within the introduction:

1. For what purposes is scenario development and analysis helpful? And how are scenarios insightful for stakeholders and decision-making? Here, we describe recent academic advances and challenges on scenario planning for biodiversity and ESS.

2. What are characteristic starting points for scenario development, analysis and planning within AQUACROSS? Here, we identify suitable methods with special focus on the integration of resilience principles for EBM.

Chapter 2 thereafter presents an overview on external databases and sources used in AQUACROSS and shortly reviews potential pitfalls and benefits while using external scenarios as inputs for our own scenario building processes. Chapter 3 provides an overview on how different case studies within AQUACROSS have worked with scenarios so far and how they intend to use them further. The fourth chapter presents the scenario development process from two case studies more in depth to serve as guidance for other cases that are currently at different stages of the scenario planning process. Those two AQUACROSS cases serve as distinct examples since one is more oriented towards participatory methods to develop qualitative narratives (CS 6 – Sweden) whereas the other one includes participatory processes but is more model-based (CS 2 – Spain/Morocco). The final chapter concludes with a preliminary discussion on how scenarios in AQUACROSS are analysed with models and how this Deliverable 7.2 feeds into Deliverable 7.3.

1.1 Clarification of terms

- **Scenario**: **a coherent, internally consistent, and plausible description of a potential future trajectory of a system** to assess current practice, screen new opportunities, and improve the design and implementation of policy responses (Gómez et al. 2017). Within a case study, a scenario builds on different assumptions about future developments and the effects of management measures to understand their impact on the future trajectory of the system, when no action is taken or when alternative options are considered, and uncertainties associated with complex dynamic systems. Sometimes less refined versions of these scenarios can also be called predictions or forecasts (see Figure 1, p. 38 in Gómez et al., 2017 for a gradient of different terms with respect to the degree of uncertainty and complexity). One scenario can serve different purposes (in AQUACROSS to describe and analyse baselines and alternative policies, or external developments) and it can be constructed from multiple sources, even multiple other scenarios (e.g., external inputs, narratives or model simulations).

- **Baseline scenario: a shared view of past, current and prospective trends** and vulnerabilities in ESS and biodiversity, associated challenges and opportunities, in a case study, based on management practice as usual (sometimes called “business as usual” or BAU scenario). It is not necessarily equivalent to a scenario describing (only) the current situation, i.e. what is happening today, which is just part of the story. IT rather shows the trend if there is no change in action, i.e. what would happen if the different drivers exert pressures over European aquatic ecosystems following a specific trend, a pathway from today towards 2020 and 2030 (Gómez et al., 2017).

- **Alternative policy or management scenario: represent objectives, deficits and alternative pathways (potential management interventions) for reaching a target** (normative) or to represent, assess and compare the outcomes of several alternative policy instruments or measures (descriptive), both ex-ante or ex-post, by comparison against baseline scenarios. Alternative names for these management-related scenarios within AQUACROSS are management strategies or action strategies although we prefer the term 'scenario' since it may be viewed as broader than 'management strategies', contained by the former. In any case, as explained, these scenarios refer to alternative policy options and could therefore be named as alternative policy or management scenarios, since baselines also include policy interventions.

- **External input scenario: a trend or potential future trajectory of a larger-scale (mainly exogenous) system that definitely influences the trajectory of the case study but cannot be influenced by it in turn.** These scenarios have been developed through stakeholder processes, expert consultations, data analysis, or downscaling of larger-scale models outside of the case study. Examples include the IPCC scenarios and the EU Reference Scenario 2016. They cover aspects that are out of scope of the environmental management in the case study but may influence the effects of management scenarios regarding management objectives. They are (mostly) quantitative and provide input for developing the baseline or alternative policy scenarios. In some cases, they are used to assess those baseline and policy scenarios (management/action strategies) under each of the external input scenarios (see Chapter 3 for an overview on those external scenarios relevant to AQUACROSS case studies).

- **Narrative: a future trajectory of the SES that is described using natural language**, or an illustration (storyline) based on stakeholders' perceptions as drivers of individual and collective actions, critical for both baseline and new policy scenarios.

- **Model-based scenario: a future trajectory of the SES (trends and causal links) that is calculated using quantitative models**, dealing with scientific uncertainties linked to assessment methods and tools.

1.2 Scenario development and planning to analyse and manage social-ecological systems

The ultimate goal of building scenarios, whether they originate from models, stakeholder participation, or as it is often the case both, is to assess outcomes from alternative future trajectories, through model analysis and planning with stakeholders, to inform decision making. A more specific goal is to assess the response of the SES to alternative future trajectories, based on model analysis or expert knowledge. The scenarios should include the different views of the stakeholders on possible alternative future developments that are hard to predict and the assumptions behind the scenarios must be made transparent. The management scenarios need to represent both social and ecological challenges and alternatives to deal with them. The prediction of the response of the SES to the external input-scenarios, and the baseline and policy scenarios must rely on the current state of knowledge and sound scientific insights as a critical condition for their credibility. But even a sound scenario based on scientific methods and proven facts would only be relevant for policy action if co-developed or assumed with actors involved in the decision-making process (Gómez et al., 2017).

Multiple benefits can result from scenario planning in environmental research as well as in ESS and biodiversity management (Oteros-Rozas et al. 2015). Among them, scenario planning fosters long-term, complex, and systemic thinking which allows for exploring the dynamics of a SES. When they are more narrative-based, a lack of rigor in the process is a potential weakness, which can be compensated by its utility to identify social-ecological feedbacks, surprises (for instance creative, adaptive responses by people), qualitative knowledge that cannot be easily quantified and trade-offs that cannot be represented by more formalised modelling approaches (Bennett et al. 2003). Others highlight the potential of avoiding unnecessary experimentation and exploring the context of uncertainty, particularly when ecological outcome is closely linked to drivers such as economic growth and demography (Carpenter 2002). In fact, building scenarios is essentially a response to uncertainties related to complex dynamic systems, including human decisions. A scenario is much more than delivering projections, forecasts or predictions (i.e., estimates). Scenarios should include a storyline (a hypothetical sequence of events) with a logical narrative about the way all the events in relevant SES may unfold to focus attention on causal processes and decision points (Gómez et al., 2017).

The importance of scenario development and planning for biodiversity and ESS was only recently highlighted within the methodological assessment report on scenarios and models within the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES 2016). We follow up on this report and extend their work within AQUACROSS by linking the methods to the AF with a special focus on measures for EBM and the integration of resilience principles. The resilience principles can help identify policies that enhance the resilience of ESS taking the complex adaptive nature of SES into account. Their attention focuses on structural elements and processes that enable a SES to cope with unexpected change by adapting or transforming current practices. Resilience thinking supports the construction process of the baseline and policy/management scenarios. Making resilience thinking operational to assess the sustainability of both baseline and policy scenarios entails judging the social and ecological systems, as well as their mutual interactions, according to the three attributes or assessment criteria that determine the future trajectories of the SES: its resilience *per se*, its adaptability, and its transformability (Gómez et al., 2017).

1.2.1 What are the expected benefits? – Scenario outputs and outcomes

Multiple purposes are expected to be served by scenario planning exercises and they can range from less tangible ones (collect and negotiate diverse interests, explore options for transformation, challenge beliefs) to more concrete ones (explore effects from interventions on the environment, improve system understanding, test robustness, building capacity and developing consensus). Scenarios in general aim to challenge routine thinking, enable structured discussion on the significance of future interventions and integrate multiple and sometimes contrasting goals. They are a "common perception of the problem and its drivers" (Gómez et al., 2017).

Starting with the more tangible outputs, scenarios can be represented at different levels from more general to more concrete, such as:

- A narrative – a story describing potential future changes
- Artwork – collage, drawing, illustration
- Statistical trends
- Dynamic, spatial explicit model simulations

Their technical value as input into a model analysis is that they motivate contrasting rationales to analyse different assumptions and to visualise consequences from potential interventions: (i) confronting stakeholders and institutions with the outcomes of their own decisions and, (ii) supporting collective decision-making to integrally manage ecosystems by comparing and assessing alternative courses of action (Gómez et al., 2017). Beyond the frames of existing models, scenarios can also stimulate the improvement of weak, improbable or incomplete models.

Beyond this technical value, several benefits are associated with the scenario development process. By fostering inter- and transdisciplinary communication (Priess and Hauck 2014), well-designed scenario approaches help explore complex social-ecological trade-offs and create novel solutions (Oteros-Rozas et al. 2015). Participatory scenario planning "can facilitate discussions regarding the future effects of drivers of change on human well-being, ESS and their trade-offs, biodiversity, or other social-ecological components across multiple spatial, temporal, or institutional scales." In practice, they help identify policy recommendations for sustainable development (e.g. Palomo et al. 2011). In many cases, scenarios gained high policy relevance as they assisted in guiding and implementing potential adaptation strategies (Oteros-Rozas et al. 2015). One requirement for this outcome was often that a diversity of worldviews was represented within the scenarios. Engaging with a wide diversity of stakeholders can ultimately help to develop a shared understanding of complex SES (also referred to as social learning) and identify future management challenges. Based on such experiences, new partnerships are created among different stakeholders and management challenges can be overcome. Further, participatory scenario planning "can elicit how stakeholders might respond to future challenges, hence contributing to the management and understanding of complexity in social-ecological systems" (Oteros-Rozas et al. 2015).

However, to which degree those expectations are realised depends on how the development and planning process is designed and in particular how and when stakeholders are integrated (Biggs et al. 2012).

1.2.2 Which roles for stakeholders in scenario planning?

The degree to which stakeholders are involved in scenario planning can range from roles with information input (consulting) to mutual process design (co-development) (see also the deliverables on stakeholder involvement in Work Package 1).

Several steps of scenario development and analysis that can be opened to integrate stakeholders for discussion:

1. Identification and prioritisation of relevant system components,
2. Characterisation of past and current conditions and trends,
3. Development of a set of scenarios (explorative),
4. Choice of response variables and targets to assess scenarios according to services provided by the ecosystem (normative step), and
5. Proposal of potential management strategies to achieve a desirable future through a back casting process.

Particular methods for developing scenarios on SES change with stakeholders can range with regards to the purpose from the support of single decisions (Wollenberg, Edmunds, and Buck 2000) to the creation of long-term, strategic plans for adaptive policies that still allow for short-term actions (Haasnoot et al. 2013). Participatory scenario-planning studies show that they are able to create different visions while addressing uncertainty and that they can propose consensual management strategies (Palomo et al. 2011). Thereby it is still a challenge to integrate views from multiple stakeholder groups including experts and scientists but a framework to reconcile those has been proposed (Priess and Hauck 2014). A prominent example for coupling multiple data sources and stakeholder views for developing scenarios has been carried out for a watershed in Wisconsin (Carpenter et al. 2015). This also exemplifies a link from scenario development and model analysis.

A practical guide towards the development of scenarios for diverse purposes can be found in the “Field guide to the Future” (Evans et al. 2006), where the authors differentiate between scenarios, projections, visions and pathways. In their understanding, projections are more analytical, focused on single outcomes and not considering uncertainties, in difference to more creative, multiple outcome scenarios that address uncertainty. Whereas scenarios and projections explore consequences from response behaviour, they do not consider ambiguities that might arise from early stakeholder discussions on the desired future. If a consensus on a common desirable future has not been reached yet, but collaborative planning is a goal, then exercises to create visions and develop pathways seem to be better suited.

1.2.3 Where are challenges and pitfalls?

Scenario planning is seen as a promising tool to disentangle complex phenomena in SES. However, depending on the way that a scenario is represented, different features of the complex system are emphasised. For instance, the mechanisms of feedbacks and nonlinear dynamics are highlighted through model simulations but are hard to capture within a snapshot illustration. On the other side, human ingenuity and behaviour are hard to simulate by models and may only be discovered through participatory discussions of particular management challenges.

On the technical side, it is tempting to include as much information as present (such as provided by external scenarios for drivers and pressures) to describe the currently studied system that is of stakeholder interest. However, “key external scenarios such as long-term Gross Domestic Product (GDP) development are produced through more expert-driven simple models and are not subject to stringent technical quality control measures” (IPBES 2016). The challenge is thus to identify all assumptions that underlie external input scenarios and to do a consistency check before integrating them into the main scenario planning process (Rounsevell and Metzger 2010; Zurek and Henrichs 2007). The bottom line is that many challenges stem from the dialogue between more technical modellers and non-technical stakeholders.

Also, on the stakeholder side, one might want to include as many and as diverse stakes as possible. However one might then run into limitations to capture all of them in the scenario analysis. In addition, conflicts arising among stakeholders might need special treatment from a qualified moderator before results are taken further for scientific analysis. Nevertheless, this is also one of the strengths of the scenario analysis that if people disagree about some of the assumptions about the future, we can include alternative scenarios with different assumptions and analyse how sensitive the SES is to these assumptions. However, the capacity for doing this is again limited within each case study. These challenges from "too much information" highlight once more that the principle of parsimony (also called Occam's razor) applies not only to modelling but to the whole scenario planning process.

A recent review of 23 case studies identified four main challenges of scenario planning processes (Oteros-Rozas et al. 2015):

1. A tension between explorative and normative scenario analysis – most processes are described as explorative but multiple norms still play an important role during scenario development and analysis. It is therefore suggested to make those norms and value-choices more explicit.

2. Navigating conflicts among diverse unequal stakeholders – inherent power dynamics need facilitation while a diverse representation of interests should be maintained (Kok, Biggs, and Zurek 2007)

3. Communicating results to a diverse group of stakeholders – besides scientific output and technical reports, outputs that also combine science and art are recommended.

4. Assessing impact from scenario exercises – due to lack of formal mechanisms for evaluation, outcomes from scenario processes are highly variable and often unknown. An adaptive management approach, in addition to accounting for project time for evaluation and monitoring is recommended.

