Report on "Multifunctional assessment methods and the role of map analysis -Using and Integrated Ecosystem Service Assessment Framework"

Deliverable 4.8

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Enhancing ecosystem services mapping for policy and decision making

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Preface

Mapping and the assessment of ecosystems and their services (ES) are core to the EU Biodiversity (BD) Strategy 2020. Specifically, Action 5 sets the requirement for an EU-wide knowledge base developed by Member States designed to be: a primary data source for developing Europe's green infrastructure; a resource to identify areas for ecosystem restoration; and, a baseline against which the goal of 'no net loss of BD and ES' can be evaluated.

In response to these requirements, ESMERALDA (Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking) aims to deliver a flexible methodology to provide the building blocks for pan-European and regional assessments. The work will support the timely delivery of EU Member States in relation to Action 5 of the BD Strategy, supporting the needs of assessments in relation to the requirements for planning, agriculture, climate, water and nature policy. This methodology will build on existing ES projects and databases (e.g. MAES, OpenNESS, OPERAs, national studies), the Millennium Assessment (MA), IPBES and TEEB. ESMERALDA will identify relevant stakeholders and take stock of their requirements at EU, national and regional levels.

The objective of ESMERALDA is to share experience through an active process of dialogue and knowledge co-creation that will enable participants to achieve the Action 5 aims. The mapping approach proposed will integrate biophysical, social and economic assessment techniques.

The six work packages of ESMERALDA are organised through four strands (see Figure P1), namely policy, research, application and networking, which reflect the main objectives of ESMERALDA.

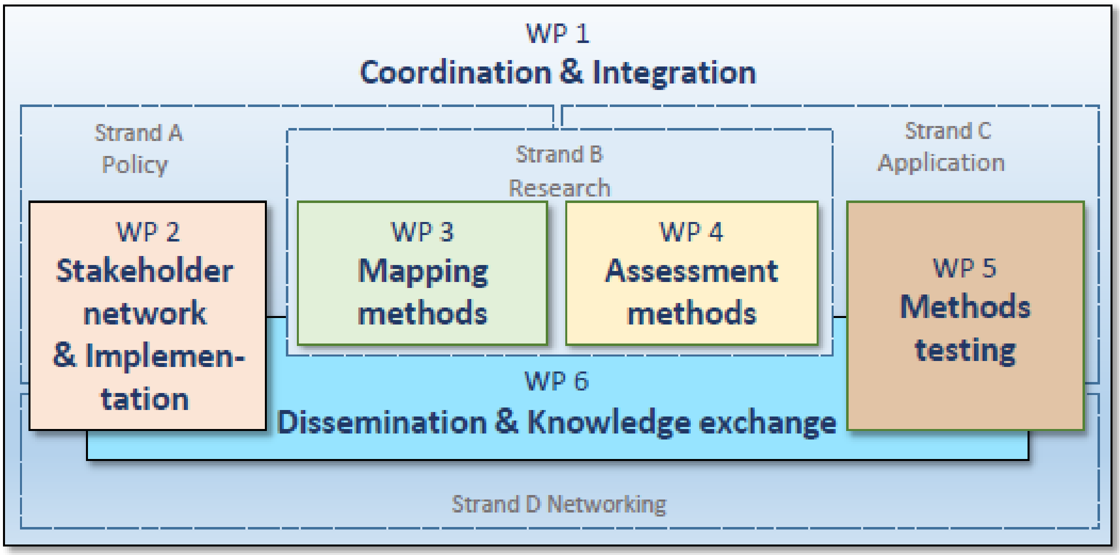

Figure P1: ESMERALDA components and their interrelations and integration within its four strands.

This report sits within work package WP4 "Assessment Methods" and its Deliverable 4.8, as specified in the Description of Action for ESMERALDA (2015). The focus of this report is to present a broad assessment framework and to test it. The framework aims to illustrate the integrated assessment cycle for practitioners. The framework also places in context the work being undertaken in ESMERALDA and 'Mapping and Assessment of Ecosystems and their Services' (MAES) within the other assessment activities, such as scenarios and assessing policies. The final design of any integrated assessment is shaped through the questions which are being asked by stakeholders and the mandate they provide for the assessment.

Summary

The process and frameworks used for ecosystem assessment are not well documented and seldom evaluated. The work within ESMERALDA for an integrated ecosystem assessment was developed to review the field and provide assessment practitioners and decision makers with a tool that enables them to flexibly bring together different activities of existing ecosystem assessment frameworks in an integrative way. With close alignment to the Millennium Assessment (MA, 2005) and MAES frameworks, this integrated ecosystem assessment (IEA) framework uses spatial approaches as a baseline to integration but also extends this approach through links with non-spatial methodologies. The level and extent of integration is at the users' discretion according to the data, time and resources they have available, as well as to the specific objectives of the assessment. Beyond the biophysical parameters at the core of the MAES framework, emphasis is given to the inclusion of social and economic factors to ensure policy relevance.

The refined ESMERALDA framework places at its heart key mapping activities around ecosystem services which are fundamental to the work of MAES as well as ESMERALDA. The framework places the spatial element of analysis within the wider landscape of activities which are undertaken within an ecosystem assessment.

The consultation process on the Integrated Ecosystem Assessment framework has been internal to the project Consortium (see also Milestone 22 report, Brown et al., 2018). This deliverable report presents the 'final framework' which has now been agreed by the members of the ESMERALDA consortium. Further consultation by means of a survey and interviews, e.g. with EU members states, has developed this framework further and identified good practice examples that illustrate aspects of its application.

To test ideas developed within the Project, the work has drawn upon seven case studies that have used and explored the ESMERALDA integrated ecosystem assessment framework (see chapter 3); they examine its suitability for policy- and science-related questions. The individual contributions discuss advantages and disadvantages of using a holistic approach in relation to their issue compared to the one that was initially applied in the case study.

In the final block of work we reflect critically on the revised integrated assessment framework presented here and develop recommendations regarding its future use and development. We suggest that:

- Given the different ways in which notions of integration are applied in different assessment, it is essential when discussing or presenting the framework in relation to a particular study to be clear about what form this integration takes and how and where it occurs.
- The investigation of ecosystem condition and ecosystem services cannot be approached by two independent analytical pathways. And while general condition measures might be identified, ultimately the functional underpinning of each service (or bundles of services) has to be related to *particular* condition measures if a robust and credible assessment is to be made.
- Given that assessments, even those undertaken within the context of the EU Biodiversity Strategy, have to be relevant to social needs and concerns, the investigation of ecosystem condition and ecosystem service needs to be linked to the analysis of benefits and values.

- Despite the limitations that are evident in the revised framework shown it is sufficiently flexible and rich in its content to be able to represent the concerns of range of studies developed within the MAES community.

The work in Task 4.4, together with the deliverable presented here, partly forms the base of the following publications:

Brown, C., Burns, A. and A. Arnell (2018): A Conceptual Framework for Integrated Ecosystem Assessment. *OneEcosystem* 3: e25482

Potschin-Young, M.; Burkhard, B.; Czúcz, B. and F. Santos-Martín (2018): Glossary of ecosystem services mapping and assessment terminology. OneEcosystem 3: e27110. https://doi.org/10.3897/oneeco.3.e27110

1. Introduction

By
Claire Brown (UNEP-WCMC), Marion Potschin-Young (Fabis), Abigail Burns (UNEP-WCMC) and Andy Arnell (UNEP-WCMC)

1.1. Why is a framework needed?

Governments have long recognised that human well-being is dependent on healthy functioning ecosystems and the services they provide, as set out in the global Aichi Targets and the Sustainable Development Goals. Despite this, ecosystems are being significantly reduced in extent and threatened with loss of function, putting at risk the ecosystem services they deliver (Leadley et al., 2014). However, it appears that national policy setting and decision making processes still do not adequately take into account biodiversity and ecosystem services. Historically, the impact of humans on the environment has been the main focus of environmental policy. We now need to transition to environmental policy paradigm that more fully recognises the dependence that human societies have on ecosystem services.

Ecosystem assessments apply the judgement of experts to existing knowledge generated from the scientific community (and other forms of knowledge) to provide credible answers to policy-relevant questions. And therefore, ecosystem assessments are a tool that can support the development of an evidence base that meets the needs of different sectors and encourages integration (Berghofer et al., 2016; Ash et al., 2010). By taking into account a range of biophysical, social and economic parameters, integrated ecosystem assessments can be a useful tool for characterising and communicating the true societal value of ecosystem services

Integrated assessments and specifically ecosystem assessments are not a new concept. Examples of such global efforts include the Millennium Ecosystem Assessment (2005), The Economics of Ecosystems and Biodiversity (TEEB), and of course the suite of assessments being undertaken by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). There are also a number of national efforts, especially in the EU Member States but also in countries such as Ethiopia, Cameroon, Viet Nam and Colombia. Common to all ecosystem assessments are the principles of credibility, legitimacy and relevance. Therefore, ecosystem assessments are typically characterised by:

- Involving governments and other stakeholders in the initiation, scoping, review and adoption of the assessment reports (this involvement promotes credibility, legitimacy and relevance at policy level);
- Operating through an open and transparent process, run by a group of experts that has a balance of disciplines, geography and gender. They use agreed conceptual frameworks, methodologies, and support tools and are subject to independent peer review (this process promotes credibility, legitimacy and relevance at scientific level); and
- Presenting findings and knowledge gaps that are policy relevant but not policy prescriptive, where the level of confidence and the range of available views are presented in an unbiased way (this approach promotes relevance at both scientific and policy level).

(IPBES Guide for Assessments, 2018)

There are many benefits that can be realised by undertaking an integrated ecosystem assessment, however, ecosystem assessments are not always the appropriate tool to use. A selection of the advantages and disadvantages can be found in Booth *et al.,* (2012); UNEP (2015); Berghofer *et al.,* (2016):

Advantages of using an ecosystem assessment process	Disadvantages of using an ecosystem assessment process
Brings together experts from different disciplines and stakeholders around an issue or question	Can have little impact or resonate if not embed within a political or decision making process (e.g. have a mandate)
Demonstrating the benefits, risks and costs of different policy options	Can be costly and time consuming, requiring large amounts of resources. (However the cost of not assessing environmental pressures and risks may be a lot higher).
Influencing the goals, interests, beliefs, strategies, resources, and actions of interested parties which can lead to institutional change and to changes in the discourse about the issue being assessed	If poorly designed and/or managed ecosystem assessments can be unnecessary (only re-stating the obvious), inappropriate (not capturing the essence of an issue), or even counterproductive (leading debates in the wrong direction)
Identifying new research directions	
Strengthening the relationship between science and policy by providing the means through which science can inform decision making	
Providing an authoritative analysis of policy relevant scientific questions	

Underpinning all these assessments has been the creation of conceptual frameworks. In simplest terms a conceptual framework for an ecosystem assessment is a concise summary in words or pictures of the relationship between people and nature, including how those relationships are changing over time. Thus, such conceptual frameworks tend to be anthropocentric, as such assessments tend to focus on issues of human well-being and how this is shaped by the environment and how decision makers can change the trajectory of change (Ash *et al.,* 2010). Therefore, ecosystem assessments are inherently integrated (e.g. different data types, different sectors involved). Conceptual frameworks are often referred to as the scaffolding for an assessment, given their role in assisting in the organisation of the material within assessments (Diaz *et al.*, 2015; Potschin and Haines-Young, 2016).