1.2.4 How can the resilience principles help inform scenario development and analysis processes?

The seven principles for enhancing the resilience of ESS are processes and structural features of a social-ecological system that have shown to enhance the resilience of bundles of ESS to pressures and ongoing change across many case studies (Biggs, Schlüter, and Schoon 2015). They include three principles related to the SES itself, namely its diversity, connectivity and slow variables and feedbacks. The four other principles relate to its governance system, namely complex adaptive systems thinking, participation, learning and polycentric governance. The principles provide important entry points for environmental governance as they highlight features of a SES that impact the future development of the system as well as its responses to pressures and change. These features concern the social and the ecological systems alike.

Complex adaptive systems thinking is the core resilience principle that underlies the other six. Scenario development and analysis is a central tool for understanding and analysing SES as a complex adaptive system as scenarios promote a systemic view of the development of a SES and allow the consideration of consequences of uncertainty.

The principles can help inform scenario development by pointing towards structural elements and processes that are critical for maintaining and enhancing resilience and thus should be considered in the development of both baseline and policy scenarios. The effect of a policy and trajectory of the SES for instance will strongly depend on existing feedbacks and the creation of new ones that may enable or prevent a change towards reaching a policy target. Slow variables can relate to external drivers such as climate change or a value change in society, but also to internal processes such as the degradation of regulating ESS that underlie the provisioning of other services. The interaction between slow variables and feedbacks can lead to regime shifts, which are abrupt changes of an ecosystem and the related social system to an undesirable state, e.g. when a lake shifts from clear to turbid (Scheffer et al. 2001). Connectivity is critical for resilience because of the potential for maintaining ESS and supporting their recovery after a shock (ecological connectivity) and the potential to enhance understanding of SES dynamics through connecting different knowledge sources, e.g. people from different places with different experiences. Connectivity, however, can also undermine the resilience of ESS when it supports the spread of a shock or leads to homogenisation of views and understandings. Taking the principles into account when developing and analysing a baseline scenario can help identify existing weakness, e.g. principles that feature very low, challenges but also opportunities for enhancing the resilience of ESS. When developing policy scenarios, the principles can help identify priorities, targets and measures to enhance those principles that have been identified as particularly critical. The interactions of principles in synergistic, facilitating or antagonistic ways, e.g. participation can facilitate learning, while too much diversity may negatively affect a participatory process, remains an important research frontier and a challenge for the operationalisation of the principles.

The four governance-related principles provide guidance for the design of effective scenario development and analysis processes. Participation and learning are well recognised as important factors for the governance of SES. A scenario development process provides opportunities for participation and learning as it brings together different stakeholders to jointly develop and assess different future trajectories of their SES (see sections above). The creation of new partnerships among stakeholders was identified as a strength from participatory scenario processes (Oteros-Rozas et al. 2015). A process of consolidation of narratives can facilitate the integration of multiple stakeholder views (Priess and Hauck 2014), but consolidation is not always possible or desirable. One may aim to develop a set of alternative scenarios and assess their implications. When designing participatory scenario development processes, it is important to ensure a good level of diversity of participants and take into account power structures and vested interests of different groups. And, while these processes themselves foster learning, it is equally important to design a longer-term process of continuous monitoring and evaluation that allows the adaptation of policies along the way when new information becomes available in an adaptive governance process.

1.3 Scenario development in AQUACROSS

We focus here on the role of scenarios in37 stakeholder processes (and stakeholder processes for scenarios) to (co-)develop and assess ways to enhance the provision of desirable sets of ESS and biodiversity. Ecosystem-based management (EBM) approaches provide new policy responses to build alternative scenarios. The complexity of many governance and management challenges in aquatic SES pose particular challenges. Administrative boundaries along which management is carried out, for instance, often do not overlap with the biophysical boundaries of a river catchment. This misfit between institutional and ecological scales and dynamics is often at the core of environmental problems and a major challenge for EBM (Moss 2012). Similarly, many EBM or adaptive management measures require integration of water management with spatial planning, which are often located in different authorities with little overlap and coordination (Moss 2004). Finally, marine resources are common pool resources which, when unregulated can lead to a tragedy of the commons, i.e. a situation where a mismatch of individual and social goals leads to overexploitation.

Scenario development can be a useful process to create awareness, articulate and search for feasible solutions to the challenges of governing aquatic SES highlighted above. In the following, we provide an overview on the functions that scenarios have in AQUACROSS case studies to support ongoing scenario development activities. Within this deliverable lies a special focus on the involvement of stakeholders and how their input is linked to scenario analysis and planning. To this end, we extended existing scenario classification from the IPBES methodological assessment report (IPBES 2016) and adapted it to the terms already introduced in the AQUACROSS AF (Gómez et al., 2017).

Case studies vary widely, e.g. relevant policies, (spatial and temporal) scales, type of engaged stakeholders, methods of engagement etc. Therefore, the guidance for developing scenario does not aim to provide a rigid methodological framework or a one-size-fits-all approach; instead this chapter aims to provide the necessary conceptual and process ideas to build context-adapted scenario development processes.

In AQUACROSS, we differentiate between baseline and policy/management scenarios. Baseline and policy scenarios are connected through an implicit order. While baseline scenarios depict current trends and forecast existing management strategies into the future, new policy scenarios are expected to demonstrate an alternative trajectory with new policy/management measures in place that go beyond current practice.

Here, we suggest a stepwise procedure to progress from the baseline scenarios and develop policy/management scenarios:

1. Choose a relevant **baseline** (agreed with stakeholders) as a reference for policy scenario assessments.
2. Identify problems, challenges, barriers (formulation of an objective) and specify **targets** (as a result from the baseline assessment).
3. Screen **measures** and instruments (partly suggested by stakeholders) suitable to be analysed with scenarios and models.
4. Design and construct alternative **pathways**, or indicator trajectories, i.e. response actions derived from EBM strategies, through models and/or narratives.
5. Build relevant **policy** scenarios and analyse **outputs** with regard to EBM.

The next section presents three conceptual views that characterise different processes of building baseline and policy/management scenarios. More specific guidance is provided thereafter to indicate how they can be used respectively in AQUACROSS to build baseline and policy/management scenarios. Within AQUACROSS, we described the case studies according to their characteristic features within the above-mentioned procedure (Table 4).

1.3.1 Three perspectives for developing scenarios

Scenarios can be classified according to multiple criteria, such as the goals, treatment of norms, or the function that they have within a participatory process (van Notten et al. 2003; Oteros-Rozas et al. 2015). The specific type has consequences for how the scenario is built (Börjeson et al. 2006). We identified three approaches to developing scenarios that are of particular relevance for AQUACROSS cases. These can be explorative, or more normative or descriptive.

Explorative scenarios are characterised by emphasising alternative future pathways without a predetermined target. It can rather be the objective, to agree on a common target thereafter. Within AQUACROSS, explorative baseline scenarios form an entry point, e.g. through a narrative, to identify the issue at hand linked to a selection of drivers, pressures and response variables of interest (see Gómez et al., 2017, section 2. 1). A scenario process could for instance be developed to explore different pathways that may result from enhanced cooperation across administrative boundaries (increased institutional fit) or the lack of it. Such a process can create awareness and a sense of urgency regarding the need to enhance collaboration to enable an EBM approach but also point to its challenges and potential pitfalls. Unlike in the IPBES report on scenario development, AQUACROSS case studies aim to build scenarios about the system response or target variable, instead of just reflecting driver scenarios. The **response or target variable** is derived from the broader objective and should be formulated as a quantifiable attribute or indicator of the system for which changes can be measured (e.g. a diversity index). A target specification, the concrete level of the response variable at a certain time, is the desirable output from discussing baseline scenarios with stakeholders, in case it has not been predetermined by policies.

Particularly for a heterogeneous stakeholder group, it can be very valuable to contrast, through an exploratory analysis, how different interests and currently applied measures, e.g. to manage the commons of a coastal area, lead to different potential trajectories of the shared SES (Gómez et al., 2017, section 2.1.7 for how resilience principles support this process). In this way, explorative scenarios can assist in the facilitation among contrasting interests to define common goals or targets. The insights collected through the explorative phase with baseline scenarios as representations of on-going processes, form the basis to work with policy scenarios thereafter, helping define policy targets and management strategies at the scale of any study site.

Normative approaches are used to build scenarios when a target has been clearly defined and alternative measures to reach this target need to be assessed (Figure 2). A scenario process can for instance be helpful to assess the implications of historical legacies, such as high levels of phosphorous in lake sediments, for proposed measures to reach the target. In difference to normative approaches, descriptive ones are used to contrast the effect of different implementation measures on the ecosystem or in our case the SES to evaluate how close the measures lead to fulfilment of one or multiple targets. In this regard, normative and descriptive approaches are best used during the building of policy/management scenarios in AQUACROSS. Depending on the more specific purpose and data availability, the policy scenarios can be based on more normative or descriptive approaches.

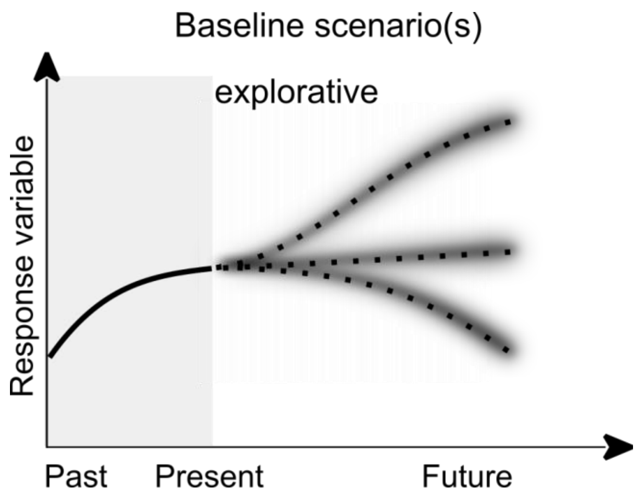

Figure 1 Baseline scenarios in AQUACROSS, showing alternative pathways of system response variables assuming the current management practice but three different external input scenarios (e.g. for socio-economic development). The grey background of alternative pathways denotes the respective uncertainty of the response variable conditional on each external input scenario.

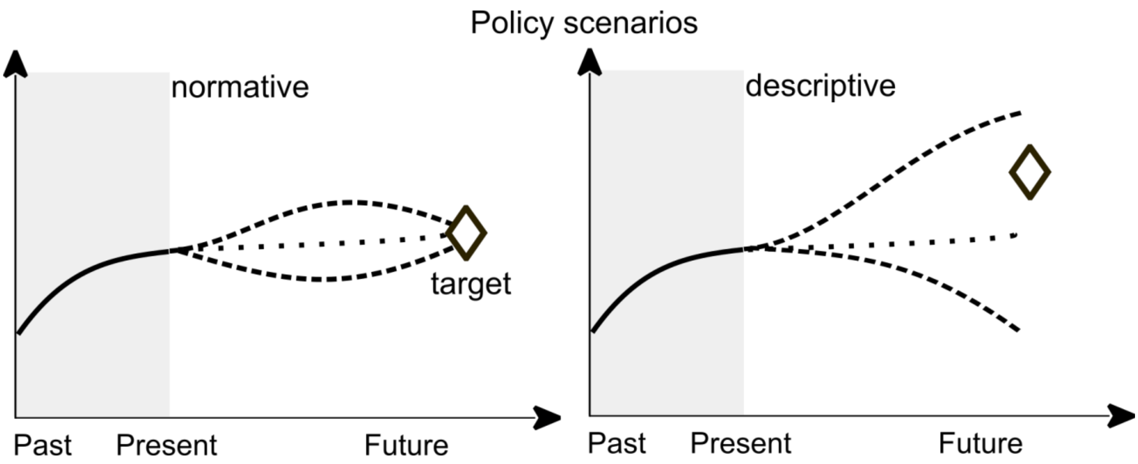

Figure 2 Alternative pathways (dashed lines) compared to the baseline scenario (dotted line). Within each case study, some scenarios may be more normative (left side) in the way that the target is set first, and the question is about how to get there. Other case study scenarios may be more descriptive for the purpose of policy or measure screening, where the question is about how the measures affect the system. Similar to the baseline scenario the policy scenarios may be subject to uncertainty and may show different trajectories in response to external input scenarios (not shown in this Figure for clarity).

Box 2 Baseline and policy/management scenarios applied to the implementation of the WFD: a theoretical example

Building a baseline scenario, representing the system, and ascertaining the management challenge are closely connected to each other (Gómez et al., 2017). For example, at the European scale, the Water Framework Directive established in 2000 has the target to reach the good ecological status of water bodies by 2015. Baselines might have served to identify and explain the underlying causes of impacts such as water depletion and biodiversity losses due to overabstraction among other pressures. Explaining the factors that drive these processes (such as wrong incentives, market conditions, inappropriate policy responses, etc.) help designing new policy responses and scenarios to compare against the baseline and to change trajectories to reach this target, considering SES interactions and trade-offs between interests. Those responses and scenarios were included within River Basin Management Plans and Programmes of Measures at the end of the first planning cycle (2009). Despite the efforts made, the last WFD implementation report showed gaps and delays in objective achievement; so new management scenarios have to be considered for the next planning cycle.