However conceptual frameworks should not be confused with the assessment process required to assess the interactions that they set out. The assessment process or framework which underpinned the MA, integrated ecosystem assessments more generally (see Figure 1.1), as well as IPBES, usually consist of four key steps. The steps are: i) exploratory (where the need or mandate for the assessment is articulated); ii) design or scoping (what will the assessment cover); iii) implementing the assessment; iv) communication and disseminating the findings of the assessment. Within each of these steps are a number of activities and decisions which have to be made, including where and how integration will occur.

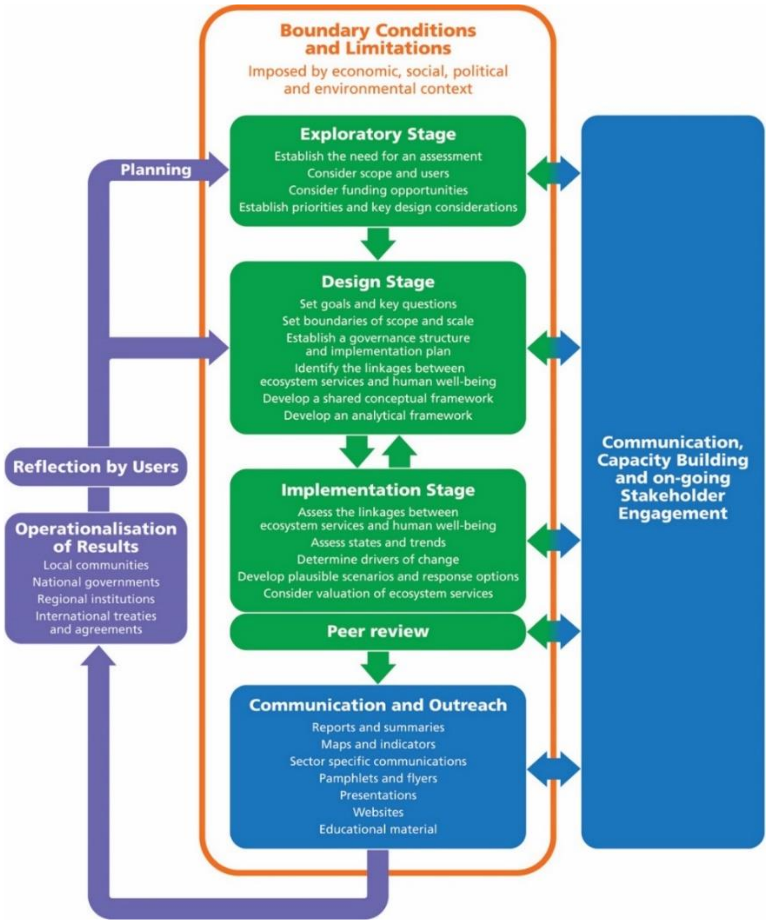

Figure 1.1. Ecosystem Assessment Framework (Ash *et al.* 2010)

This deliverable report presents an assessment framework which attempts to set out more comprehensively the different activities to be undertaken in implementing an assessment and indicating where decisions on integration should be made.

The remaining parts of Chapter 1 describe the background to the development of the idea of integrated assessment in ESMERALDA, and examine what the concept of 'integration' entails. Chapter 2 provides the results and analysis of a consultation exercise undertaken across Member States on the material developed within the Project on integrated assessment; the material on which the consultation was based developed out of an initial framework developed in MAES, but which explicitly identified the wider dimensions of integrations. The aim of the consultation was to understand what elements of ecosystem assessment frameworks were useful or important to different users and to develop a common understanding of integration within the assessment process by assessment practitioners. As a result, eight examples of good practice in ecosystem assessment were identified and summarised as a way of reflecting on the different characteristics of the proposed integrated framework (see Annex A).

Chapter 3 reviews the application of the proposed integrated assessment framework in the context of seven local case studies. These were selected from the group of partners within the ESMERALDA Consortium because their work involved some form of integration. The aim here was to test further the concept of integrated assessment developed in ESMERALDA by examining the advantages and disadvantages of using the holistic approach proposed, compared to the approach that was initially applied within the study; in other words the ‘added value’ of the evolving ESMERALDA integrated framework. A particular focus was on the extent to which the proposed framework was able to help address the types of policy questions that arise in the context of ecosystem service applications.

1.2. Background to the integrated ecosystem assessment (IEA) framework

The proposed framework that formed the basis of consultation was developed from the MAES mapping framework and examples of best practice in ecosystem assessment (see Appendix A for Case Studies). It is an adaptation of the assessment framework developed in the Millennium Ecosystem Assessment (MA), published in 2005 (see Figure 1.2), and is closely aligned with the conceptual framework developed in 2013 as part of the Mapping and Assessment of Ecosystems and their Services (MAES) initiative within the EU Biodiversity Strategy to 2020 (see Figure 1.3).

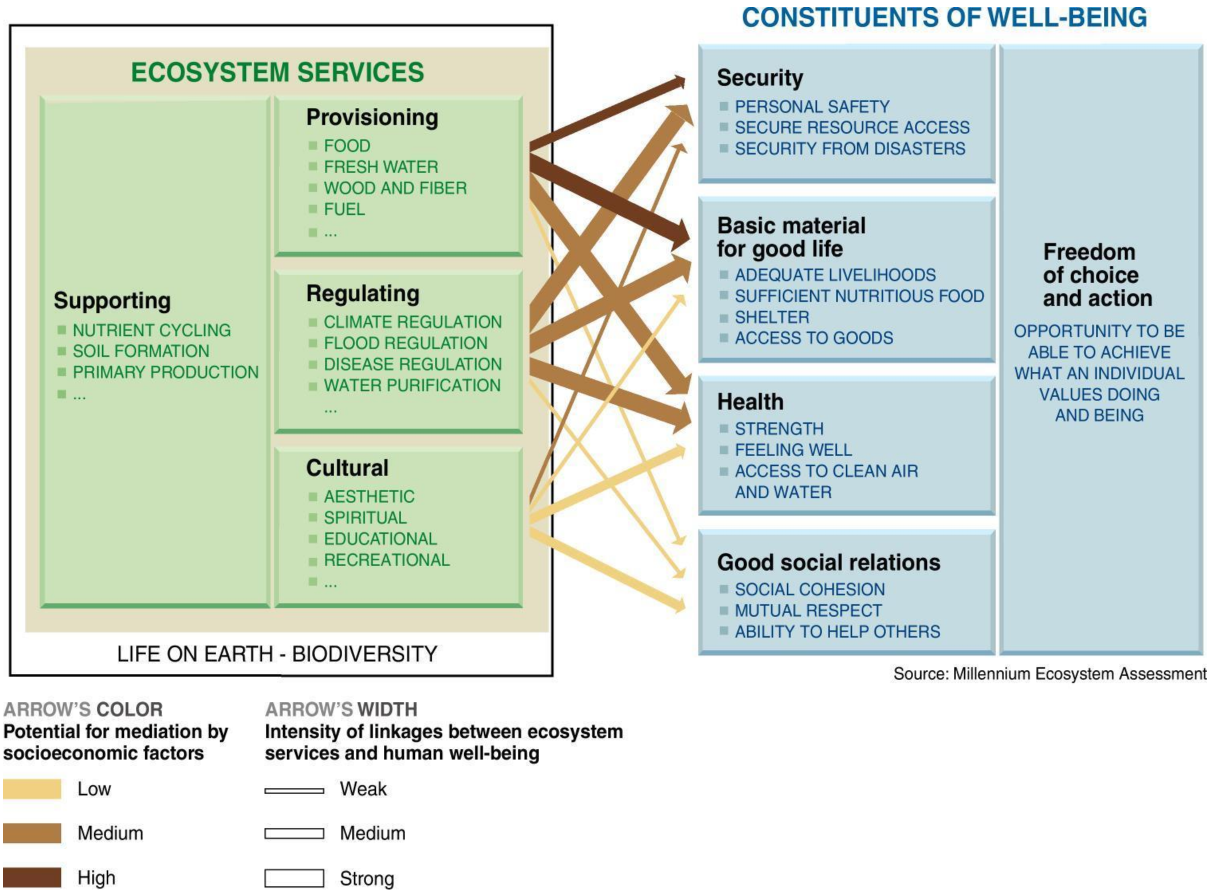

Figure 1.2. The Millennium Ecosystem Assessment Framework (MA, 2005)

The MAES framework was developed as an essential part of the EU Biodiversity Strategy to 2020 to ensure a consistent approach to ecosystem assessment across the EU. A key objective of the MAES initiative is to develop a comprehensive benchmark on the condition of EU ecosystems and the value of the services they provide by 2020 (European Commission, 2014a). The analytical schema is based on the DPSIR framework (Drivers, Pressures, State, Impact and Response), thus enabling characterisation of the link between human actions and environmental impacts. Importantly, the 'state' element of this framework refers to the condition of ecosystems. Understanding how ecosystem condition is affected by different pressures is an important element in designing policy responses (European Commission, 2016). The common conceptual framework and toolkit (see Figure 1.3) developed under MAES can therefore support Member States carrying out mapping and assessment activities. It proposes a common typology of ecosystem types and services that allow for consistency and comparison across scales (European Commission, 2013).

A series of ecosystem pilot cases were carried out by the MAES initiative to test the MAES analytical framework following its adoption in 2013. The work was based on a 4 step approach (Figure 1.3) (European Commission, 2014b). The analytical framework has been further enhanced by the identification of a comprehensive set of indicators for ecosystem condition (European Commission 2018). This framework purposely focuses on the spatial elements of an ecosystem assessment in response to the policy context of which MAES is set at the European scale and the existing 'assessment landscape' (e.g. State of Nature Reporting). However, the European Commission recognise that the work undertaken within MAES should be adapted to suit the needs of the Member State in question.

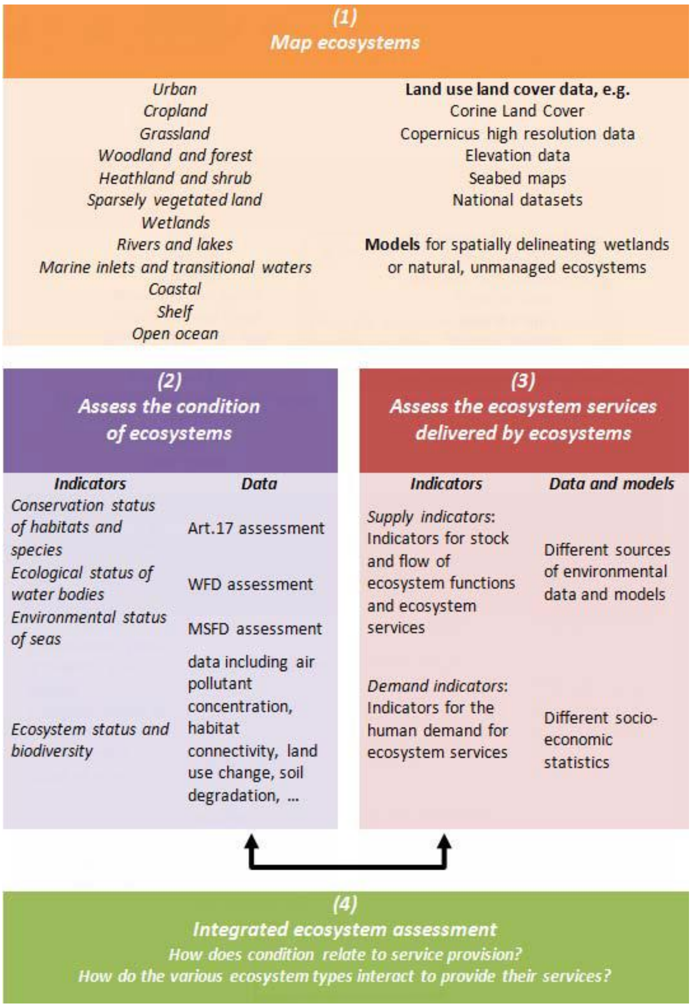

Figure 1.3. The common assessment framework that guided the work of ecosystem pilot cases within the MAES initiative in 2013-14 (European Commission, 2014b).