Preliminary considerations for building scenarios

To begin with, we suggest the following questions to formulate basic ideas and build on existing AQUACROSS deliverables before building scenarios:

1. What is the purpose of/objectives for scenario development for researchers, stakeholders and policy- makers? Who are the target audience? Do the scenarios feed into a management process?
2. Which objectives/goals are important? For whom? Which response variables (attributes) can measure the fulfilment of the objectives?
3. Which information and data are available to estimate the effects of drivers, pressures and other dynamic factors on the response variables?
4. Which set of mechanisms or processes are assumed that allow us to project a change over time? (indicators and their target/limit reference values)
5. On which level are scenarios discussed or analysed? Choose among: Framework – narrative – artwork – statistical trends – time series – model simulation

Beside stakeholder-based narratives, data-driven scenarios (incorporating spatially-explicit information on e.g. climate and land-use changes) provide a direct measure to assess the impact of alternative storylines on biodiversity, ecosystem functions (EF) and ESS. The spatial modelling framework is described in AQUACROSS Deliverable 7.1 (Domisch et al. 2017), where such scenarios can be directly ingested to map spatially prioritised areas and changes thereof. Such data typically consists of time series of an ensemble of models given the heterogeneous parameterisations, enabling to evaluate a statistical trend over time and across scenario models and to assess uncertainties (IPCC 2007).

1.3.2 Baseline scenarios in AQUACROSS

Baseline scenarios, as they are applied in AQUACROSS, are driven either by external input scenarios and/or by alternative assumptions and views stated by different stakeholders on possible future pathways. They may be explorative in the sense that a new target has not yet been chosen or that the pathways are not yet assessed against a specific target and reflect the current management practice or business as usual. In some cases, baseline and policy scenarios are evaluated quantitatively including the quantification of the associated uncertainty.

Baseline scenario should describe what could be achieved to tackle the main biodiversity issues, based on management measures currently in place/planned and policy instruments supporting their implementation (Section 4 of the case study report).

Baseline scenarios may be based on the following components:

- Characterisation of current and planned future social-ecological dynamics, including drivers, pressures, state and impact on ESS and biodiversity (this can be informed by the results of the work packages on drivers, pressures, EF and biodiversity links in WP4 and WP5).

- Characterisation of relevant current and planned future policies, including objectives, targets and management measures (this can be informed by the results of the policy analysis in WP2).
- An assessment of current deficits and limitations in implementing EBM, which should be overcome through the new policy/management scenarios (this can be informed by the results of assessment of EBM measures in WP8).

The development of the baseline scenario may require the following activities (all or some of these steps may be followed, in the following or other order depending on the case study):

- Desk-based collection of information to inform the key components of the baseline scenario (see above)
- A structured process with stakeholders to build the scenario
    - Essentially led by the research group: stakeholder engagement is used to adjust / validate the proposal by researchers on the baseline scenario. Can be based on “light” engagement techniques, e.g. key informant interviews.
    - Essentially led by stakeholders: stakeholder to explore implications of current/planned social-ecological dynamics, management measures and policies. Should be based on stronger stakeholder engagement (e.g. workshop).

1.3.3 Policy/management scenarios in AQUACROSS

New policy or management scenarios consist of one or more EBM management strategies that aim to achieve the policy objectives. EBM strategies are combinations of (nature-based) measures and supporting policy instruments (see upcoming deliverable on the assessment of policy scenarios (D 8.1), and section 4.2 of the CS report).

The development of policy or management scenarios may be based on the following components:

- A characterisation of selected EBM strategies, including their technical specification, scales, etc. (this should be informed by the tasks carried out in the upcoming deliverable D 8.1 on EBM assessment)
- An assessment of the expected impact of the EBM strategies on social-ecological dynamics (target improvements / assumed effectiveness)
- A characterisation of supportive policies and their instruments, including an assessment of how the existing institutional settings and policy framework, i.e. the set of policies already in place affecting ESS provision or biodiversity conservation, supports EBM strategies and what would need to be changed

The development of policy/management scenario may require the following activities (all or some of these steps may be followed, in the following or other order depending on the case study):

- Desk-based collection of information to inform the key components of the policy/management scenario (see above)
- Using the normative or descriptive approaches:
    - Describe what a normative or descriptive approach essentially means for your case study.
- A structured process with stakeholders to build the scenarios (i.e., develop the strategies):
    - Essentially led by the research group: stakeholder engagement is used to adjust / validate proposal by researchers. Can be based on "light" engagement techniques, e.g. key informant interviews.
    - Essentially led by stakeholders: stakeholder to co-design EBM strategies, identify assumed effectiveness, identify supporting elements in policy and reform needed. Must be based on stronger stakeholder engagement (e.g. workshop).

1.3.4 Scenario characteristics

Table 1 presents an overview on the respective ingredients and expected outputs for baseline and policy scenarios. The particular ingredients under each of the three scenario classes in Table 1 can be used as inspiration for case studies but also to select and refine focus questions developed within each case study.

As a current snapshot of scenario development processes within AQUACROSS case studies, we present an overview on each case studies narrative for the baseline and their research focus within their scenarios based on Table 1. Their current progress on the steps suggested above is laid out in Table 4, section 3.2.

Table 1 Prerequisites and further inputs for building scenarios. While the prerequisites depict questions that need to be answered before a scenario planning process of the respective type is started, tangible input and intangible conditions are rather answered through the development process. The last line shows examples of models that are suitable to analyse respective scenarios.

	Baseline scenario(s) Explorative	Policy scenarios	
		Normative – to optimise measures	Descriptive – to screen measures
Question	What is possible?[1]	What is desirable?	What is plausible?
To consider in advance	Purpose? Expected output? Expected outcome from the process? Level of analysis?	Purpose? Drivers, pressures, response variable? Objective for optimisation? Constraints? Means of assessment? (which norms are accounted for)	Purpose? Drivers, pressures, response variable? Effect of policy measure on human behaviour? Optional: a tool to measure gap between target and scenario end points
Scenario input	Main drivers? Pressures? Current practices with impact on SES? Response variable? Sources of uncertainty?	Target(s)? Measures for changing SES to test? Uncertainty? Time frame?	Time frame? Alternative measures or policy options to implement in SES? Uncertainty?
Procedural conditions	Role of stakeholder? When and how? Who interprets output? Who benefits from the process in what way? How realistic are the scenarios supposed to be? How will stakeholder preferences be represented in the model?	When a target has been identified, are stakeholders excluded then who disagree and/or might compromise measures to reach it? Who decides on how the scenarios are used?	Which measures are excluded that might have a strong environmental or social impact?

[1] "Possible" standing for something that can be done, whereas "plausible" is evaluated together with its probability.

1.4 Guidance for stakeholder participation in scenario development

For all participatory processes in scientific projects, there is the tension between producing high quality scientific results and at the same time facilitating success in the participatory process for stakeholders. Within this deliverable, we focus on the different development steps for scenarios while their assessment and integration into plans is dealt with in WP 8.

Particularly for researching and guiding ecosystem-based management, inherent trade-offs between multiple stakeholder groups are known and a careful choice of different degrees of interaction with them is needed (Röckmann et al. 2015). Within AQUACROSS, not only a broad range of stakeholder interests but also different scientific foci in the process need to be tackled. To guide considerations in each case study to meet these challenges, we provide an overview of scenario development steps linking to particular stakeholder interactions, their purpose and how this interaction can be supported, while addressing the most recent challenges in scenario development processes (Table 2). The main purposes we focus on with regards to ecosystem based management are improving salience of scientific input, legitimacy of the participatory process and credibility in knowledge production (Röckmann et al. 2015). We foresee different weightings between those three purposes in the different steps and suggest specific interactions to focus on in each step. Open challenges for participatory scenario planning were reviewed lately for 23 case studies (Oteros-Rozas et al. 2015) and we highlight those that may become relevant during scenario development.

Table 2 Guidance on promoting stakeholder interaction during scenario development.

Scenario development steps	Purposes and suggested interactions	Challenges and suggested measures
1. Choose a relevant **baseline**	• Scientific input: Making sure the problem is well defined for the perspective of decision makers • Knowledge production: Making sure all relevant actor groups are aware and included in the process	• Communication with a diverse group: investment of time and effort to discus and finally take a well informed decision
2. Specify **targets**	• Scientific input: Making sure the goals are well defined and shared among decision makers, as well as other actor groups	• Tension between explorative and normative analysis: Be transparent about whose aims are respected with normative analyses and how explorative analyses support learning

		▸ Navigating conflict: Use of a facilitator to enable compromises and ensure progress in the process
3. Screen **measures**	▸ Knowledge production: Making sure that the choice of measures to test is well reflected with multiple actors	▸ Communication with a diverse group
4. Construct alternative **pathways**	▸ Participatory process: If facilitated by scientists, assure transparency of causal changes over time. If facilitated by decision makers, cross check the reasoning for expected change over time with multiple actors.	▸ Communication with a diverse group
5. Build relevant policy scenarios and **analyse outputs**	▸ Scientific input: Verify and validate that the analytical scenario output relates to the earlier agreed targets	▸ Assessing impact: Have formal measures ready to evaluate impact

In summary, it seems that participatory activities are more relevant in the beginning of the scenario development process than in the later, technical evaluation. Participation from multiple actors and the broad civil society in ecosystem-based management should be facilitated by decision makers, who in turn interact with science to support the process. Direct interaction between scientists and multiple actors, including the civil society, is only advisable for improving the credibility in knowledge production or in case of doubts about sufficient participation established with decision makers. However, caution with advising more participation is recommended in cases where the costs of participation become too high and ecosystem regimes may be locked in undesirable states (Lynham et al. 2017).

2 Scenarios of external drivers and pressures such as future climate and socio-economic development relevant for AQUACROSS cases

Scenarios that are based on quantitative data provide valuable, spatially-explicit information to assess potential impacts of external pressures on biodiversity, EF and ESS. For instance, climate, land use and land use change scenarios are typically calibrated along a baseline (e.g., the past 50 years) and given different narratives on possible societal changes, they reflect and translate into a direct change temperature of land use in a specific region (IPCC 2007). However, a challenge with quantitative scenarios is that they can promote false confidence when the degree of uncertainty is magnified, and it would be better to look for general patterns, signals or trends. Within the AQUACROSS spatial modelling framework (Domisch et al. 2017), such information will be used to re-project the present-day spatial representation of biodiversity, EF and ESS, to assess the impact of possible pathways and trajectories of societal developments on BD, EF and ESS.

Table 3 provides an overview on those external scenarios and data sources that are currently used, or under consideration, in AQUACROSS, reflecting various categories such as climate, land use, or demography.

Scenarios have always to be explicit about their underlying assumptions as well as the models that are used to predict the response of the ecosystem to the scenarios. Despite a thorough calibration and validation under past conditions, models on the one hand project the response to novel environmental conditions based on scenarios (e.g., an increase in 2°C can have a stronger effect on precipitation regimes than under the observed period). On the other hand, abrupt changes, tipping points and societal developments cannot always be foreseen (as models for prediction have not necessarily been calibrated under such conditions). These drawbacks are particularly relevant for socio-economic scenarios, such as on long-term Gross Domestic Product (GDP), that are produced through more expert-driven simple models. They "are not subject to stringent technical quality control measures; therefore the credibility of such driver projections typically rests on the reputation of the expert team" (IPBES 2016). Structural uncertainties are thus inherent to the underlying method; however, scenarios still provide a cost-effective first approximation of potential pathways. For such drivers it might be important to include several scenarios that span the range of possible future developments to allow us to assess the sensitivity/robustness of the SES to changes in such drivers.

Scenarios that describe the state of biodiversity, for example on global freshwater systems (Janse et al. 2015), or the expected development of European water consumption[2] can become relevant to compare outputs from the models used in AQUACROSS.

2.1 Example for the use of external scenarios to estimate plant biodiversity value

As an example, the ARIES implementation of Weka BayesNet (BN) was used to propagate site-based expert estimates of 'plant biodiversity value' and to build a map for the entire Sicilian region (Villa et al. 2014). The original biodiversity value observations were made and ranked by experts as a result of assessments made with multiple visits by flora and soil experts along Sicily. The same experts who had ranked high-value sites were asked to identify sites of low biodiversity value, which were used for model training as well. These data were collected originally to provide a map of biodiversity value to support policy- and decision-making. Using ARIES, we instructed the machine-learning algorithm to access explanatory variables, indicated by the same experts who provided the estimates used in training as the most likely predictors of plant biodiversity value. The data used by the machine-learning process included, among other variables: distance to the coastline and to primary roads, normalised difference vegetation and water indices, minimum and maximum annual atmospheric temperature, annual precipitation, etc. The trained model was then used to build a map of plant biodiversity value for the entire island, computing the distribution of biodiversity values for all locations not sampled by the experts. The resulting map was subsequently discussed and validated by the same experts who collected the data. Furthermore, the model was finally re-computed for year 2070 using a climate change scenario for temperature and precipitation, based on RCP 8.5 and the CCSM4 model, and results of biodiversity value clearly decreased in the study area, except for the highest areas, where changes in precipitation and temperature were lower (see Figure 3).

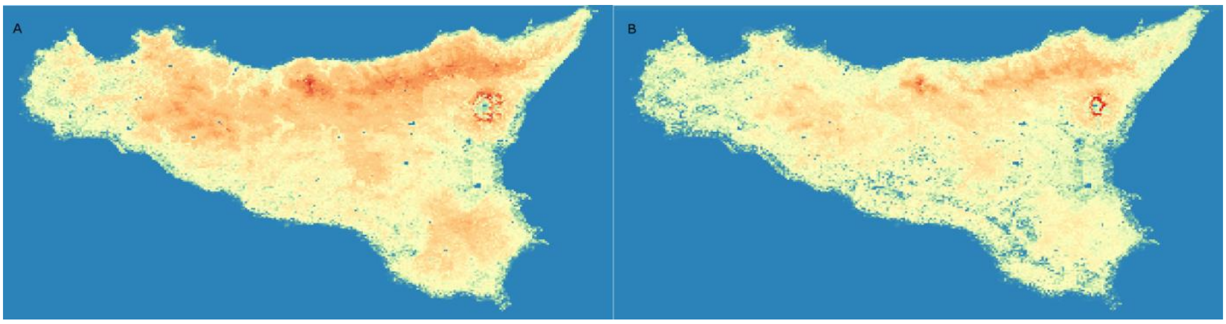

Figure 3 Predicted plant biodiversity value in Sicily (Italy) under (A) current conditions and (B) a climate change scenario based on the BN model (red colours represent higher values).