The MAES initiative's common assessment framework was further enhanced by Burkhard in 2016 to develop an initial version of the integrated ecosystem assessment framework for ESMERALDA (Figure 1.4) which began to set out the steps required within the assessment process. Although this framework does highlight the role of mapping within assessments, it does not place it within the broad ecosystem assessment process such as valuation of ecosystem services, use of scenarios or the assessment of policies. These are essential elements that need emphasizing within an ecosystem assessment framework to ensure policy relevance of results.

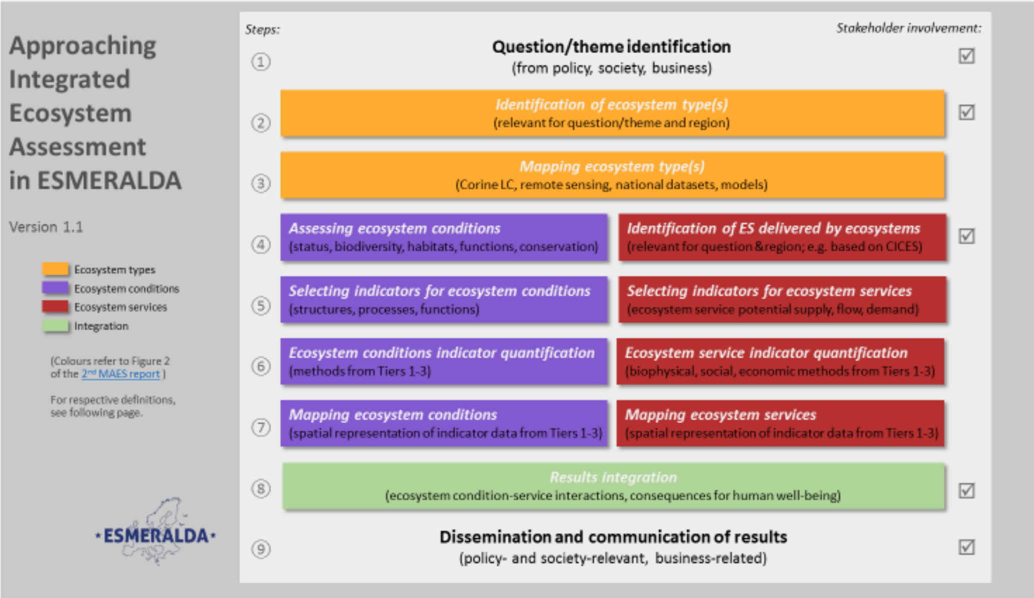

Figure 1.4. Approaching Integrated Ecosystem Assessment in ESMERALDA, Version 1.1 (Burkhard et al., 2016, personal communication).

The next version of the framework (Figure 1.5) therefore placed the core mapping elements within the wider assessment process or framework, particularly with regard to enabling flexibility as to where integration takes place, as well as emphasizing the role mapping can play in leading, or forming the basis, of integration. This draft version, with explanatory text, was sent out to the ESMERALDA Executive Board for comment, and then the wider Consortium and stakeholder network. The final version of the ESMERALDA integrated ecosystem assessment framework can be found in this report as Figure 2.2.

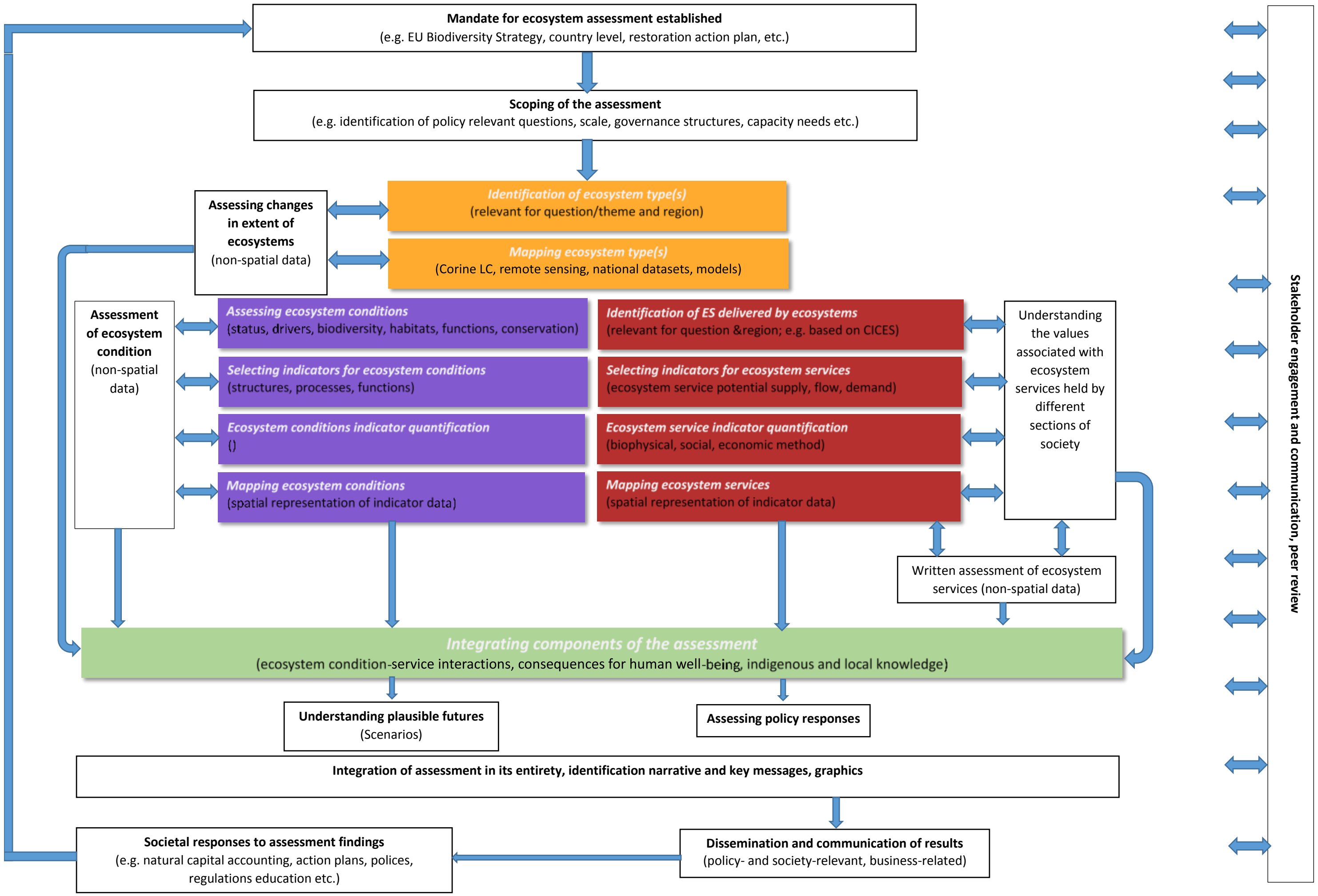

Figure 1.5: Towards an IEA framework in ESMERALDA drafted by Brown, C.; Potschin, M. and R. Haines-Young (2017) based on Burkard et al. (2016) and Maes, J. et al. (2014) 2nd MAES report for consultation within the ESMERALDA Stakeholder network and Consortium.

1.3. Defining 'integration' within integrated ecosystem assessments

An important element in the development of a flexible, integrated approach for ecosystem assessments, is to establish a common understanding of what an IEA entails. The level of integration within existing ecosystem assessments varies, but usually includes: i) combining; ii) interpreting; and, iii) communicating knowledge from diverse disciplines. For example, integration may focus on biophysical elements; integrating ecosystem condition with the services that the ecosystem provides (e.g. MAES assessment framework). Others have extended integration to include socio-economic information and links to human well-being (e.g. Millennium Ecosystem Assessment) and indigenous and local knowledge (e.g. IPBES Assessments).

Other assessment practitioners may use the word integration to simply refer to the inclusion of stakeholder consultation within the assessment process, or the overall governance structure that they are implementing. The extent and stage at which integration occurs will alter according to variables such as the policy question being asked and or available data, resources and tools. It should also be noted, however, that while it is generally assumed integration is a benefit, very few assessment processes have been documented or evaluated. Guidance around what makes an ecosystem assessment 'integrated', as well as the development of indicators to assess the level and effectiveness of integration, will be a useful step in better documenting and evaluating these experiences.

This framework shown in Figure 1.5 is designed to give the user flexibility as to when, where and to what extent they use integrated methodologies in their assessments. At the core is mapping ecosystem condition and ecosystem services and this forms the basis of integration. However, extensions to this core aim to encompass other social and economic processes. An understanding of how users interpret and determine integration has been crucial in the development of the final framework. This understanding has been developed through extensive consultation with ESMERALDA stakeholders; described in Chapter 2.

2. The Integrated Ecosystem Assessment framework development process within ESMERALDA

By Claire Brown (UNEP-WCMC), Marion Potschin-Young (Fabis), Abigail Burns (UNEP-WCMC) and Andy Arnell (UNEP-WCMC)

2.1. The consultation processes

The aim of the consultation was to understand what elements of ecosystem assessment frameworks were useful or important to different users, and to develop a common understanding of integration within the assessment process by assessment practitioners. Specific questions asked of respondents included:

- What kind of integration needs to occur and where does it take place in the assessment process?
- How different is an *integrated* ecosystem assessment compared from a 'non-integrated' one?

The development of the assessment framework began in March 2017 and was finalised in January 2018 (Figure 2.1). After consultation at the ESMERALDA Board Meeting prior to March 2017, it was agreed that the framework would be developed through consultation with the ESMERALDA stakeholder group, which included members of the scientific and administrative communities as well as representatives of private enterprises and national and international funding bodies. ESMERALDA workshops provided a space for the framework to be presented and reviewed. A final round of consultation was sought outside the ESMERALDA consortium within the broader community of assessment practitioners (e.g. the Sub Global Assessment Network).

Figure 2.1: Integrated ecosystem assessment framework consultation timeline. Blue: workshops where the framework was either discussed or presented and where comments were welcomed. Orange: consultation phases. Green: outputs.

2.2. The comments incorporated- why and how

Between March and October 2017 members of the ESMERALDA stakeholder group and Consortium were invited to provide written feedback on the framework. The comments, as well as how the authors of the framework responded to these comments, have been summarised in Table 2.1 and 2.2. Some comments were not incorporated into the framework graphic as they are deemed too complex for this sort of visual representation.

Table 2.1. Themes from written comments received from the ESMERALDA consortium that were incorporated into development of assessment framework graphic, and how they were incorporated

Comment theme	How comment was incorporated into framework
Wording	Generally wording/terminology edits to improve clarity of the framework were incorporated
Layout	Generally, layout suggestions which improve clarity were incorporated (e.g. removal of many of the arrows)
Scoping stages	Incorporation of comments to ensure the scoping stage was sufficiently comprehensive
Non-spatial vs spatial data inclusion	Improved clarity over where spatial and non-spatial elements can be incorporated
Clarity over complexity of ecosystem condition	The complexity of defining ecosystem condition is represented to a degree sufficient for the purpose of this framework within the broader objectives of ESMERALDA
Location of assessment stage	The position of where in the framework the actual assessment takes place was made clearer and placed more appropriately (green box)
Improved clarity over wording within assessment stage	Wording suggestions, particularly for the green assessment box were considered carefully and incorporated to ensure flexibility in integration of different elements
Improved policy relevance	Suggestions which would ensure the wording in the framework would be more relevant to decision-makers were incorporated

Table 2.2. Themes from written comments received from the ESMERALDA consortium that were not incorporated into development of assessment framework graphic

Comment theme	Why comment was unable to be incorporated into framework graphic
Wording	Wording edits that were deemed to already be captured sufficiently were not incorporated
Layout	Layout suggestions which may impede clarity were not incorporated
Clarity over complexity of ecosystem condition	The complexity of defining ecosystem condition is represented to a degree, however this is not the focus of ESMERALDA and so therefore will require further work outside of the scope of this Deliverable
Insufficient incorporation of economic/valuation stages	Emphasis has been given to those processes upon which an economic value can be placed, this is clearly not everything.
Further substeps to enhance particular stages	Too many stages would be confusing. Further exploration of elements such as ecosystem types, pilot studies, policy responses, scenarios, and the use of spatial and non-spatial data need further exploration beyond the scope of this Deliverable.

2.3. The Finalised Assessment Framework

The Integrated Ecosystem Assessment Framework presented here builds on work that already exists, namely the MA, IPBES and MAES. However, it also introduces new ways of understanding to what constitutes an IEA, whilst taking into consideration the wider ESMERALDA project given its own specific objectives. Extensive stakeholder consultation has helped to shape the final version and it has now been agreed upon by the ESMERALDA board. The final integrated ecosystem assessment framework can be found in Figure 2.2.

The framework does not represent the totality of thinking in ESMERALDA on the notion of integrated assessment, however, it captures the state of current thinking within the community. In the remaining parts of this Deliverable, we document how the framework is viewed at the level of individual case studies that are dealing with issues related to implementing the EU Biodiversity Strategy. In the final part of this document we return to a critical evaluation of the scheme, and recommendations on how it might be used and developed.

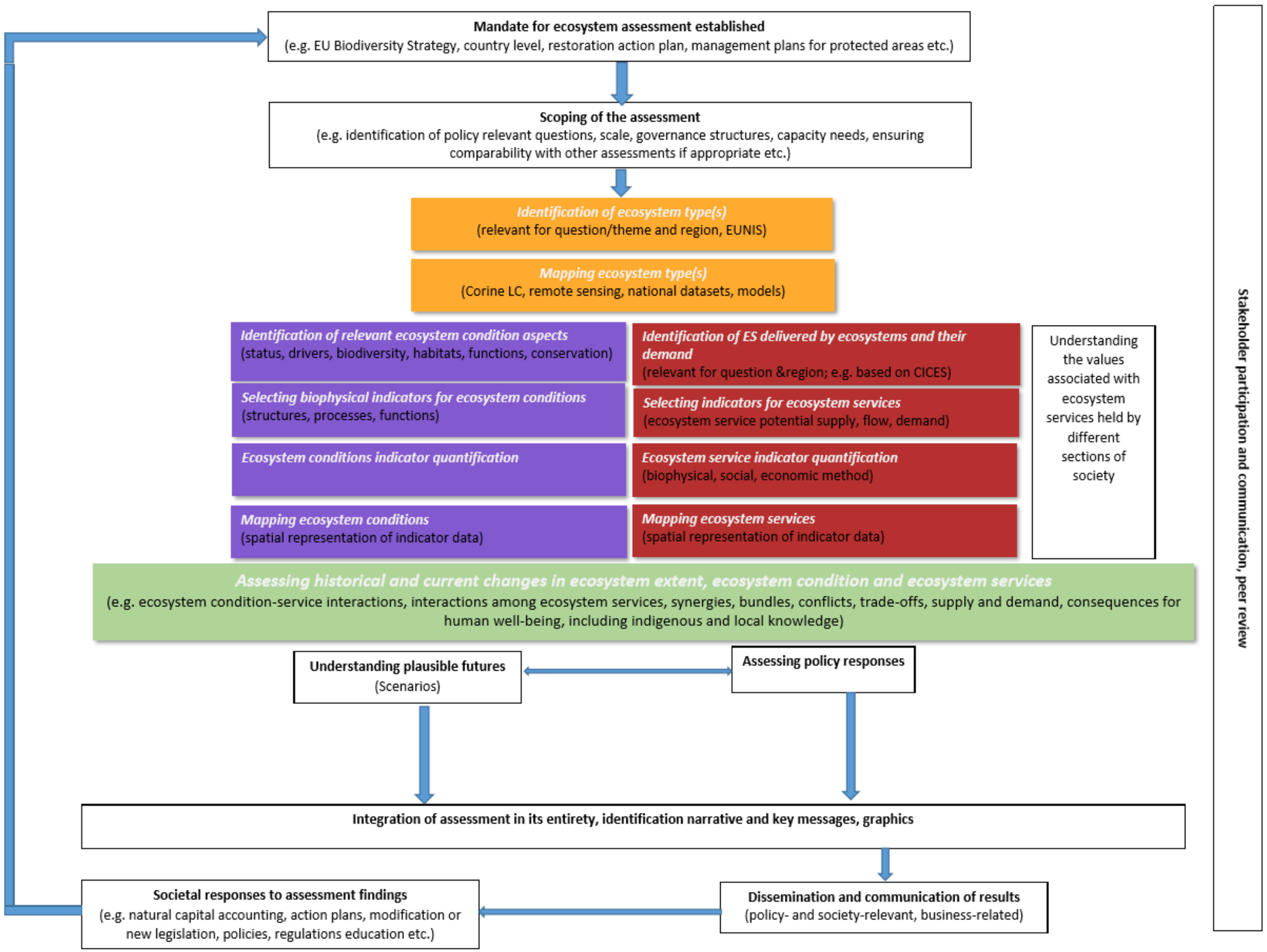

Figure 2.2. An integrated ecosystem assessment framework as developed within the ESMERALDA project drafted by Brown, C.; Potschin, M. and R. Haines-Young (2017) based on Burkard et al. (2016) and Maes, J. et al. (2014) 2nd Maes report – Final framework following consultation within the ESMERALDA Consortium. The core of the framework is built up from elements from the Burkhard et al. (2018) framework: identification and mapping of ecosystem type (orange), ecosystem condition (purple), and ecosystem services (red). These are placed within broader set of assessment activities (white) such as 'understanding plausible futures' and 'assessing policy responses' that enhance understanding and integration of the diverse values and benefits provided by ecosystem services. The green box indicates a point in the assessment process where integration of information should occur. This will enable the characterisation of trade-offs, synergies and consequences for human well-being.

2.4. Outlook: Consultation across the EU Member States

2.4.1. Online consultation

One of the aims of ESMERALDA is to provide assistance to Member States in integrated ecosystem assessment in order to help them deliver on Action 5 of the EU Biodiversity Strategy. In developing the integrated assessment framework wider consultation - beyond the ESMERALDA project- was therefore required to develop a better idea of the specific needs of Member States. This consultation was initiated through an online survey in an attempt to better understand how practitioners and policy-makers across the Member States have carried out integrated ecosystem assessments in the past, and what tools they have used. Results from this survey provide a better understanding of how practitioners have interpreted and implemented the concept of integration in the context of ecosystem assessments. Identification of challenges and strengths in implementing integrated ecosystem assessments have assisted in the development of a flexible methodology and guidance for integration. The survey has started the process of developing a portfolio of best practice case studies.

Engaging stakeholders across the Member States at a range of governance levels, has helped develop a broader picture of how 'integration' is defined, ensuring the framework and associated flexible methodology that the ESMERALDA project has developed is applicable to those practitioners who are currently carrying out these types of assessments.

2.4.2. Survey structure

To set the scene, the Survey's introductory text described an integrated ecosystem assessment as one that '*brings together data and information on biophysical ecosystem components with socio-economic system components and the societal and policy contexts in which they are embedded. They investigate the links between ecosystem condition, habitat quality and biodiversity, how these affect the ability of ecosystems to deliver ecosystem services, and the consequences for human well-being. Integrated ecosystem assessments also explore these relationships under a range of future scenarios and possible policy options/responses for decision makers.*' (Brown, 2017).

The survey then went into depth exploring aspects broadly associated with the following themes:

- Respondent characteristics; *the survey starts by asking respondents to describe the role that they have held within an assessment e.g. author/coordinator.*
- Overarching conceptual framework used; *questions 1 enables the respondent to identify the framework(s) that they have used to guide past assessments. A preliminary list of frameworks provided includes The Economics of Ecosystems and Biodiversity (TEEB), Mapping and Assessment of Ecosystems and their Services (MAES), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Millennium Ecosystem Assessment (MA).*
- Rationale behind use of integrative methods; *questions 2 and 3 look into the reasons behind the respondent using, or not using, integrative methods.*
- Description of the assessment process; *questions 4 to 6 go into depth, with multiple sub-questions, investigating the actual assessment process and approach to integration. Respondents are given an opportunity to elaborate on their definition of integration. Questions follow that attempt to elicit information on the types of data and economic methods used*

within assessments, as well as the extent to which stakeholders were engaged in a participatory process.

- Added value of an integrated assessment (vs. non-integrative); *question 7 gives the respondent an opportunity to provide their perspective on the differences between integrated and non-integrated assessments, as well as the benefits, if any, of using an integrated approach.*
- Lessons learned; *question 8 asks respondents to identify any specific pointers to pass onto practitioners carrying out future assessments, and whether any further, non-monetary, resources would enhance integrated assessments moving forwards.*

See Appendix B for the full set of survey questions. The survey’s user interface can be found at this link.

2.4.3. Survey distribution

During the first phase of this online consultation, the survey was sent to the MAES working group, the SGA Network and the ESMERALDA stakeholder group and Consortium. These contacts were targeted in order to provide the project team with a broad perspective, at an early stage, of interpretation and experience of integration within ecosystem assessments. This first phase of online consultation was open from December 2017 to January 2018 and elicited 15 responses. Respondents, although providing useful and informative responses, were identified as not providing a broad enough insight into experiences of carrying out integrated ecosystem assessments from across the different Member States. More engagement from country representatives was therefore deemed necessary, and a second phase of this consultation was established in which 45 MAES country contacts within Member States were approached. This phase of the survey started in January 2018 and came to an end in March 2018. This approach, eliciting 22 responses in total, has provided 16 detailed accounts from those who have carried out integrated ecosystem assessments, as well as from authors of internationally recognised assessment frameworks.