[2] http://data.europa.eu/89h/jrc-luisa-lf311-water-consumption-ref-2014

Table 3 External driver and pressure scenarios used in AQUACROSS case studies.

Category		Name	Input data /methods	Assumptions	Output			Source link
					Spatial resolution	Temporal resolution	Time span	
Pressure	**Land use change**	IMAGE	Based on the Representative Concentration Pathways (RCPs) starting from the base year 1970, trajectories until 2100	see "Climate change" for RCP description	0.5 x 0.5 degree (approx. 50km)		1970-2100	https://www.ivm.vu.nl/en/Organisation/departments/Environmental-Geography/CLUMondo/index.aspx
		CLUMondo	User-defined model that allows to create custom land use scenarios	explicitly addresses the role of land use intensity and livestock systems				"https://www.ivm.vu.nl/en/Organisation/departments/Environmental-Geography/CLUMondo/index.aspx
		LUISA - REF 2016 scenario	LUISA is integrative tool that allows coherent linkages with macroeconomic and biophysical models and with thematic databases to produce land-use maps for a period between 2010 to 2050.	The land-use follow the assumptions of the EU Reference Scenario (LUISA, updated configuration 2014), which is consistent with the current trends and settings of the economy, demography and policies in place in 2013 (hence including the 2020 renewable energy targets).	Modelled at 100m x 100m, covering the pan-European area and made available at 1km x 1km grid.	Land-use maps for 2010, 2020, 2030, 2040 and 2050	2010-2050	https://data.jrc.ec.europa.eu/dataset/jrc-luisa-land-use-ref-2014
	Climate change	IPCC RCPs	Representative Concentration Pathways (RCPs) starting from the base year 2000, trajectories until 2100 (Raster layers of max and min temperature and precipitation for 2050 and 2070 at: http://www.worldclim.org/cmip5_30s)	RCP 2.6: scenario in which greenhouse gas emissions (and indirectly emissions of air pollutants) are reduced substantially over time	0.5 x 0.5 degree (approx. 50km), downscaled to 1km	daily - 30year climatologies	2000-2100	Raster layers of max and min temperature and precipitation for 2050 and 2070 at: http://www.worldclim.org/cmip5_30s (van Vuuren et al. 2007)
				RCP 4.5: stabilisation scenario where total radiative forcing is stabilised before 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions	0.5 x 0.5 degree (approx. 50km), downscaled to 1km	daily - 30year climatologies	2000-2100	Raster layers of max and min temperature and precipitation for 2050 and 2070 at: http://www.worldclim.org/cmip5_30s 29, 2009. (Holdsworth et al. 2005)

				RCP 6.0: stabilisation scenario where total radiative forcing is stabilised after 2100 without overshoot by employment of a range of technologies and strategies for reducing greenhouse gas emissions	0.5 x 0.5 degree (approx. 50km), downscaled to 1km	daily – 30year climatologies	2000-2100	
				RCP 8.5: scenario characterised by increasing greenhouse gas emissions over time representative for scenarios in the literature leading to high greenhouse gas concentration levels	0.5 x 0.5 degree (approx. 50km), downscaled to 1km	daily – 30year climatologies	2000-2100	
	Invasive species	EASIN	JRC-EC	EASIN facilitates the exploration of existing Alien Species information from a variety of distributed information sources through freely available tools and interoperable web services, compliant with internationally recognised standards.	10 km * 10 km			https://easin.jrc.ec.europa.eu/
Driver	**Demo-graphic**	GPW	CIESIN	For GPWv4, population input data are collected at the most detailed spatial resolution available from the results of the 2010 round of censuses, which occurred between 2005 and 2014. A set of estimates adjusted to national level, historic and future, population predictions from the United Nation's World Population Prospects report are also produced for the set same set of years.	Gridded, 30 arc-seconds (approximately 1 km at the equator)	The input data are extrapolated to produce population estimates for the years 2000, 2005, 2010, 2015, and 2020.	2000-2020	http://sedac.ciesin.columbia.edu/data/collection/gpw-v4

		LUISA - REF 2016 scenario	LUISA is a modelling framework that aims to capture the impacts of territorial policies on Europe. This platform encompasses methods to regionalise national-level reference demographic projections. Eurostat´s population projections ´EUROPOP2010´ is the main source used.	The population projection follows the EU Reference Scenario (LUISA, updated configuration 2014), consistent with current trends and settings of the economy, demography and policies in place in 2013 (hence including the 2020 renewable energy targets).	100m x 100m, covering the pan-European area and made available at 1km x 1km grid.	Projected population maps for 2010, 2020, 2030, 2040 and 2050.	2010-2050	Dataset: Jacobs Crisioni , Chris ; Lavalle, Carlo (2014): OUTPUT - Population distribution (LUISA Platform REF2014). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-luisa-population-ref-2014 Method: Batista E Silva Filipe; Lavalle Carlo; Jacobs Christiaan; Ribeiro Barranco Ricardo; Zulian Grazia; Maes Joachim; Baranzelli Claudia; Perpina A Castillo Carolina; Vandecasteele Ine; Ustaoglu Eda; Barbosa Ana Luisa; Mubareka Sarah; (2013) Direct and Indirect Land Use Impacts of the EU Cohesion Policy. Assessment with the Land Use Modelling Platform. Luxembourg, Publications Office of the European Union. http://publications.jrc.ec.europa.eu/repository/handle/JRC87823
	Socio-cultural	Anthromes version 1	Putting people in the map: anthropogenic biomes of the world					http://ecotope.org/anthromes/v1/data/

3 Developing scenarios and analysis in AQUACROSS

As case study activities are at different stages and progress at different pace, this section will depict a snapshot of how scenarios were developed so far, or which type of scenarios are foreseen in the near future. The main purpose here is to clarify the role in which scenarios are connected to stakeholder involvement and model analysis. In general, and for cases beyond AQUACROSS, the following purposes for developing scenarios were discussed:

- Improve system understanding, covering the whole SES, including the management strategies,
- Collect and negotiate diverse interests regarding targets, measures and pathways, manage trade-offs,
- Identify measures that are robust against socio-economic drivers and constraints (as perceived by stakeholders) ,
- Optimise investment for measures to reach common target.

In the following, our cases demonstrate how those purposes can be mixed and can vary in the degree that they matter. This is for any case particularly relevant to consider in the early phase of a case design as well as for periodic reflections.

3.1 Overview of scenario processes in case studies

This section provides a summary of the topics from each case study and how they relate to goals and measures that might be implemented to achieve those goals. Furthermore, we will summarise the possible effect that the measures might have on ESS, biodiversity and the social consequences that might be of importance in each case. The following narratives can be viewed as a step towards creating a baseline scenario.

CS1 – The North Sea

The problem: The overarching theme for the scenarios in the North Sea case is the conservation of seafloor habitat. The measures that have been implemented to reach that goal are Marine Protected Areas (MPAs), increasing emphasis on fisheries management (including a variety from catch or habitat quota to technical measures), and Marine Spatial Planning (MSP) . These measures are predicted to affect the ESS food provisioning, while they conserve beneficial, regulatory and cultural services from the seafloor. These measures specifically involve the fishing sector, as in particular bottom trawling may negatively affect the seafloor habitat in the North Sea. The main driver for this is the global market and demand for fish. At the same time the driver for sustainable energy, i.e. offshore wind, is laying a major claim to large parts of the North Sea, previously considered fishing grounds. This also has major consequences for MSP and the state of the seafloor. *Scenario building process:* Decisions on those measures face the challenge to answer to contrasting policies, as both, conservation of the seabed habitats and biodiversity is a specific policy goal as well as the requirement to reach a maximum sustainable yield. Research design is based on the calculation of indicators to represent the food provisioning aspect (i.e., catches), the state of seabed habitat, indicators of the performance of the fishing fleets and the management measures acting upon them. *Expected outcome:* The indicators to evaluate the different scenarios are expected to show trade-offs (e.g. food provisioning - seabed conservation) to the stakeholders to help select the most appropriate EBM strategies.

CS2 - Morocco/Spain

The challenge: The overarching aim of the scenarios in the Intercontinental Biosphere Reserve of the Mediterranean, Andalusia (Spain) - Morocco case study is to design a multi-functional green and blue infrastructure (GBI) and deploy measures for meeting conservation and socio-economic goals in the IBRM and its AoI.

Scenario building process: The scenarios will explore the multifunctionality of the GBI (for e.g. protect and support biodiversity, restore degraded ecosystems, and trade-offs) according to the baseline scenario and an EBM scenario, by implementing different EBM goals of biodiversity features and ESs, namely regulation and maintenance, cultural and provisioning services (e.g. provision of fishing, aquaculture, water, material -e.g. cork and wood- and energy). The assessment of the SES, namely the characterization of the demand side and the supply side is the starting point for configuration of the GBI baseline and EBM scenario. From one side the SES assessment facilitate the identification of the key threats in the CS areas; from the other side, the identification of the EBM objectives and measures that target the reduction of the key pressures, or/and activities, or/and the restoration of ecosystem thus improving the capacity of their services. The measures address a wide range of EBM targets, for example aiming to protect species and habitats, maintain and restore biodiversity and habitats, make agriculture and fishing more sustainable and in general improve the status of the ecosystems according to the EU biodiversity policy targets to 2020. As part of this process, the technical/scientific team and the stakeholders have been working interactively to understand the baseline of the CS areas, define the EBM targets and the GBI management zones taking into consideration the trade-offs and synergies between biodiversity and ESS and translate all this information into modelling scenario assumptions. The impact of the EBM measures will be analysed by testing the existent SES (baseline) and future EBM measures. The stakeholder participation has been a key piece in the entire scenario building process, especially in three different phases: initial phase for the assessment of the SES, second phase for the discussion of the baseline and define the EBM targets and measures, third phase during the modelling exercise for the discussion of the modelling results. On a local level, Biosphere Reserve's Management Council and Stakeholders Network are involved. Regional actors are, for example, the Ministry of the Environment and Mining and Ministry of Energy. Many actors that are of importance on a regional level (e.g. mines, ministry of energy) are also of significance on national level. On a national level, actors of importance are the Ministry of the Environment and Planning. The international drivers are water and marine directives whereas the Sustainable Development Goals are important globally (see section 4.2 for details on the methods).

Expected outcome: A strategically planned GBI according to a baseline scenario and an EBM scenario where EBM measures are implemented to achieve the EBM conservation and socio-economic goals.

CS3 – Danube

The problem: Hydro-morphological alterations, such as river fragmentation or disconnection of wetlands, are seen as one of the most relevant threats on riverine ecosystems and their biodiversity in general and are specifically relevant in the area of the Danube catchment. Therefore, the main focus in terms of scenarios/measures of the Danube CS3 will be related to hydro-morphological pressures at catchment and regional scale focusing on alterations in longitudinal and lateral connectivity and the effects on the goals of WFD and Natura 2000 Directives.

Scenario building process: One focus based on quantitative models will be on the interaction of multiple human activities/ESS and biodiversity in river floodplain systems along the navigable stretch of the River Danube related to hydro-morphological alteration. The management measures include hydro-morphological river-floodplain restoration and rehabilitation defined as measures of basin-wide importance to conserve biodiversity, ensure the good status in the river stretch, flood protection, pollution reduction and climate adaptation. Further, we include the effect of different scenarios including socio-economics e.g. related to urban development, transport or energy production and show their potential synergies and conflicts with biodiversity and ESS targets.

The main focus of Danube Delta will be eutrophication at the regional scale, specifically focusing on lakes and floodplains along the Danube Delta's channels. The management measures that will be evaluated include restoration and rehabilitation of lakes and floodplains within the Delta.

Expected outcome: The models will explore trade-offs and synergies of biodiversity, ESS and multiple human activities related to hydro-morphological alterations of rivers and their floodplains within the Danube catchment. This can serve as a basis for a more integrated management and prioritisation for the restoration of those systems considering multiple targets related to biodiversity, ESS and socio-economic benefits in line with the principles of EBM.

CS 4 – Lough Erne

The problem: Lough Erne faces several management challenges involving many interactions between different primary activities, including the generation of hydroelectricity, agriculture, tourism and recreation including hunting, fishing, game and coarse angling and motorised and non-motorised boating. Each activity has different and sometimes competing requirements from the system.

Scenario building process: In order to understand the complexity of the system and the linkages between different primary activities and biotic components of the ecosystem, a Fuzzy Cognitive Mapping exercise was held in July 2017 with a diverse group of stakeholders. The purposes of the exercise were:

1. To develop consensus on how the SES functions,

2. To identify critical key components of the system this will be most amenable to management efforts.

The development of scenarios will be based on the identification of common key components of the five FCM models.

Expected outcome: The models will be used to develop scenarios to assess interaction and trade-offs resulting from changes in individual primary activities.

CS 5 – Vouga River

The challenge: The main topic concerning the Vouga River Natura 2000 case study connects to integrated management of aquatic Natura 2000 sites, from catchment to coast, and reducing the risk of surface salt-water intrusion. The case study includes freshwaters, transitional waters (Ria de Aveiro coastal lagoon that includes the Vouga river estuary), and the adjacent marine waters. Measures to reduce the impact of changes in the ecosystem hydrology and tidal prism are soil bank protection levee, agricultural buffer zones and wetlands that will decrease shoreline erosion, surface salt-water intrusion and regulate water levels. These hydrological changes have created negative environmental and social consequences, for instance shoreline erosion, the loss of crop production and the loss of the landscape 'bocage', which is characterised by living edges that support multifunctional ESS (e.g., green corridors, habitats for endemic species, and natural measure for water retention and regulation).