2.4.4. Results

Background to respondents and assessments

From the set of respondents 17 of the 22 identified their role within the assessment process; nine were authors, six were coordinators and two were users. With regards to the overarching conceptual framework used to guide their assessments, 15 of the 22 respondents had used the MAES conceptual framework, 8 had used the MA framework, and 5 the TEEB framework. Other methods detailed included following the UKNEA, SENCE and CICES frameworks as well as employing a flexible methodology adapted to the local context.

Of the 22 responses received, 16 had used integrated methods within the assessments that they had either authored or coordinated. Reasons given for not using integrated methods included lack of time, resources, technical capacity and funding.

Integration in ecosystem assessment

Of the 16 respondents that had used an integrated approach, 12 used this to ‘identify trade-offs among ecosystem services, stakeholders and ecosystem bundles’; 10 to ‘identify which ecosystem services are relevant to people’; and 9 to ‘identify potential social conflicts arising from different stakeholder needs and perceptions’ (See Figure 2.3).

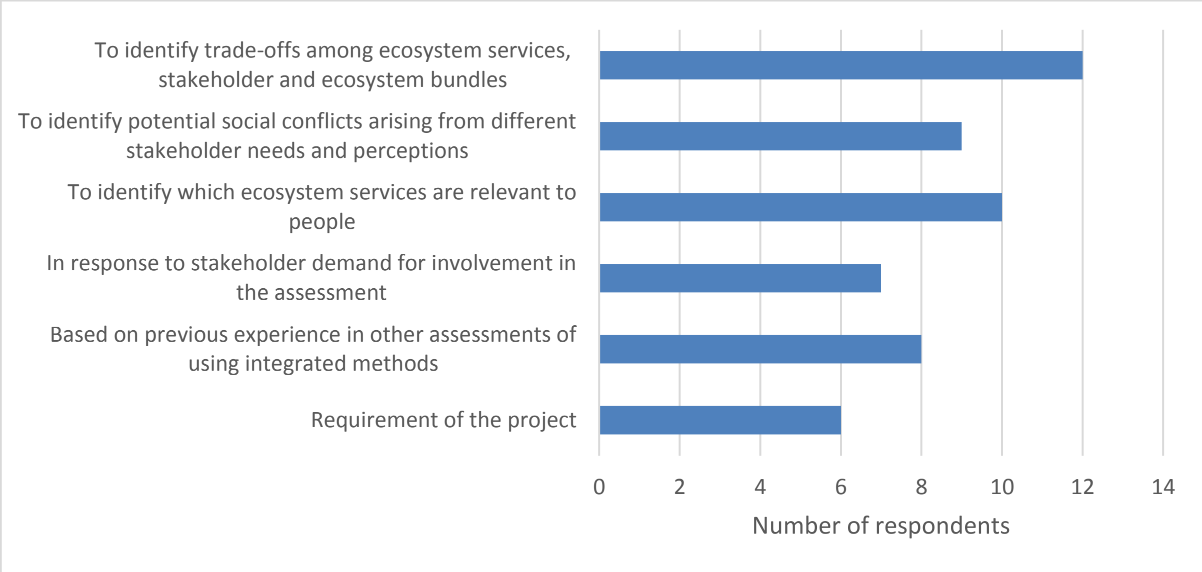

Figure 2.3. Reasons behind respondents choosing an integrated approach in their ecosystem assessments

When questioned about how ‘integration’ had been interpreted within their assessment respondents focussed on different elements of the assessment process. Interactions and interdependencies between biophysical, socio-cultural and economic dimensions was a common theme. This included characterising the interaction between ecosystem functioning and socio-economic condition, or using biophysical and social data to assess ecosystem condition. The necessity to bring data together from multiple sources was emphasised, including the integration of different views and perspectives. Multiple respondents stressed the importance of stakeholder involvement; ecosystem services can only be accurately quantified if stakeholder interests are taken into account. One respondent highlighted quantifying changes in ecosystem service as an important element within integrated ecosystem assessment, whilst another considered the comparison of multiple impacts due to changes within a complex system. Using a mixed methods approach was mentioned multiple times as an important process by which ecosystem assessments can become integrative. Mapping was mentioned as a method by which different datasets can be integrated.

14 out of 16 respondents used social, economic and environmental data in their integrated ecosystem assessments. The main types of social data used were recreational use data and cultural data. Other types of social data used include health benefits and political data (See Figure 2.4). Market-based and cost-based methods were economic methods most frequently used by respondents, followed by revealed preference, stated preference and other non-monetary methods (Figure 2.5).

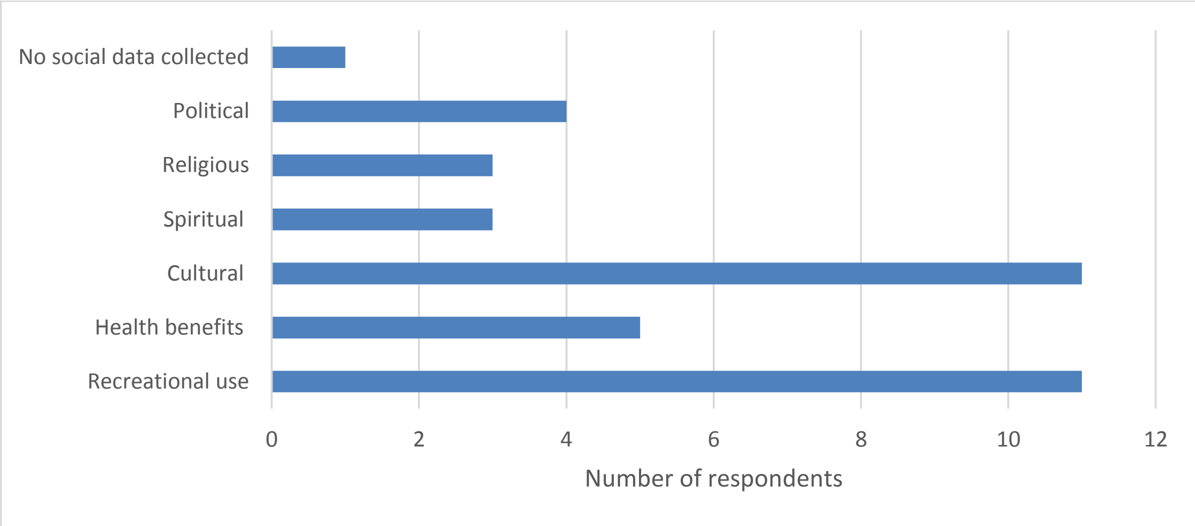

Figure 2.4. Types of social data used by respondents carrying out integrated ecosystem assessments

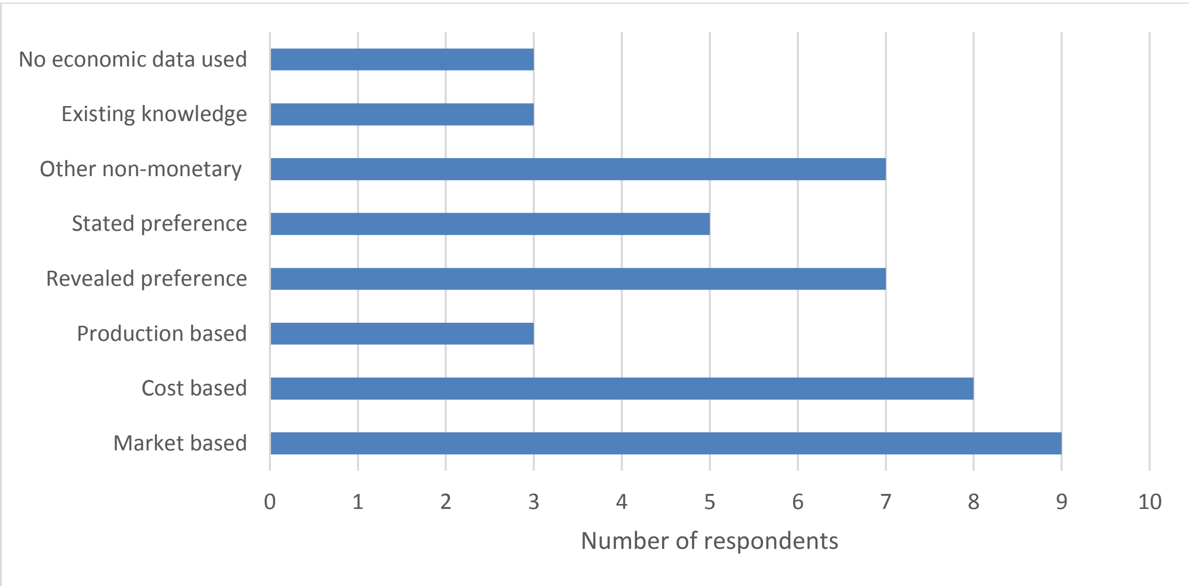

Figure 2.5. Economic methods used by respondents carrying out integrated ecosystem assessments

Regarding stakeholder involvement in the integrated ecosystem assessment, 13 of the 16 respondents engaged external stakeholders through a consultative process. The type of stakeholder and stage at which they were consulted varied. Figure 2.6 shows that those already involved in statutory decision-making (e.g. government stakeholders or local decision-makers) were the most frequently engaged stakeholder group across all stages, whereas civil society was the least involved- only being stated as a type of consulted stakeholder within two assessment stages; 'exploratory' and 'implementing work programme'. These stages were also those that elicited the highest level of stakeholder engagement overall. 'Developing output and communicating findings' was the stage that elicited the least. Figure 2.7 shows that across all stages, stakeholders are more frequently engaged in a consultative capacity as opposed to decision-making.