Scenario building process: The existing and foreseen changes connected to water management and land use, have been triggered by grass root activities, as locals have demanded politicians to act and thus affected their political will to implement measures. This has in turn led to funding of measures for reducing the risk of surface salt-water intrusion. In view of the proposed measures to reduce the impact of changes in the ecosystem hydrology and tidal prism, we will model prospective scenarios, considering the best available information, in order to explore trade-offs and synergies of biodiversity and ESS.

Expected outcome: Model-based scenarios options considering biodiversity and ESS trade-offs and synergies; maps and figures to support communication with stakeholders, and co-development with stakeholders of the best EBM options.

CS 6 – Rönne å catchment area

The problem: Our goal in the Swedish case is to better understand the decision-making process by local and regional actors on measures to improve water quality and ESS. As an example, we look at measures in response to eutrophication. On the regional level, we focus on the role of water councils to engage with neighbouring councils and how they integrate municipality representatives, while they target concrete measures for improving water quality (for instance biomanipulation or improved private sewage treatment). On the local level, we look at municipalities to see to which degree they engage with measures suggested by water councils while they develop comprehensive plans for improving a set of ESS within their area (see 4.1 for details on the methods).

Scenario building process: Scenarios in the form of narratives are constructed to describe alternative pathways for local and regional actors to collaborate in different degrees to reach common or distinct goals. The function for stakeholders in this scenario processes is to a) co-develop knowledge with people from different sectors and levels, b) so that networking becomes a resulting benefit as, c) learning about the concept of ESS and its use in practice.

Expected outcome: The output narratives explore besides the baseline the implementation of WFD related policies (to improve water quality) and different ways of increased collaboration. Our focus on collaboration links to resilience thinking mainly through the principle of "broadening participation".

CS 7 – Swiss Plateau

The challenge: The aim of case study 7 is to evaluate the effect of diverse river restoration measures with the goal of improving the ecological state of the freshwater ecosystem at large scales, while taking costs of restoration and ESS trade-offs into account.

Scenario building process: The management measures (or alternatives) that will be evaluated are: (a) morphological restoration of stream reaches, (b) the upgrade of waste water treatment plants to remove micropollutants, (c) reduction of the impact of pesticide usage from agriculture, and (d) reduction of the impact of hydropower on connectivity in the stream network on bedload movement (i.e., sediment export) and on the natural hydrological regime. Our goal is to optimise the management of freshwater ecosystems by assessing different combinations of management measures at various locations, under several future external input scenarios (i.e., climate change, population growth or economic development). Particular focus will be given to the assessment of the ecological state at the catchment scale and trade-offs with and among ESS, with an emphasis on the recreational potential, the provision of drinking water, and hydropower generation. The management measures are implemented at a local level through one of, or a combination of, the following: (i) restoration of specific river reaches, (ii) reduction of local pollution from urban and agricultural areas, or (iii) restoration or improvement of the connectivity at hydropower dams.

Expected outcome: The local management measures improve the ecological state of a stream reach, which in turn improves the ecological state of the catchment it is part of. Our assessment aggregates the properties of the individual reaches to a summarised catchment assessment. This will allow us to re-assess the state of a catchment again, once a series of management measures is implemented, to find out if and to what extent, the overall outcome of the management strategy is successful under particular external input scenarios.

CS 8 - Azores

The challenge: Scenarios will be used in the Azores case study to describe possible futures under different management strategies for the Faial-Pico Channel Marine Protected Area, a 240km^2 coastal and marine area in the Azores. The challenge is to identify costs and benefits accruing to local society groups under different possible futures. The scenarios will be used to discuss possible trade-offs and understand management priorities.

Scenario building process: The scenarios will primarily be qualitative (i.e., a narrative) and co-created with stakeholder input, following interviews with local stakeholders including, e.g. professional and recreational fishers, tourism operators, environmental NGOs, scientists, and regulators/administrators, amongst others. Each of the groups holds a stake in the area and are selected because they are the primary groups benefiting from, managing, and seeking to preserve the area. Multiple scenarios may be considered, for example including a scenario promoting fishing benefits, a scenario promoting benefits from tourism (including diving, whale watching, and other non-extractive marine activities), and a scenario promoting benefits from multiple uses. In each scenario, the resulting increase in pressures on and competition for ESS (i.e., costs of degradation) will be considered. The policy and management options will consider e.g. fishing restrictions (temporal and spatial exclusions, amongst others), economic policy instruments (including payment for ESS, compensation for fisheries restrictions, tourism taxes, amongst others), and local, national, and European biodiversity policy.

Expected outcome: The scenarios will be qualitatively described but will aim to include clearly defined targets for biodiversity and ESS indicators in the Channel, as well as socio-economic outcomes (including local employment, sectoral income, total income) for local stakeholders and the local region as a whole. The scenarios will be supported by current and projected, multi-disciplinary quantitative data regarding biodiversity, EF, and (especially) ESS when sources are available.

3.2 Overview on case study characteristics for scenario processes

As suggested in section 1.3, case studies follow a number of steps for progressing from a baseline assessment towards developing a new policy scenario that is assessed against that baseline. However, the cases differ with regards to the way they ask scenario questions which can be more explorative, normative, or descriptive while investigating EBM measures. Further, the degree of stakeholder involvement for the different scenario development steps and coupling to model analyses differs. Here, we provide an overview on the current state of scenario development in AQUACROSS case studies (Table 4), while highlighting the following major steps:

1. Target setting
2. Select measures
3. Develop pathways
4. Evaluate outcome

Table 4 Framing of targets for scenario development and how measures, pathways and outputs were or will be generated.

CS	Objective and target	Stakeholder involvement and their benefits	Methods for scenario process –measures and pathways	Functional relation to models	Outputs and outcomes	Link between policy and scenarios
1	Conservation of seafloor habitat.	They identify issues/topics and thus shape knowledge base and phrase issues they deem most relevant.	Proposed measures already existed, but new ones are discussed with individual sectors. Pathways result from model forecasting, perhaps accompanied with narratives, various models/methods to assess the performance/progress towards the policy targets.	Suitability of various models will be assessed and those suitable will be applied to assess the outcome of the EBM measures (= policy scenarios).	Set of suitable or best EBM measures	Not directly (as in not applied) but the knowledge base should become the basis to guide policy.
2	Decision support for policy processes to identify a suite of potential locations for a multifunctional GBI. Target definition with stakeholders ongoing.	Stakeholders are consulted for exploring their expectations, collective goals, perceptions, social acceptance and the feasibility of measures that are proposed. This would help us in defining the biodiversity, ecosystem status and ESS objectives, select the conservation features and constraints.	Apply various methods to assess the performance progress towards the policy targets. Measures are the NbS to restore the GBI, pathways are developed based on assumptions analysed in the models.	Systematic Conservation Planning (SCP) combined with the SDM and ESS mapping will be used to prioritise allocation of conservation actions for the GBI design.	A strategically planned GBI and a list of potential measures (NbS) to restore GBI, with one optimal solution for investment.	Assessing the consequences of selected management measures. Develop recommendations to craft suit of location of GBI areas based on options generated through the Marxan analysis, and their own knowledge.
3	Hydromorphological alterations and their effects on ecological status. Conserve a) biodiversity (birds) in Danube delta and, b) biodiversity (fish, inverts) in tributaries, c) biodiversity in protected areas along the navigable stretch of the Danube River. Targets derived from WFD and Biodiversity strategy.	They are involved by drafting (and later redefining) the scenarios and thus including their insights. The benefit is that they learn about complex problems and some trade-offs could be transformed into synergies.	Participatory and D-P-S analysis. Measures are derived from the River Basin Management Plan and pathways will show management alternatives.	e.g. models of unused hydropower potential	Model-based impact assessment to evaluate which measures support policy target.	Assessing the effect of renewable energy development, navigation, on WFD and Nature directive targets.
4	Increase access for recreational activities and reduce invasive species in the system is the objective by stakeholders.	Stakeholder workshops in summer 2017. They get to explore ways to reduce invasive species and improve recreation access to lake.	Stakeholder workshops and modelling, linkage based on network analysis.	One scenario relates to model input. Invest + GIS Modelling.	Narratives and model-based impact assessment for stakeholder.	How invasive species can be reduced.

5	Management of Natura 2000 areas from freshwater to coastal waters focused on EBM measures.	Participatory methods to co-develop scenarios, allows for inclusion of stakeholder expectations.	Participatory process with prospective scenarios, to set priorities and enable a multi-criteria analysis. Stakeholder consultation for measures and co-development of pathways, supported by multi-criteria analysis.	Models are used to assess a scenarios effect on habitats, ESS and biodiversity.	Model-based, maps, figures and best management options for stakeholders.	Evaluation of effective implementation of Natura 2000 habitats directive, WFD, and targets 1 and 2 from biodiversity strategy.
6	Implications of water governance on the co-production of ESS. Exploring ways to improve management to increase multifunctional landscapes.	Scenarios are created based on workshops and interviews, and stakeholder benefits are knowledge exchange, new contacts and improved collaboration.	Participatory methods: workshops and interviews. Inductive-deductive coding for analysing types of collaboration, scientists identify main storylines to create scenarios.	Narratives are used to motivate alternative ABM simulations. The modelling process is embedded in the overarching participatory process.	Narratives together with model analyses may support ongoing discussions for improving water governance organisation.	Stakeholder involved work with WFD, which naturally affected the discussion and scenarios.
7	Improving the ecological state of rivers at the Swiss plateau while taking costs of management measures and ESS trade-offs into account and including external input scenarios for considering future changes in boundary conditions such as socio-economic development and climate change.	Stakeholders are involved to derive information about current management policies and their state of implementation, management objectives, and for discussion of the results of our analysis. They will benefit from learning from our predictions about the current state of knowledge about the effects of different management strategies under different external input scenarios.	Management strategies are derived from policy assessment, a deficit analysis of current policies, and expert knowledge about reducing current deficits. External input scenarios are derived from literature and discussed with stakeholders. We will explore effects of different planning cycles.	Used as input. Analysis: 1) model predictions for consequences of management strategies, 2) compilation of degree of fulfilment of management objectives for each management strategy.	Model-based impact assessment results in an assessment of the fulfilment of the objectives for each management strategy under each external-input scenario.	Assessing consequences of current policies and associated management strategies under different external input scenarios for societal decision support.
8	Managing trade-offs among fishing, tourism (diving, whale watching) and multiple-uses: e.g. fishing, tourism, ferries and, biodiversity. No defined targets yet.	Aiming to include stakeholders in the development and assessment of scenarios. Their benefits would be identification of trade-offs (benefits & costs) that are associated with different measures.	Participatory development of narratives and discussions with stakeholders.	Scenarios will be used to define potential inputs for qualitative modelling.	Narratives, list of measures and trade-offs showing different "futures" based on effects of policy.	Assessing the consequences of different management measures on fishing, tourism and biodiversity.

3.3 Preliminary insights from AQUACROSS scenarios

There is a strong emphasis on best management practice within AQUACROSS case studies scenario development. Focus lies on understanding the effect of different water-related management strategies on ecosystems and biodiversity, or the social-ecological interactions (e.g., between tourism and recreational fishing). Often, the case studies comparatively analyse management strategies to understand trade-offs (descriptive policy scenarios) or which choice might be most cost-efficient (normative policy scenarios).

Overall, a lot of emphasis is placed on recreational value (or ESS) and cultural ESS. The link to tourism is discussed which emphasised the importance of recreational values connected to water quality and management. Improving water quality does have trade-offs and social consequences, and the link is most often connected to farmers and their potential loss of crop production and thus foregone revenue connected to aquatic management strategies. Specific to the freshwater realm, one must ask for implications from reduced local food production; does it imply the need for a larger share of imported crops (as e.g. in Sweden)? Or is a larger pressure exerted on land which is not in the vicinity of water bodies and thus less affected by WFD motivated measures?

The changes that are expected to happen in the case studies – be it improved water quality or further stress – is most often driven by top-down processes on an EU/international level (e.g., EU policy directives or subsidies on national level). However, a few cases as Vouga river estuary, within Ria de Aveiro lagoon, and Rönne River are also influenced by grass-root change, e.g. with reorganisation of local institutions and rules.

4 Example cases for scenario processes

This section provides two example cases of scenario development processes within AQUACROSS. The first case explores GBI in Andalusia (Spain) and Morocco with maps for optimal allocation of management zones as the main output. Stakeholders are engaged iteratively in the whole research process, but the alternative scenarios are mainly based on models. The second case of Rönne å catchment in Sweden investigates social-ecological co-production of aquatic ESS and pathways to reach best-practice water governance. Knowledge co-development with stakeholders is a fundamental element throughout the process and results in narratives as a main output. Therefore, labelling the scenario processes as "model-based" vs. "narrative-based" is still a matter of an ongoing discussion because the examples do not represent pure types and to a degree mix multiple methods for input analysis and output production.

Providing example cases aims to give the reader an understanding of the diversity of scenario development processes within AQUACROSS. Each case describes the research design, methods and outcomes. Thereafter follows a comparative discussion about strength and weaknesses that aims to assist the other case studies in their scenarios processes.

4.1 Model-based scenarios for CS 2 – Spain/Morocco

Objectives of the baseline and policy scenario

Case Study 2 aims to uncover best practice examples of NbS for aquatic ecosystems at the Intercontinental Biosphere Reserve of the Mediterranean: Andalusia (Spain) – Morocco (IBRM) through the development of direct recommendations to increase the establishment of GBI in the management and planning of transboundary water ecosystems.

The objective of the EBM plan is to design a GBI for the IBRM and its area of influence (AoI) that maximise the multifunctionality of the infrastructure while meeting the EBM targets by 2025. For this purpose, we explore different multifunctional GBI configurations according to a baseline scenario and an EBM scenario that allow the deployment of EBM measures for meeting conservation and socio-economic goals in the IBRM and its AoI. We assess different alternatives for the spatial planning of GBI that allow conserving biodiversity, maintaining ESS capacity while the costs of the restoration actions are minimised.

The scenario development will put the AQUACROSS assessment framework to practice, namely it will integrate the pressures and the state of the ecosystems, the important areas for biodiversity and the multiple ESS delivery capacity in the aquatic realms of the IBRM, as further explained below.

Baseline scenario

The baseline scenario aims to identify the configuration of the multifunctional GBI, assuming its current capacity of the ecosystems to deliver multiple services (e.g. regulation and maintaining services, cultural and provisioning) at the same time protect the biodiversity assuming the current policies in place.

Policy scenario addressing EBM targets

The policy scenario aims to propose a strategically planned GBI that improve the capacity of the ecosystems to deliver more services, to promote/enhance biodiversity and promote the societal well-being. This scenario will therefore propose a future GBI configuration based on alternative targets that help to reduce the key pressures at the IBRM case study area. The GBI under this scenario will then identify and prioritise potential restoration areas for the investments of the EBM measures to reach the EU Biodiversity Strategy 2020 target 1, 2, 3, 4 and Target 6.

Process and methods to screen measures and develop pathways – Green and Blue Infrastructure Design Based on Spatial Conservation Prioritisation

The assessment of the SES, namely the characterization of the demand side (i.e., primary activities, pressures, ecosystem components) and the supply side (i.e., the ecosystem function and services) was the starting point for configuration of the GBI baseline and EBM scenario (Figure 4). The SES assessment facilitated from one side the identification of the key threats in the CS areas and from the other side identification of the EBM objectives and measures that target the reduction of the key pressures, or/and activities, or/and the restoration of ecosystem thus improving the capacity of their services.

As part of this process, the technical/scientific team and the stakeholders have been working interactively to understand the baseline of the CS areas, define the EBM targets and the GBI management zones taking into consideration the trade-offs and synergies between biodiversity and ESS and translate all this information into modelling scenario assumptions.

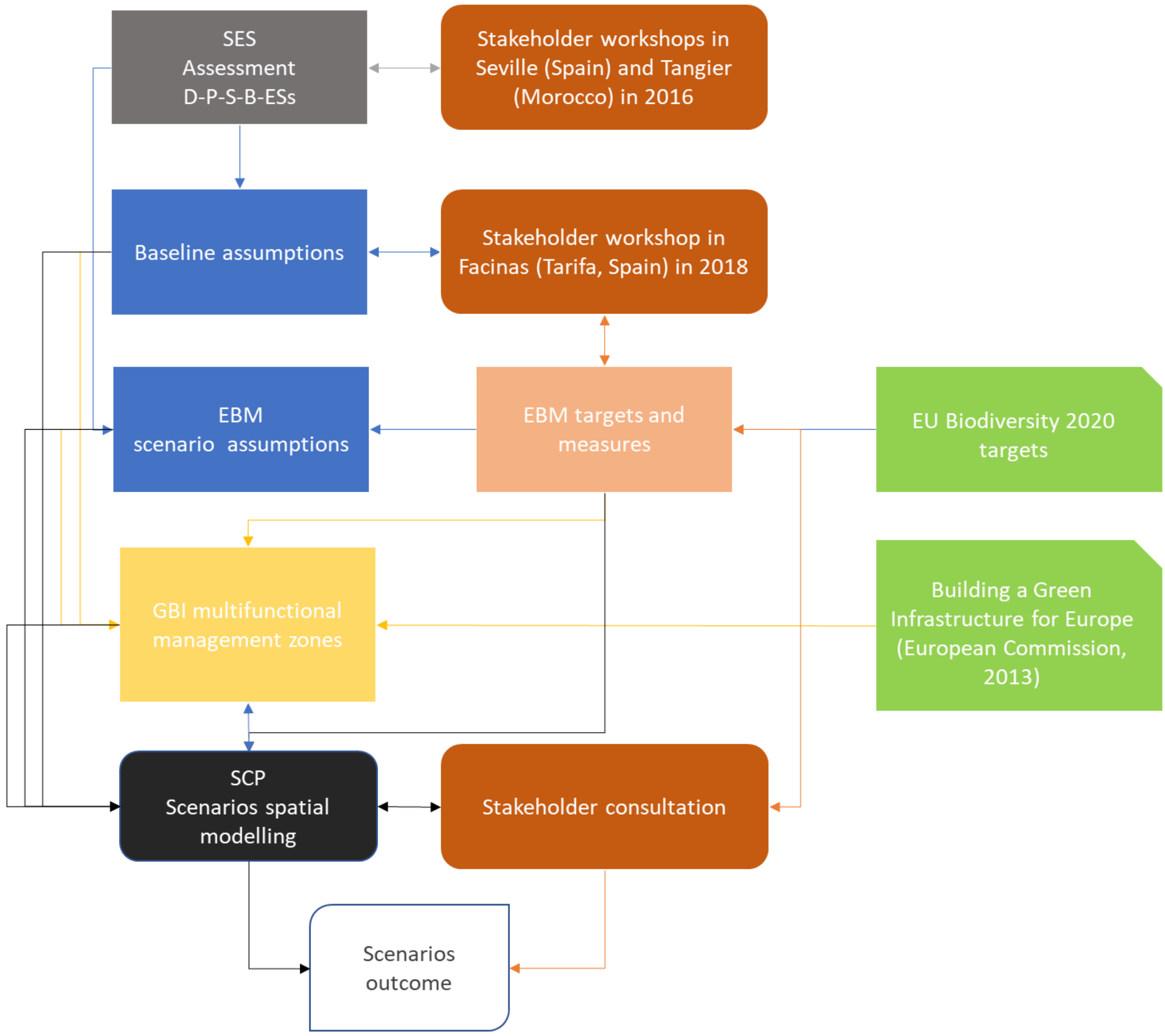

Figure 4 Simplification of the participatory scenario process of the CS2 – IBMR Andalusia and Morocco.

The impact of the EBM measures will be analysed by testing the existing SES (baseline) and future EBM measures. From one side the impact of the EBM measures will be assessed by comparing the GBI under the EBM scenario against the baseline. From the other, we will also run a sensitivity analysis to assess the impact of each assumptions considered within each scenario.

In this section, we explain how we identified the baseline assumptions and tested the impact of current policies, and how the alternative EBM targets would benefit the baseline GBI by testing the implemented of the EBM targets.

Understanding the baseline

The AQUACROSS AF proposes a linkage framework for the assessment of the SES. The participation of the stakeholders was fundamental to define the current SES of the case study area and establish a baseline for the CS area. For this purpose, two workshops have been held with the Spanish and Moroccan authorities. The first workshop has been organised in April 2016 in Seville with delegates representing the Regional Ministry of Environment of Andalusia – Ministry of Environment and Spatial Planning of Andalusia, including the director of the IBRM. A similar workshop concerning the Moroccan section of the IBRM has been organised in October

2016 in Tanger (Morocco) with the Regional Observatory of the Environment and Sustainable Development (OREDD) of Tangier Tetouan. In both workshops, the following objectives were achieved:

1. To present of the case study goal and objectives;
2. To initialise the discussion on the work plan, including a presentation of the different phases, identification of the key actors, when and how;
3. To discuss and agree on the boundaries and planning units (Pus) of the case study (Figure 1);
4. To discuss and agree on the data and information exchanges and support tools available by REDIAM and the High Commission for Waters, Forests and Desertification of Morocco;
5. To discuss about the drivers and pressures of the case study;
6. To initialise the discussion on the mapping and assessment of the ecosystems and their services at the IBRM AoI;
7. To open the discussion on the scenario development process, modelling tools and data needs.

In order to better understand the relative importance of the natural (species, habitats and ESs) and socio-economic elements (economic activities and cultural heritage) in the design of the GBI, the baseline scenario has been subdivided into three complementary scenarios that allow alternatively focusing on the demand and the supply sides of the CS area while spatially planning the GBI.

- Scenario 1a: aims to identify the configuration of the multi-functional GBI, solely based on the current capacity of the ecosystems to deliver multiple services (e.g. regulation and maintaining services) and at the same time to protect the biodiversity but without considering the socio-economic dimension. This scenario is based on the principle of GBI aiming at “protecting and enhancing nature and natural processes” (European Commission, 2013). We will analyse the impact of only prioritising natural "conservation features" (species, habitats and ESS), i.e. how the GBI would look like if only natural elements are considered separately;
- Scenario 1b: the second scenario aims to identify the design of the GBI in we only prioritising "socio-economic features" (economical activities and cultural heritage), i.e. we analyse how the GBI would look like if only socio-economic elements are considered separately;
- Scenario 1c: in the third scenario, both "conservation features" and "socio-economic features" prioritise a configuration of the GBI considering both natural values (threatened species, habitats and regulation and maintaining services, climate change adaptation and mitigation benefits) and from the other side the socio-economic

benefits derived from provisioning as well as cultural services (e.g. provision of fishing, aquaculture, water, material -e.g. cork and wood- and energy) all together.

Definition of the policy strategies – EBM scenario

Similar to the baseline scenario, the starting point of the identification of EBM policy targets was the result of the assessment of the current state of the SES linkage framework. The characterization of the CS IBRM was presented and discussed during the third workshop, organised in February 2018 in Facinas - Tarifa (Spain). The main purpose of this workshop was from one side to present the result of the SES assessment and discuss the developed baseline for the CS IBRM. From the other side, it was aimed to identify which new EBM measures and targets could be implemented to design an alternative GBI that allow to restore ecosystems, are able to protect more biodiversity, improve their services, and reduce the pressures caused by key economic activities in the area.

In order to understand the design of the GBI under the EBM scenario, the impact of setting new conservation goals and/or socio-economic goals will be further explored in the modelling exercise. For this purpose, a set of EBM measures that could be implemented in a new configuration of the GBI has been identified.

The design of an alternative GBI implies an investment on these EBM measures. The measures can address different EBM targets, for example aiming to protect species and habitats, maintain and restore biodiversity and habitats, make agriculture and fishing more sustainable and in general improve the status of the ecosystems according to the EU biodiversity policy targets to 2020. We will assess how single or combined measures would affect the design of the GBI components so we can prioritise which ones are more feasible and efficient in order to reach the conservation and restoration targets.

The table below shows the potential list of EBM measures and targets that will be pre-screened tested in the scenario modelling exercise.

Table 5. EBM measures for the CS at the Intercontinental Biosphere Reserve of the Mediterranean

MS #	Measure*	Type of measure, detail	Policy target of the EU biodiversity 2020
1	Reduce the disturbance of species	Mitigation/Prevention	Target 1- Protect species and habitats Target 6 - Help stop the loss of global biodiversity
2	Reduce litter at the shore recreational	Mitigation/Prevention	Target 4 - Make fishing more sustainable and seas healthier Target 2 - Maintain and restore ecosystems
3	Habitat restoration	Restoration	Target 2 - Maintain and restore ecosystems Target 3 - Achieve more sustainable agriculture and forestry
4	Improvement of water quality	Restoration	Improve ecological status (WFD) Improve environmental status (MSFD) Target 2 - Maintain and restore ecosystems

GBI zoning management

In order to solve possible conflicts among the different ecosystem services and biodiversity of the SES, we implemented a zoning management practice to spatially design the GBI. The zonation of the GBI will resolve conflicts between socio-economic values and biodiversity and detected areas to implement the EBM measures. Therefore, the second stage of the scenario development process consisted in the definition of the GBI management zones (Figure 4). The approach presented in this Case Study aims to identify a multi-functional GBI scenario using different management zones. In planning a multi-functional GBI network that is capable of stopping the loss of biodiversity and therewith enabling ecosystems to deliver their many services to people and nature, ecosystem condition should also be taken into consideration (Vallecillo et al., 2016, Vallecillo et al., 2018).

An initial proposal of management zones and conservation features according to the definition adopted from the EU policy initiative Building a Green Infrastructure for Europe (European Commision 2013) is presented below. The narrative has been presented to the stakeholders during the workshop organised in Facinas (Tarifa, Spain, 2018) and was the starting point for the discussion on the definition of the EBM targets and the potential EBM measures to be used.

Three different management zones have been considered in the GBI design depending on the main activities allowed and on their natural values: conservation zone; intermediate zone and multi-functional zone. The scenarios are expected to explore different GBI spatial configuration. Each scenario proposes three zones, where depending on the EBM targets scheme that must be achieved, the zones will have the ability to combine a wide range of ESS, different levels of ecosystem condition, diverse degrees of biodiversity protection and that allow/ban certain socio-economic activities (e.g., housing, farming, forestry, fishing, recreational). Different types of zones within a management scheme combine EBM targets which, afford varying degrees of protection for biodiversity depending on the degree of restriction of human use will address. Scenarios are aimed to spatially show these trade-offs, and their assessment would help in finding out alternative combinations of management and restoring schemes in the GBI that result in enhanced biodiversity conservation and ESS delivery at an acceptable cost for stakeholders.

Definition of the conservation features goals for each GBI management zone – stakeholder's participation

Once we have identified the zoning scheme and conservation features that has been included in the spatial prioritisation of the GBI, the next step consisted in determining the EBM targets for each one of the features Figure 4. The EBM targets defined by the technicians and stakeholders have been in accordance with EU targets (EU Biodiversity Strategy 2020) (see table above), national and regional (Hydrological management plans, marine strategy, protected figures, costal protection). For instance, we start with the EU biodiversity target which aims to maintain and restore ecosystems and their services by restoring at least 15% of degraded ecosystems by 2020. This target will be translated into specific EBM targets to reduce the pressures of the SES for the IBRM AoI with help from the stakeholders.