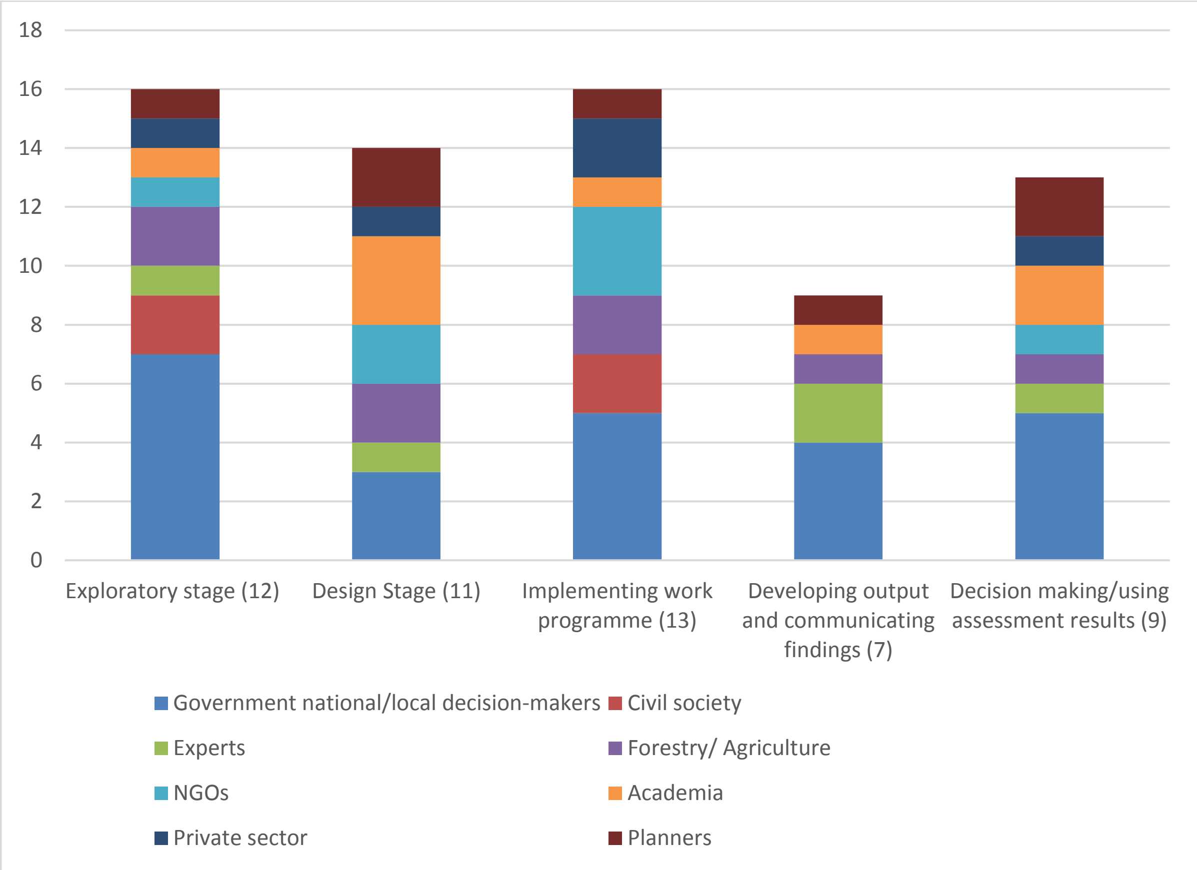

Figure 2.6. Type of external stakeholders consulted during different stages of the integrated ecosystem assessment process (bracketed number= number of respondents participating in question)

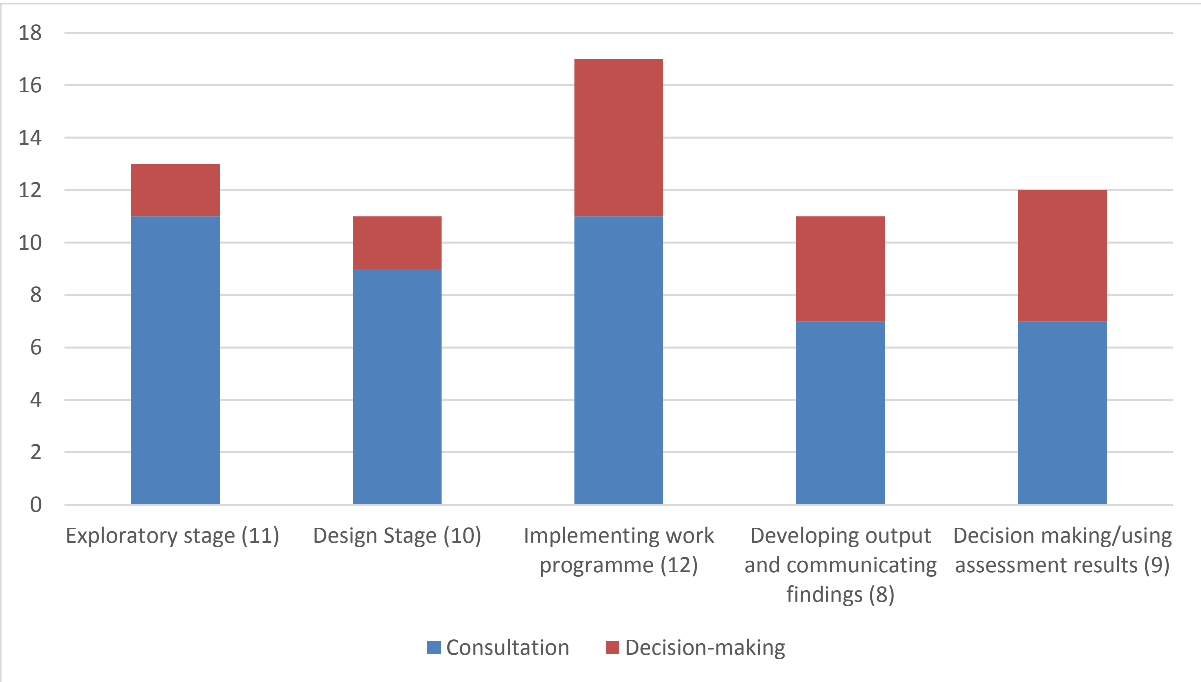

Figure 2.7. Capacity within which external stakeholders were consulted during different stages of the integrated ecosystem assessment process (bracketed number= number of respondents participating in question)

In terms of tools used by respondents to involve external stakeholders, 7 of the 16 respondents used preference assessment. Scenarios planning and multicriteria analysis were also commonly used (See Figure 2.8). Other tools named included decision support games, discussion on social platforms, and participatory mapping. The choice of stakeholder engagement method used was most frequently informed by previous use or experience, literature review, and expert consultation.

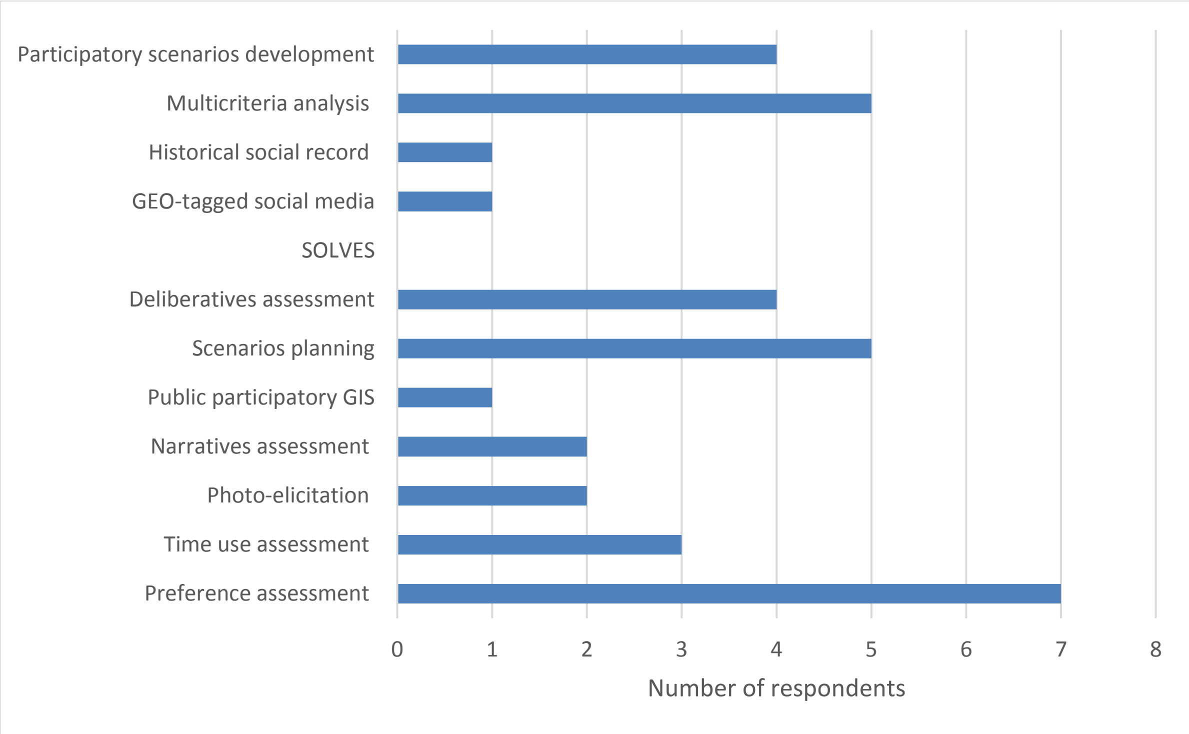

Figure 2.8. Tools used by respondents to involve external stakeholders in the integrated ecosystem assessment process

All respondents considered that an integrated approach adds value to the outcomes of an ecosystem assessment and leads to better results. More specifically, respondents argued that an integrated approach better demonstrates the complexity of an ecosystem assessment resulting in improved identification of the issue and more targeted data collection and impact. An integrated ecosystem assessment approach was also claimed to enable a better understanding of the interactions between biophysical, social and economic values. A key element of this understanding is precipitated through gaining different stakeholder perspectives. Regarding the actual decision-making process, an integrated approach is claimed to provide a useful tool by which to compare different options and impacts. This comprehensive approach is associated with greater acceptance of more valid, legitimate and policy-relevant results and decisions.

In detailing criteria for success, respondents emphasised the appropriate inclusion of relevant stakeholders in the integrated ecosystem assessment process, followed by a clear demarcation of individual roles and effective integration of feedback. Good communication with both internal and external stakeholders is important in building up a shared understanding of the concept. Data availability will also dictate the success of any assessment. Data requirements are determined by the policy question asked and subsequent complexity of the assessment. The robustness and acceptance of results is garnered through their scientific credibility and policy relevance.

9 out of the 16 respondents have also undertaken non-integrated assessments and so were able to provide some insight into perceived differences between integrated and non-integrated ecosystem assessments. Non-integrated ecosystem assessments may focus on a single issue or the needs of specific end users. They can be simpler to implement and require less resources, making them a good tool for the scoping stages of a wider assessment. However, if a problem is holistic; affecting, and affected by, multiple facets of an ecosystem, a non-integrated assessment may not be comprehensive enough to guide the decision-making process. Integration is needed in order to properly characterise and understand interactions between biophysical, social and economic parameters. A wider range of stakeholders may be more willing to accept the results of an ecosystem assessment if consideration has been given for the mosaic of elements within an ecosystem. Importantly, both the characteristics and success of any assessment- whether integrated or not- will differ according to the policy question asked.

Lessons learned in integrated ecosystem assessment

The survey drew to a close by asking respondents to reflect on lessons learned through implementing an integrated ecosystem assessment, as well as advice they would give to practitioners carrying out these types of assessments in the future.

Appropriate scoping is important prior to commencing an integrated ecosystem assessment. The level of assessment, i.e. depth and focus, must be relevant to the policy question at hand. Methods should be chosen that suit the type of integration desired i.e. tools might be chosen that simplify complex ecosystem components or social values. Available technical capacity and time should be a key considerations in the design process. The assessment should be adaptive and form part of a continuous social learning process. The policy question(s) must be kept central throughout in order to maintain focus.

Early engagement of a diversity of stakeholders was emphasised by a number of respondents as being a key element within an integrated ecosystem assessment. One respondent argued that this engagement should go beyond inter- or cross-disciplinary approaches and a transdisciplinary approach should be employed to ensure accurate characterisation of ecosystem issues and values. Developing a good contextual understanding and potential complexity involved in engaging certain stakeholders will help mitigate problems and potential conflict, and should form an important part of the scoping stage. Good communication is emphasised as a priority throughout the assessment process. Important stages within which to involve stakeholders are during the framing and decision-making stages.

Multiple respondents agree that an integrated ecosystem assessment should investigate biophysical, social and economic parameters, and should also try to investigate the interactions between ecosystem condition and the value of ecosystem services. One respondent highlighted the importance of using good quality primary data, however it was also argued that an integrated ecosystem assessment should try not to be too data-heavy or tied up with details. Priorities should be identified according to what is important to stakeholders.