During the workshop in Facinas, a group exercise was organised to discuss the GBI zoning and discuss which EBM features (e.g. which species, habitats, activities) and measures (e.g. protect more 15% of the threatened species) should be implemented in each zone in order to reach EBM targets (reduce the current pressures, promote green and blue growth and restore ecosystem and improve their services and protect biodiversity). This exercise was extremely useful to firstly identify which EBM targets are more relevant considering the different interests of the stakeholders. For this purpose, a wide range of stakeholders' representatives were: Regional Ministry of Environment of Andalusia – Ministry of Environment and Spatial Planning of Andalusia (Spain); High Commission for Waters, Forests and Desertification of Morocco; a representative from UNESCO Man and Biosphere Program and the Biosphere Reserve Network and representatives of the economic activities, namely a representative of a natural park in the IBRM, farmers, livestock producers, construction, mayors, a local association for conservation and restoration of a wetland which was transformed to irrigated croplands.

The outcomes of this workshop, were fundamental to develop the baseline scenario, the alternative scenario, i.e. the scenario that would implement the EBM measures and targets that are needed to be implemented in the design of the new GBI development and EBM planning.

Modelling exercise for selection of priority areas for GBI implementation

Once the baseline has been defined, the EMB measures have been identified and the target for each GBI management zone has been established, the next step consisted into translate this information into a spatially explicit GBI and evaluate the EBM measures. This process is an interactive process with that involve the participation of the modellers/technicians and local experts to adjust the targets and reach an agreement on the final GBI configuration.

Spatial Conservation Prioritisation is the framework used to evaluate the EBM measures. The comparative assessment of the spatial configuration of the GBI management zones and the evaluation of the EBM measures against the baseline will be based on the Spatial Conservation Prioritisation (SCP) (Margules & Pressey, 2000). SCP is a framework that involves a set of steps for the engagement of stakeholders, data collection, target setting, analysis, and implementation of conservation and explore various zoning scenarios (Margules and Sarkar 2007). Each zone will have an optimal configuration, thus can promote win-win solutions or 'small loss-big gain' combinations that deliver benefits to a wide range of stakeholders as well as to the public at large (European Commission 2013). More specifically, an initial step of SCP analysis is to give relative weights to the features accounted for, and these weights are used in the multiple zoning optimisation procedure. Weights have potentially large effects on the SCP solution (e.g., Moilanen et al. 2011) and it is therefore important to include experts and stakeholders regarding biodiversity and ESS in GBI design.

For the accomplishment of the GBI management zone according to the two scenarios, we will use Marxan with Zones (Watts et al. 2009), a substantial extension of Marxan that has the ability to specify zone-specific planning where the costs of conservation actions differ, but the conservation outcomes are equivalent, i.e. allowing different EBM targets for the EBM features but still aiming for strategically planned, multifunctional GBI management zones. Marxan[3] has been suggested as one of the tools for the spatial prioritisation of the conservation of freshwater biodiversity and different ESS related to marine, coastal and freshwater ecosystems in the context of the AQUACROSS project (Domisch et al. 2017).

We will explore multiple scenarios of GBI management zones that allow meeting different targets, while conserving biodiversity and maintaining ESS capacity at the same time and the costs of the restoration actions are minimised. After the first run of modelling exercise, the stakeholders are expected to review the output from Marxan (management scenarios evaluation) and adjust the EBM targets if necessary. Marxan provides the flexibility to address policy needs. Given a range of possible solutions, the stakeholders will be able to identify alternatives to establishing the GBI location addressing different management goals. Ideally,

[3] Marxan - conservation solutions: http://marxan.net/

the stakeholders would be able to come to consensus on a single optimum multi-functional GBI scenario.

Outcomes and outputs from policy scenarios

The impact of the scenarios will be analysed trough the comparison of the GBI spatial zonation according to the different scenarios. The main outputs of the modelling exercises are maps for the best solution of the GBI components irreplaceability, highlighting the three principal components of the GBI according to two scenarios: a baseline and an alternative scenario, which integrate the EBM measures to be implemented.

From one side, the EBM measures will be applied to reach specific EBM targets to improve the compatible and incompatible ESS provision, increase the biodiversity and improve the connectivity between the core management zones. Here, the main goal is to optimise the investment of the EBM that are cost-effective by prioritising the areas that can benefit from these interventions. In addition to the final spatial configuration of the multi-functional GBI, as part of the final recommendations of the scenario exercise would be a list of potential EBM recommended to be deployed to achieve the restoration goals established for the restored GBI management zone. At this stage, we will focus our attention on the sites, which will greatly benefit from the implementation of the strategic actions that allow enhancing ESS supply and maintain biodiversity with the minimum cost.

The comparison between both scenarios will show how the GBI will look like if no action is taken and how the GBI will look like if we implement EBM measures that aim to reach the EBM targets proposed for this CS area. A set of impact indicators will be used to evaluate the EBM measures.

4.2 Narrative-based scenarios for CS 6 Rönne å catchment area

This section aims to provide insights on the thinking behind the scenario development process throughout the paragraphs 1) objectives and research design, 2) process and methods and 3) preliminary scenarios (narrative).

Rönne å catchment area is a river watershed located in Southern Sweden and includes lakes (e.g. Ringsjön), rivers (Rönne å) and marine coastal areas (Kattegatt). Institutions in Swedish water governance are complex with multiple actors and frameworks on all scales: local (water councils, municipalities), regional (county administrative boards, water authorities), national (Swedish jurisdiction) and EU (e.g. Water Framework Directive). This calls for knowledge about social-ecological complexity, best-practice water governance, and how cross-sector collaboration might influence environmental problems and essential ESS. The scenario development process aims to explore these topics.

Objectives of the baseline and policy scenario

ESS have been described as “benefits that humans derive from nature” (MEA, 2005) but are rather co-produced in intertwined SES (Palomo et al., 2016). Co-production highlights the interaction between social (e.g., labour, institutions, technology, finances and agency) and ecosystems in their social-ecological context (Lele et al., 2013; Spangenberg et al., 2014). Social and natural interactions create trade-offs and effects the quantity, quality, resilience and equity of ESS and also human well-being (Palomo et al., 2016).

Social-ecological processes and ESS interaction is key to understand how water governance can be improved. Future scenarios foster long-term complex thinking and complements modelling well as it is adaptable and accessible (Bennett et al. 2003). Engaging stakeholders in this process fosters collective action to achieve desired goals and show how stakeholders might respond to future challenges (Bohnet & Smith 2007; Kok et al. 2007). It also provides context specific insights about water governance in Rönne å catchment area, for example, about actors on various institutional levels. The research design has developed organically and balanced research objectives and community needs. Co-production and ESS interaction (i.e., synergies, trade-offs) and how one might optimise water governance through multi-scale change is interesting from a research perspective, whereas stakeholders want to learn about ESS and how it might be mainstreamed into their planning processes. The aim is to understand, from a stakeholder perspective, the following questions:

1. What are the goals from decision makers linked to water governance and co-production of ESS in the Rönne å catchment area?
2. What are relevant processes of change for improving water governance?
3. Concerning resilience principles - what are challenges and opportunities to improve collaboration among stakeholders and how does it relate to the resilience of aquatic ESS?

Process and methods to screen measures and develop pathways

This section will outline the gradual procedure and thinking behind the stakeholder-based scenarios for the Rönne å catchment area:

1. *Understanding the baseline*

   Initially, we gathered socioeconomic, institutional and policy data to include several municipalities with similar conditions in our study. We only included municipalities that are currently updating their comprehensive (also called master) plan that states their visions and goals, as they are thinking holistically and long-term. Two municipalities were included based on our criteria, and two more were suggested by stakeholders as they collaborate on many water issues, making it four relevant municipalities for our study.

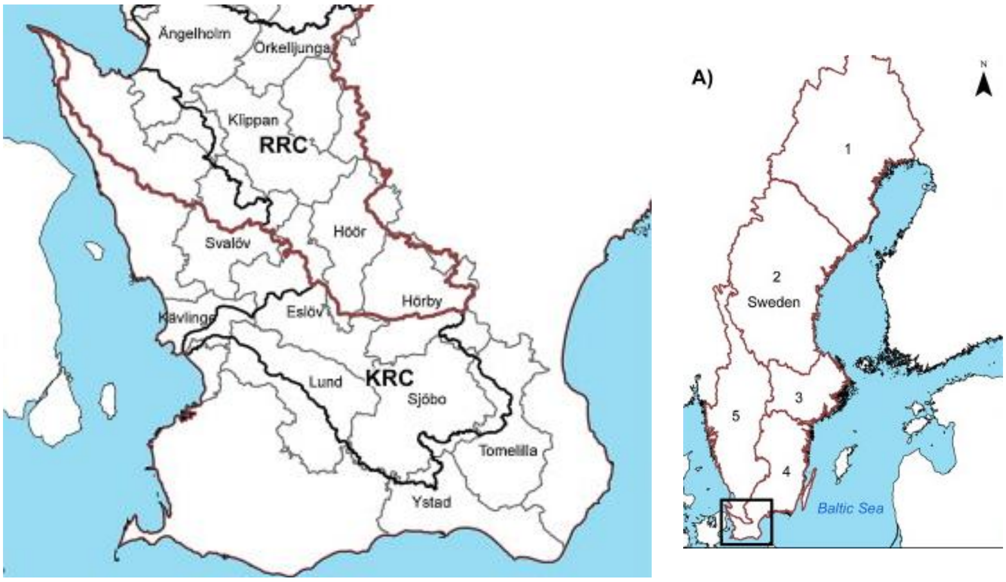

Figure 5 Location of Rönne å catchment in Sweden (to the right) and the municipalities (to the left) including the ones that participated in the scenario development (Franzén, Hammer, and Balfors 2015).

2. *Preparing stakeholder workshops*

The second step was to plan the workshops and link the research questions and exercises, while creating mutual benefits for researchers and stakeholders. For example, cross-scale communication is beneficial as it provides a holistic understanding of the topics and allows stakeholders to initiate new contacts. We intentionally mixed civil servants and politicians as 1) according to stakeholders, they rarely interact and, 2) they have complementing viewpoints, as they are decision-makers and practitioners. We aimed to create groups with a diversity of perspectives to ensure holistic, representative and cross-scale insights in water governance. We had three workshops (geographic diversity) and, included many institutional scales (e.g., municipalities, county administrative boards) as well as different sectors (drinking water, recreation and sewage). The list of participants was created together with our local contact to ensure diversity and similar group dynamics in all workshops (to ensure cross-workshop comparability). The workshops were followed-up by eight in-depth interviews to triangulate data, and to follow-up on interesting leads from the workshops.

3. *Conducting the workshops*

As we focused on creating diverse groups (with varying worldviews and opinions) we collaborated with a facilitator (from Albaeco[4]) to have respectful and fruitful discussions. We started with an introduction of ESS and how they connect to sustainable development, as a benefit for the participants. Focus groups (i.e., discussions in smaller groups that is specifically appropriate when one is trying to unravel a diversity of perspectives (Carey & Asbury, 2016) were created with one note-taker each to ensure

[4] Consultancy at the science-policy interface for strategic environmental communication, science communication and education. http://www.albaeco.se/english/

high-quality data and understanding of the discussions. One workshop lasted a full day (10-16) with a total of four exercises.

We designed the exercises to incrementally build an understanding of underlying conditions for aquatic ES in place, their interrelations and the future prospect of how they are affected by policy measures. Details on the exercise design and format can be found in the Annexes.

Analysing the results

Workshop data is used to identify interactions among ES from planned measures and to identify actors and activities that are important to reach water related goals. The preliminary narratives described in the following section as main output are based on researchers' understanding of the discussions (and dominating story-lines) about problems and solutions during the workshops. What are weak collaborative links? What is needed for them to create a more sustainable water governance? A local stakeholder in Höör municipality has read through the narratives and confirms that all three alternatives are plausible future scenarios, and the outcome will most likely be a mixture of all of them.

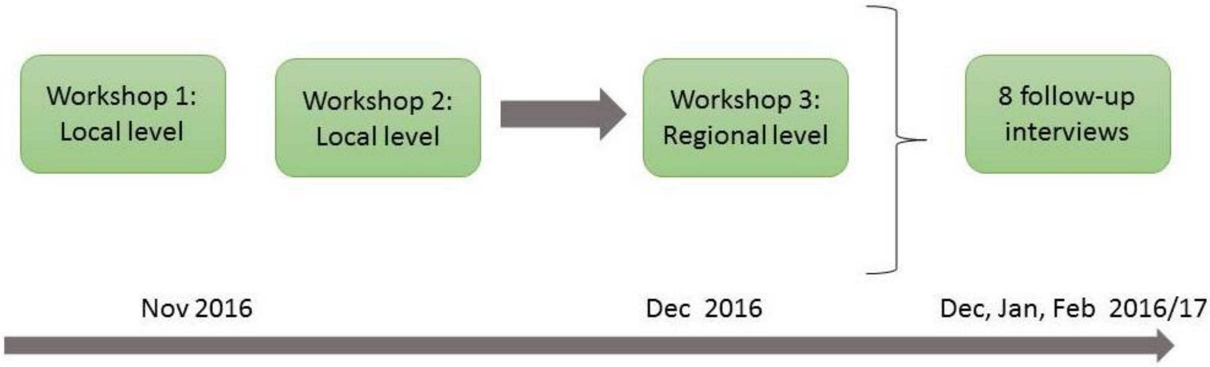

Figure 6 Shows the data collection that acted as basis for the scenarios. In total, three workshops were held and eights follow-up interviews.

Table 6 Exercises to discuss ESS co-production and build scenarios for their management

RQ	Exercise	Expected output
1. Which steps and actors characterise the co-production of aquatic ESS? - who are the beneficiaries?	Mapping co-production from natural processes, natural structures, labour + knowledge, institutions, infrastructure, money, based on prepared poster, alternative views possible	Graph of actors, natural and social factors for an ESS to become accessible for consumption for beneficiaries
2. Which interactions among ESS and land uses are perceived? (in the past, now)	Create a ESS flower (representing the distribution of ESS) by giving them petals in different sizes.	Perception on the ESS relative abundances. Discussions on interactions on a holistic level.
3. Which values / objectives are prioritised and how will they effect ESS interactions? (in natural or social side, micro- or macro-level)	Table with goals, measures and ESS	Set of objectives within each municipality, including a priority list for ESS interactions that are taken into account. -> informs target for scenarios
4. What are practical rules/processes to improve decision-making and governance with respect to objectives and trade-offs?	Define vision for municipality. Discuss what measures/processes are necessary to reach vision, based on conceptual model with scales.	Defined strategies to get there. Interaction across levels – who needs to do what and its effect. -> informs measures and pathways for scenarios

1. *Modelling*

The results of the stakeholder-based scenario development process will inform the development of a social-ecological model (a hybrid model combining agent-based and system dynamics modelling). The model will be used to analyse the social-ecological foundations and consequences of different ESS provision scenarios.

Outcomes and outputs from policy scenarios

As one output from our stakeholder activities, we created preliminary narratives. They depict stakeholder understanding of how to enhance the provision and management of ESS, and how measures could affect ESS interaction. Those narratives are also expected to stimulate further discussions among stakeholders.

Narrative 1 – Baseline /status quo

No major changes in water governance in Rönne å catchment area have occurred. The collaboration between the municipalities surrounding lake Ringsjön continues and so does the biomanipulation project that lowers eutrophication. This has a positive effect on water quality and many recreational ESS. However, biomanipulation measures are costly and change trophic cascades rather than underlying problems (e.g., agricultural runoff), which hinders a regime shift. Collaboration with municipalities up north is still limited, which creates problems in reaching "good water status". These northern municipalities in Rönne å catchment area are struggling as environmental documents are considered to be "nice guidelines" but "nothing will ever change" (workshop participant) and environmental problems are handled in an ad-hoc way rather than in a planned and structured manner.

Narrative 2 – Merging of water councils

The three water councils (Rönneå, Ringsjön and Kattegatt coastal water council) have merged and become one regional council including all 14 municipalities within Rönne å catchment area. Collaboration now crosses institutional borders in municipalities (e.g., drinking water, storm water and urban development) and sectors (both politicians and civil servants are included) but also between municipalities. They plan and govern their water in a more holistic way as they have strengthened the resilience principle of broadening participation/perspectives, and created a better fit between institutional and natural boundaries. Broadening participation is one key principle in building resilience of ESS as it adds transparency, includes a diversity of knowledge and increases legitimacy for goals, decisions and water measures. Factors that have improved water governance are 1) common understanding of contributions and distribution of financial capital, 2) a continuous rotation of which municipality is chair and, 3) improved personal relations and trust. Eutrophication is improving, and migratory barriers are slowly decreasing (and biodiversity is slowly increasing) without major conflict. Creating the new water council was time-consuming for everybody involved, but the activity was key to building long-lasting relationships.

Narrative 3 – Good water status.

In the past, it was voiced that the Water Framework Directive stated over-ambitious goals to a very complex problem. Many people thus did not take them seriously, and as over-ambitious goals can be demoralising, some people were incentivised to find loopholes instead of taking action to reach goals. In order to comply with the directive, Swedish legislation became more specific to reach "good ecological status" within the required period (2027). Politicians have been tough, and monitoring of agriculture and sewages was efficient. Measures that have been implemented are 1) merging of water councils to improve regional water governance, 2) more biomanipulation, 3) emergency plans if unforeseen events occur, 4) areas with high biodiversity have been protected and 5) cleaning storm water.

There are social consequences for some individuals as less crops and local electricity (hydro power) is being produced. However, reaching good water status and thus good water quality has had a positive effect on many recreational ESS (e.g., swimming and fishing). Local tourism in the area is blooming, as the recreational fishing has improved substantially, thus creating new jobs.

The narratives were instructive to develop corresponding policy scenarios to be analysed with our simulation model. During the remaining time of the project, the baseline and two policy scenarios will be evaluated regarding the success of restoration measures carried out at the major lake in the catchment. The resulting time lags in restoring multiple ecosystem services linked to water quality in the future will help to facilitate negotiations for necessary investments now.

4.3 Discussion on CS 2 and CS 6 insights for the Assessment Framework

This section aims to discuss and compare our two cases that can be fruitful for the other cases, as it gives more insights on the motivations that are lying behind the scenario processes.

Diverse perspectives add up to a more holistic picture

Case study 2 demonstrates a top-down procedure, how EU policies guide regional scenario development supported by specific targets where local and regional stakeholders contribute with prioritisation of conservation features. Case study 6 differs in that regard, that local and regional decision-making processes, mainly guided by national policies, interact with water councils working with EU policies such as the WFD. Hence, we observed a mixed bottom-up, top-down process where the implementation of measures is dependent on this bargaining process between local and regional decision makers (as e.g., in municipalities and water councils).

This has implications for the type of scenarios suitable to further support stakeholders in the case studies. Whereas in case study 2, constraints and pre-analyses are provided before the scenarios in the form alternative management zones are embedded in a model analysis, the common target of case study 6 stakeholders still needs to be defined. That is why case study 6 scenarios are more explorative in the sense that alternative perspectives form a basis to discuss future collaborations and the model analysis targets a subset of consequences from these. In contrast, case study 2 scenarios are more normative in the sense that common targets were mainly set from the beginning of the interaction process, and the purpose of the scenario process is to an improved set of conservation measures for different management zones.

Perceived challenges and benefits with stakeholder integration in scenario development

In all AQUACROSS case studies, it is a goal to co-create relevant knowledge with stakeholders to improve management strategies in and at a specific water body. Because of heterogeneous roles and functions, not all participants are familiar e.g. with ESS as a concept and how to integrate it into their planning. In case study 6, an introductory but short presentation in the beginning of each workshop provided a common ground. Participants were very keen on discussing the topics and were able to grasp the concept quickly. This also means that every example that was provided, affected participants in their thinking and understanding of the concept and therefore the data that they generated. Therefore, this approach required intensive crosschecking of opinions through follow-up interviews.

Stakeholder fatigue is one risk from intensive participatory processes, not only for scenario development but also for different steps of baseline and policy analyses. This increases the importance of stakeholder events being co-planned and activities that are fruitful for both scientific and practical purposes (cross-check this with stakeholders beforehand). Long-term collaboration beyond single research projects advantageously also increases trust and intensity of collaboration.

A particular challenge we see as important to discuss for future projects is the handling of conflicts and trade-offs between alternative measures suggested in the scenarios. For example, to which degree can multifunctionality for trade-off management zones be achieved and negotiated when mutual exclusive activities or interests exist (e.g. industrial harbour activities vs. international tourism)? This is particularly difficult if the time horizon for expected benefits to unfold is different among stakeholders or the dynamics of values for, e.g. when a set of conservation features is unclear.

5 Outlook for analysing scenarios with models

This deliverable has presented a snapshot on the scenario development processes in AQUACROSS case studies with a focus on stakeholder engagement at different steps and scenario characteristics that link to the AF. We provide an outlook of how we expect to analyse scenarios with models for the purpose of policy assessments.

The goal in most of our AQUACROSS case studies is to map out the expected consequences from existing policies on biodiversity and ESS levels through scenario analyses. In summary, from observing the AQUACROSS case studies in their scenario development processes, it can be said that scenario development is to different extents embedded in the overall analysis. In some cases, there is a clear strength in linking quantitative, often also spatial, data on biodiversity indicators and related ESS with models to estimate their levels under future policies. Other cases highlight more the dynamic aspects of human interaction with aquatic systems, accounting for changing behaviour under different policy options. For those latter cases, the scenario development process is framing the model analysis, which can only highlight subsets of considered future changes.

Since it is too early in the process to report on lessons learned from scenario development processes, this will be revisited in the upcoming task on scenario assessment (Deliverable 8.2) and the update of the AQUACROSS framework (Deliverable 3.3). So far, it has become evident in several case studies that not all stakeholders linked to a problem can be reached to develop scenarios. This is challenging, as desirable management strategies consequently cannot be executed. Innovative insights are expected from assessing the scenarios, to which degree they consider resilience principles for improving EBM strategies. Practical questions will be, for instance, which feedbacks are considered, or which types of change anticipated; does the type of governance, participation and learning play a role? A recent example on global ocean futures shows how scientific evidence can be accompanied by strong narratives on non-linear change (Merrie et al. 2017).

On the technical side, the next step in AQUACROSS is to link the scenarios to model analyses (Deliverable 7.3). This will then map out which model approaches have been used in AQUACROSS case studies to develop forecasts of biodiversity features and ESS for baseline and policy/management scenarios.

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Annex

Annex A: Responses to CS questionnaire on the scenario process, February 2017

Table A: Shows an overview of the scenario characteristics in AQUACROSS case studies. The table encompasses the type and main topic of the scenarios, their purpose and outcome as well as methods, how stakeholders may have been involved and the potential benefit is for them and the link to models, ESS and biodiversity.

CS	Main Topic	Type & purpose	Outcome(s)	Methods	Stakeholder involvement and their benefit	TLink between policy & scenarios	Connection to models	Link to biodiversity/ESS
1	Conservation seafloor habitat.	Product oriented scenarios with participatory and data based approach for policy and research	Degree to which they contribute to the achievement of objectives.	Apply various models/methods to assess the performance/progres s towards the policy targets.	They identify issues/topics and thus shape knowledge base and phrase issues they deem most relevant.	Not directly (as in not applied) but the knowledge base should become the basis to guide policy.	Suitability of various models will be assessed and those suitable will be applied to assess the outcome of the EBM measures.	Both ESS and biodiversity are considered.
2	Green and blue infrastructure.	Data-based and product-oriented scenarios that support policy processes.	A list of measures.	Different consideration measures, costs.	Function: product-oriented. Involvement: Se previous WP benefits: Se previous WP	Assessing the consequences of selected management measures.	Modelling tools will provide the scenarios of the GIBI components. The population projection can be used to model future water abstraction.	ESS and biodiversity are both integrated in model marxan as consideration features for the definition of the GIBI components.
3	Hydromorphic alterations effects on ecological status. Conserve a) biodiversity (birds) in Danube delta and, b) biodiversity (fish, inverts) in tributaries.	Product-oriented scenarios that support policy processes. Participatory and data-based scenarios.	Model-based impact assessment.	Participatory and D-P-S analysis.	Process-oriented and product oriented. They are involved by drafting (and later redefining) the scenarios and thus including their opinion. The benefit is that they learn about complex problems and some trade-offs could be transformed into synergies.	Assessing the effect of renewable energy development on WFD targets.	Models of unused hydropower potential	WFD targets are closely related with biodiversity and ESS.
4	Increase access for recreational activities and reduce invasive species in the system.	Exploratory and product-oriented scenarios that mainly contributes to research. Created with	Narratives and model-based impact assessment.	Stakeholder workshops and ECOPATH modelling, linkage based on network analysis.	Stakeholder workshops in summer 2017. They get to explore ways to reduce invasive species and improve recreation access to lake.	How invasive species can be reduced.	One scenario relates to ECOPATH model input. Invest + GIS Modelling.	Achieving the goal of increasing recreational access and decreasing invasive species could influence several recreational users,

		a participatory approach.						some regulating and maintaining services and biodiversity.
5	Management of Natura 2000 areas from freshwater to coastal waters.	Product oriented scenarios created with participatory methods.	Model-based assessment (impact was crossed over) and best management options.	Participatory process, analysis is based on agent-based models.	Participatory methods to co-develop scenarios. Allows for inclusion of their expectations. Both process-oriented and product-oriented.	Assessing consequences for management measures.	Models are used to assess a scenarios effect on ESS.	Biodiversity and ESS are integrated in the scenarios.
6	Implications of water governance on the co-production of ESS. Exploring ways to improve management to increase multifunctional landscapes.	Process oriented scenarios mainly for research purposes, created through participatory methods.	Narratives.	Participatory methods: workshops and interviews. Inductive-deductive coding. Back-tracking methods to create scenarios.	Process-oriented. Scenarios are created based on workshops and interviews, and stakeholder benefits are knowledge exchange, new contacts and improved collaboration.	Stakeholder involved work with WFD which naturally affected the discussion and scenarios.	Used as input for models.	The scenarios will explore the link to ESS, based on discussions with stakeholders on the possible effect between ESS (synergetic, trade-offs and, one-directional) and effects on ESS from measures.
7	Climate and social change.	Supports policy and research processes and created through participatory processes but without strong stakeholder involvement.	Model-based impact assessment results in a list of measures.	Scenarios: formulate effect and influence factors in the models. Analysis: 1) model predictions for consequences of measures, 2) compilation of degree of fulfilment of objectives.	Stakeholders are asked about programs already influencing the process and the effect and efficiency of measures. They can later use our results to argue why these measures should be implemented.	Assessing consequences of measures for societal decision support.	Used as input.	They have an immediate effect on both.
8	Fishing, tourism (diving, whale watching) and multiple-uses: e.g. fishing, tourism, ferries and, biodiversity.	Participatory scenarios that are exploratory and product-oriented with purpose to support research and policy processes.	Narratives, pictures and maps, list of measures and trade-offs showing "futures" based on effects of policy.	Participatory development and discussions with stakeholders.	Aiming to include stakeholders in the development and assessment of scenarios. Their benefits would be identification of trade-offs (benefits & costs) that are associated with different measures.	Assessing the consequences of different management measures on fishing, tourism and biodiversity.	To be determined!	They are the objectives.

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