Looking forward, many respondents highlighted the need for additional guidance in order to improve future integrated ecosystem assessments. Practitioners emphasised the need for the development of a simplified, standard accepted methodology or framework for integration. This should include recommendations on how to go about integrating different aspects of an assessment i.e. data from different value domains, as well as steps to ensure that assessment results are useable in a policy context (Clark, van Kerkhoff, Lebel, & Gallopin, 2016). Other resources required included capacity building for carrying out integrated assessments, and financing to facilitate transdisciplinary research. The provision of these additional resources, including best practice examples and case studies, could be made available through online tools or knowledge exchange platforms.

2.4.5. Discussion

There is a diversity of views from across the EU in what constitutes an integrated ecosystem assessment, with emphasis given to different stages and elements according to practitioners' viewpoint and experience.

Although the definition of 'integration' within ecosystem assessment is contentious, many respondents emphasise that at a basic level, an integrated assessment should investigate biophysical, social and economic parameters. Consideration of all of these elements is seen as beneficial, leading to better and more accepted results. However actually carrying out an integrated ecosystem assessment can be time consuming and complex. Reasons for not implementing an integrated approach relate to resource limitation rather than practitioners believing an integrated approach would be detrimental.

Another key feature of integrated ecosystem assessments that respondents put forward was stakeholder engagement. In some cases, the impression is even given that integration has occurred simply by involving stakeholders in a consultative process. This poses the question as to whether you can call this is a sufficient level of 'integration'? In order for benefits to be derived from this type of engagement, stakeholder feedback needs to shape the assessment process, and therefore the results. Importantly, integration has, and can be, implemented in a flexible way. Practitioners should feel able to translate and implement the term in a way that is applicable to the local context and policy question at hand.

Stakeholder engagement is most likely to occur during the exploratory and implementing work programme stages. However, respondents raised the point that it is important to also involve them in the decision-making/using results stage, showing that there is some discrepancy between optimum engagement level and what is happening in practice. Further to this, civil society remains the least engaged group, despite anecdotal evidence that acceptance of results is enhanced through their involvement. Further case studies of best practice in stakeholder involvement in both consultative and decision-making capacities may assist practitioners in enhancing engagement at more appropriate assessment stages.

Stakeholders may not demand to be involved in an assessment, however their engagement leads to more acceptance of results and/or policy decisions made as a result. Only through engagement of a range of relevant stakeholders, and consideration of both social and economic parameters alongside biophysical ones, can a reliable understanding be developed of the interactions and values of elements within an ecosystem.

This online consultation process has highlighted that although there are some good examples of integration within ecosystem assessment across the EU, there is still a paucity of experience and guidance with regard to best practice. The ESMERALDA integrated ecosystem assessment framework presented in Chapter 1 is a step in the direction of developing some clear guidance around this topic. Further development should seek to address capacity gaps and uncertainties, such as how to integrate data from different value domains, and how to ensure results remain relevant and applicable in policy decision-making.

2.5. Conclusion

It is essential when designing an ecosystem assessment to consider how and where the concepts of integration will be considered. The integrated assessment framework for ESMERALDA, highlights the importance of the design phase of an assessment as well as the many tasks which can take place within an ecosystem assessment. It is important to note that the integrated assessment framework presented here represents an ideal situation, and should be adapted to suit the national situation. However, while integrated ecosystem assessment processes are not well documented or evaluated, the evidence that is available suggests that integration through the governance structure (inclusion of stakeholders), combining of different data sources and the use of tools allows for greater impact of the ecosystem assessment report within decision making. What also has emerged, is that they key contribution that the notion of integrated assessment provides is the ability to consider the synergies and trade-offs of a range of ecosystem services associated with one or more ecosystems. Overcoming the barriers and limitations of 'siloed thinking' is perhaps the main feature of the integrated frameworks in general and especially of the one proposed here. Without such cross-sectoral thinking it is difficult to see how proper account of biodiversity and ecosystem services can be fully taken into account by decision makers.

2.6. Acknowledgements

We acknowledge all those people involved at different stages during the development of this framework, offering their time and knowledge to this work.

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3. Using an integrated Ecosystem Assessment

3.1. Introduction

In this chapter seven case explore the ESMERALDA integrated ecosystem assessment framework, and to examine its suitability of their policy- and science-related questions The individual contributions discuss advantages and disadvantages of using a holistic approach, as framed by the work in ESMERALDA as a way of investigating their issues, compared to the approach that was initially applied in their work.

The specific brief given to each of them was to consider the finalised framework presented in Figure 2.2 and indicate:

- what part of the framework is you study currently dealing with?
- how the work benefit by considering other elements of the framework?
- where does integration take place in your case study and how does this fit into the diagram?

In addition they were asked to:

- identify what methods being considered by ESMERALDA methods are being used in the case study,
- where in the IEA could/is this method(s) applied, and,
- which policy question the case study is addressed.

The case studies interpreted this brief very loosely and so it has not been possible to present the material using these pointers as headings. However, the material provided is rich in content and will be used as the basis of the more general discussion of the finalised IEA in Part 4.

3.2. Ecosystem Condition and its role in an integrated ecosystem assessment

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3.2.1. Introduction

Increasing demand for local and regional-scale ecosystem service (ES) mapping and assessment to support biodiversity management (Nagendra et al., 2013; Posner et al., 2016), land-use planning (Darvill and Lindo, 2015; Kopperoinen et al., 2014) and environmental impact assessment (Geneletti, 2013) drives the need for ES mapping and assessment related methods. Nevertheless, assessing ES capacity or demand are not the only requirements for evaluating the sustainability of ecosystem capacity to provide them. At the EU level, the Biodiversity Strategy requires Member States to assess and map the state of their ecosystems and their services. The Mapping and Assessment of Ecosystems and their Services Working Group (MAES WG) was mandated to coordinate the Action 5. In a recent report (Maes et al., 2018), the MAES WG proposed guidelines for the evaluation of ecosystem condition at EU level and proposed that ecosystem condition is directly supporting ES capacity. The ESMERALDA project, a Support and Coordination Action (SCA), funded under the European Commission's Horizon 2020 funding scheme with the specific aim of supporting the implementation of Action 5 in EU Member States proposed an integrative ecosystem assessment framework for evaluating ecosystem condition and ES (see Chapter 2 and Brown et al., 2018). The aim of this sub-chapter is to introduce the notion of ecosystem condition and related concepts, to quickly present options for indicators and references required for ecosystem condition mapping and assessment.

3.2.2. Defining ecosystem condition

Environmental and ecological literature, discussing the state of ecosystems, use various wordings and concepts to conceptualize and to describe the degree of intactness of ecosystems, with agendas ranging from ethical considerations on pristine and untouched nature (Leopold, 1949) to very practical issues such as defining metrics to evaluate the degree of degradation of river ecosystems (Jungwirth et al., 2002). The upshot is that policies setting conservation and sustainability target-states to secure long-term maintenance of ecosystems are framed in different terms, such as ecosystem integrity (Karr, 1993), ecosystem condition (Roche and Campagne, 2017), ecosystem state or ecosystem health (Rapport, 1989).

The recent development of the ES approach and sustainable use of natural resources has brought a resurgence in use of the ecosystem integrity approach as a measurement of ecological condition or capacity to maintain fundamental ecological functions and sustainably deliver ES and resources (Müller et al., 2000; Müller, 2005; Kandziora et al., 2013).

The specific goal of the notion of ecosystem condition is to link the state of ecosystems to the capacity to sustainably provide services and resources to meet both natural and human needs (Revenga, 2005; Nelson et al., 2006; Menzel et al., 2013; Schröter et al., 2016). As such ecosystem condition is closely related to concepts such as ecological health (Rapport, 1989; Costanza et al., 1992; Rapport et al., 1998) and ecosystem or ecological integrity (Woodley et al., 1993; Müller et al., 2000; Andreasen et al., 2001; Kandziora et al., 2013). For Roche and Campagne (2017), the notion of ecosystem condition (including ecosystem health and ecosystem quality) is used and related to an anthropocentric vision of nature, either as the state of the ecosystem in response to human pressures and disturbances or as the ability to continue to provide services to people. Ecosystem condition can be defined shortly as "… the sum of biophysical properties that underpin services" (Schröter et al., 2016: p819). This definition is used almost identically in the 5th MAES report (Maes et al., 2018), there the ecosystem condition is defined as "Ecosystem condition refers to the physical, chemical and biological condition or quality of an ecosystem at a particular point in time."

The MAES report uses 'ecosystem condition' and 'ecosystem state' as synonymous terms (Maes et al., 2018; p11). According to the SEEA-EEA definition, ecosystem condition is "*the overall quality of an ecosystem asset, in terms of its characteristics (...which) also underpins the capacity of an ecosystem asset to generate ecosystem services*" (Czúcz and Condé 2018; p5). This definition refers to the Millennium Assessment definition, ecosystem condition is "…*the effective capacity of an ecosystem to provide services, relative to its potential capacity*" (MA, 2005).

As a conclusion, the definition of the SEEA-EEA appears to be a very good compromise and we propose to use it slightly modified to avoid using the term quality.

Based on the existing literature, we propose here to define the ecosystem condition as

"The overall state of an ecosystem asset in terms of its biophysical characteristics that underpins its capacity to generate ecosystem services sustainably".

Besides the focus on ES capacity, the ecosystem condition is largely overlapping with other notions relating to the state of conservation of ecosystems and their biodiversity. We are going to introduce below some of these notions that can be encountered in the scientific literature and policy documents.

3.2.3. Other definitions and notions related to ecosystem condition

According to De Leo and Levin (1997); Czech (2004) and Tierney et al. (2009) Ecosystem integrity has basically two components:

- integrity — "*the state of being unimpaired, sound" and "the quality or condition of being whole or complete*", and
- ecosystem — "*the system of interacting physico-chemical environment and wildlife*".

Conservation ecology and ecosystem management address 'integrity' through the prism of the natural dynamics and functioning of ecosystems. Accordingly, one aspect of ecosystem integrity, that could be named "Ecosystem functional and structural integrity" (Roche and Campagne, 2017), can be estimated based on evidence of non-alteration of natural processes, such as natural disturbance regimes (i.e. flooding patterns in riverbeds or natural forest gap disturbances caused by dying tree falls; De Leo and Levin 1997; Minshall 1998; Clewell and Aronson 2006). According to the Society for Ecological Restoration (2004), the good health of an ecosystem is the state or condition in which its dynamic attributes are expressed within normal ranges of activity. Barkmann et al. (2001) also refer to functional ecological integrity as a political target for the preservation against non-specific ecological risks that are general disturbances of the self-organizing capacity of ecological systems.

Other aspects of integrity are related to the ecosystem stability and resilience (Table 3.2.1). It is linked to the previous aspect but focuses more on species and community responses. Andreasen et al. (2001) proposed that natural ecosystems possess high capacities of resistance and resilience to disturbances—be they natural or anthropic. A *resistant* system is a system that changes little following a disturbance, whereas a *resilient* system is a system that quickly and/or efficiently recovers its state following a disturbance. Parrish et al. (2003, p852) gave a closely related definition: "*An ecological system or species has integrity or is viable when its dominant ecological characteristics … can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions*". These assumptions rely on the observation that natural ecosystems usually possess high species and functional diversity and redundancy and thus also possess higher resistance and resilience capacities than impaired ecosystems.

Finally, quite often the notion of ecological quality or status is referred to in policy targets (Table 3.2.1). From this perspective, ecosystem integrity is defined by goals and objectives of ecological quality and conservation state that fit with societal demands. This definition has roots in the previous aspects of integrity but is operationalized by translations into 'evaluable' targets. This aspect ties into what Manuel-Navarrete at al. (2004) define as the systematic-normative discourse and ecosystemic-pluralistic discourse, where ecosystem integrity is defined either as a norm, even though based on ecological knowledge, or as a participatory definition of what is considered 'integrity' after a negotiation phase involving not just experts but society-wide stakeholders. Accordingly, potential indicators could be protected areas, red-list species, absence of pollution, aesthetic value, etc.

The aim of this section was to introduce the diversity and complexity of the concepts and wordings associated with ecosystem condition. Beyond, the lexical side of this review, it is important to acknowledge their differences and this will have consequences for the type of indicators than can be used and their meanings.

Table 3.2.1: Aspects of ecosystem integrity, definitions and potential indicators (based on Roche and Campagne, 2017)

Strands	Aspects	Definitions	Potential indicators
Nature Conservation	Integrity of wilderness	An absolute state of being entire, in perfect condition and unimpaired by human activities.	Biodiversity, Composition, Human activity, Hemeroby index
	Functional and Structural Integrity	A state in which the dynamic attributes are expressed in normal ranges of variability relative to its evolutionary stage of development.	Food webs Vegetation cover Habitat fragmentation
	Stability and Resilience	The ability to withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions.	Species traits Spatial connectivity Resilience capacity
Human Use of Nature	Ecosystem condition	The capacity and the ability of an ecosystem to provide the services that human expect.	NPP Energy efficiency Nutrient cycling Structure and patterns
	Ecological quality and status	A norm or a state with reference to what is considered as a good state for humans and societal needs.	Red list species Aesthetic value Natural heritage Absence of pollutions

3.2.4. Potential indicators that could be mobilized

The biodiversity and naturalness approach of ecosystem integrity puts the emphasis on the absence or the limited impact of human past and present activities as well as natural species composition and abundances. Some indicators have been proposed and implemented to quantify the degree of naturalness or intactness. We can cite here two indices: the Hemeroby Index (Machado, 2004; Walz and Stein, 2014) and the Biodiversity Intactness Index (Scholes and Biggs, 2005; Newbold et al., 2016). The hemeroby is an index based on the evaluation of the degree of pressure on nature mainly evaluated through the importance of anthropogenic land uses (urbanization, channelization, fragmentation, cultivation…). It can be quite easily estimated based on land cover maps and field evidence. Some papers such as Machado (2004) or Walz and Stein (2014) provide guidelines to allocate the hemeroby scores. Ecosystem condition is thus estimated as the absence or moderation of anthropogenic alteration of natural land covers/ecosystems. The Biodiversity Intactness Index is an indicator of the overall state of biodiversity in a given area, synthesizing land use, ecosystem extent, species richness and population abundance data. It is sensitive to the drivers and changes in the populations of species that typify the process of biodiversity loss, and robust to typical variations in data quality (Scholes and Biggs, 2005). It is model based and aims to evaluate the degree of departures from natural biodiversity levels. A global BII value GIS layer is available for download at approximately 1km resolution.

Considering the ecosystem condition as defined previously, potential indicators should refer to the biophysical aspects of the ecosystem and preferably relates to ecological function supporting a wide range of ecosystem services. As an example, the ecological functions that could be considered as those most important ones to sustainably supporting the provision of ecosystem services will be related to productivity, energy fluxes and nutrient cycling. We want also to state that it is important to identify the links between the potential indicators, the nature of what is supposed to be indicated and the goals of use. The MAES Framework (Maes et al., 2018) aims to identify a set of indicators addressing a large spectrum of ecosystem/landscape characteristics that can be linked with different aspect of ecosystem state, ecosystem services and policy objectives.

The 5th MAES Report proposed guidelines regarding the requirements for potential ecosystem condition indicators (Maes et al., 2018) that is particularly interesting in the context of ecosystem condition monitoring (Table 3.2.2). But these guidelines appear to be oriented toward supporting policy and environment legislation and mixes up two different aspects that are different: the ecosystem condition and the ecosystem quality. Four out of nine requirements classes refer to policy linked issues (supporting environmental legislation, policy relevant, include habitat and species conservation status and being application for natural capital account). The others refer to the scientific soundness, soil condition, spatial and temporal issues that are more directly related to biophysical characteristics and ecosystem condition.

The policy relevance of some indicators proposed in Maes et al. (2018) such as the protection status of habitat and species (Table 3.2.2) is more related to ecosystem status than to ecosystem condition; they describe societal responses rather than the state of nature. We would recommend considering separately ecosystem status indicators and ecosystem condition indicators. Having a high ecosystem status does not preclude ecosystems to be in a low condition and good condition ecosystem could have no protection status.

Ecosystem condition indicators can be grouped into two main groups: physico-chemical indicators and biological/ecological indicators. The physico-chemical indicators define the condition of the biotope associated with the ecosystem functioning (i.e. nitrogen, soil carbon, temperature, light …). The ecological indicators include all species and ecological structure of the ecosystems (i.e. species richness, diversity, life form spectrum, vegetation height, photosynthetic activity, productivity, fragmentation …). The 5th MAES report refers to these two groups respectively as "Environmental quality" and "Biological quality" (Maes et al., 2018).

Table 3.2.2: Requirements for the MAES indicator framework for ecosystem condition (from Maes et al. 2018).

Requirements	**Description**
Scientifically sound	Indicators should be based on the best available knowledge while giving a good representation of the ecosystem characteristics addressed
Supporting environmental legislation	Indicators should support the implementation of environmental legislation in the EU
Policy relevant	Indicators should be policy relevant: they have multiple policy uses and can support a policy narrative which links pressures, ecosystem condition, ecosystem services and policy objectives.
Include habitat and species conservation status	The conservation status of habitats and species (and in particular the parameters "area" and "structure and function") reported under Art.17 of the EU Habitats Directive should constitute a major indicator for assessing ecosystem condition.
Include soil related information	Terrestrial ecosystems are not in good condition if their soils are not in good condition. Specific indicators which assess the condition of soils should therefore be included.
Applicable for natural capital accounts	The indicator framework should support the development and testing of ecosystem extent and condition accounts.
Spatially explicit	Ecosystem condition is not equal across space. Different spatial gradients of pressures and differences in the response of ecosystems to pressures result in spatial variance of ecosystem condition which needs to be acknowledged in the indicator selection.
Baseline	Indicators should be measurable relative to a baseline year (e.g. 2010)
Sensitive to change	Indicators should be able to detect change over time.

Biological/ecological indicators can be related to different components of ecosystems: processes, structures and stocks (Figure 3.2.2). The processes indicators can be expected to be related to regulating services but also to support provisioning services. The structure indicators are supporting a wide range of ecosystem services from provisioning to cultural ones. The stock services are directly related to provisioning goods and services. The next step is to identify data sources that could document the proposed indicators for mapping and assessment exercises.

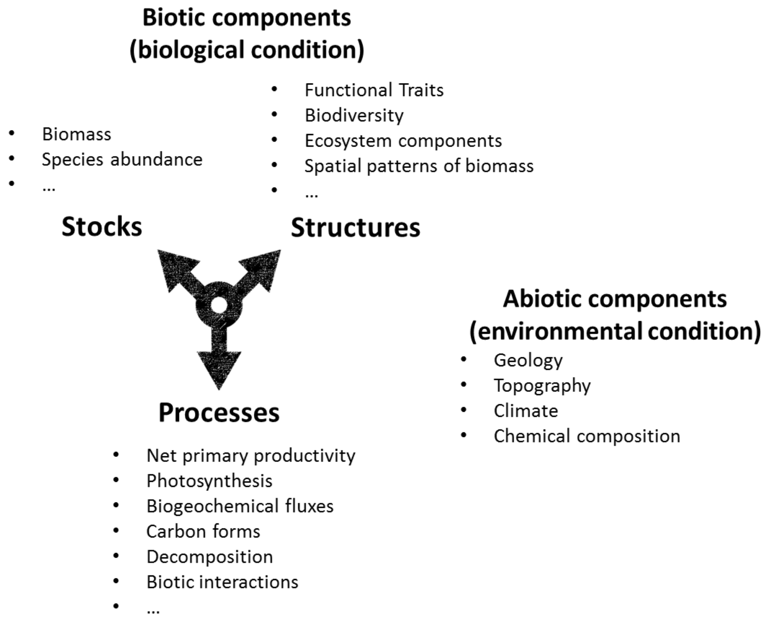

Figure 3.2.1: Potential indicators linked with different ecosystem components.

Alternatively, Roche and Campagne (2017) regrouped indicators based on the targeted type of ecosystem integrity considered, including ecosystem condition (Table 3.2.1). This helps to identify the range of ecosystem and species characteristics to be considered as functionally related to the definitions of ecosystem integrity.

Indicators of ecosystem condition are diverse and may address different aspects of ecosystem, their biodiversity and their abiotic environment (Figure 3.2.1 and Table 3.2.1). Ecosystem condition focuses on the capacity to support ES and many potential indicators should be related to functioning indicators such as NPP, energy efficiency or nutrient cycling, notably for provisioning services. However, some ES are more related to structural and compositional aspects of ecosystems (i.e. recreation, aesthetic value, erosion control, habitat and nursery, etc.) and could be addressed using proxy such as spatial structure and patterns, vegetation cover, species traits, etc. However, indicators could be overlapping between the different forms of ecosystem integrity. The idea here is more to propose some guidelines to identify indicators and relevant aspects of ecosystem integrity than to define a closed list.

The MAES ecosystem condition framework proposes that some indicators should be related to policy relevance, environmental legislation or accounting capability. We would prefer to use these types of indicators separated from ecosystem condition and use them to assess ecosystem status and/or ecosystem value. The prevalence of protection levels or red list species is not by itself an indicator of ecosystem condition; some protected areas could be in a degraded state while unprotected areas could be in very good condition. Keeping the ecosystem condition indicators and the ecosystem status indicators separated offers more opportunities to assess the efficiency of environmental policy and environmental legislation.

3.2.5. Relations between ecosystem condition and ecosystem services capacity

Ecosystem condition as defined previously is an integrated proxy to ecosystem properties supporting ES. The relationships between ES capacity and ecosystem condition are expected to be different between the categories of ES. Braat and ten Brink (2008) propose the theoretical relationships between biodiversity/naturalness and ES values. They proposed that some services such as regulating services and cultural services (excluding recreation) will increase with the ecosystem condition, while others will peak at some level of ecosystem condition (Figure 3.2.2). Using the hemeroby as a pressure indicator we adjusted the hemeroby score for each CLC classes to the ES capacity scores proposed by Stoll et al. (2015). We can observe using nonlinear models that the adjusted curves are following quite well the theoretical proposition of Braat and ten Brink (2008). The notable difference is that the scores for all services falls for the most natural ecosystems. It can be considered that the capacity for regulating services are monotonically related to ecosystem condition as in the Braat and Brink (2008) model (i.e. good condition is related to good functioning) but the use of regulating services will peak in semi-natural ecosystems since the most natural ones, have high capacity but low use due to lack of human activities.

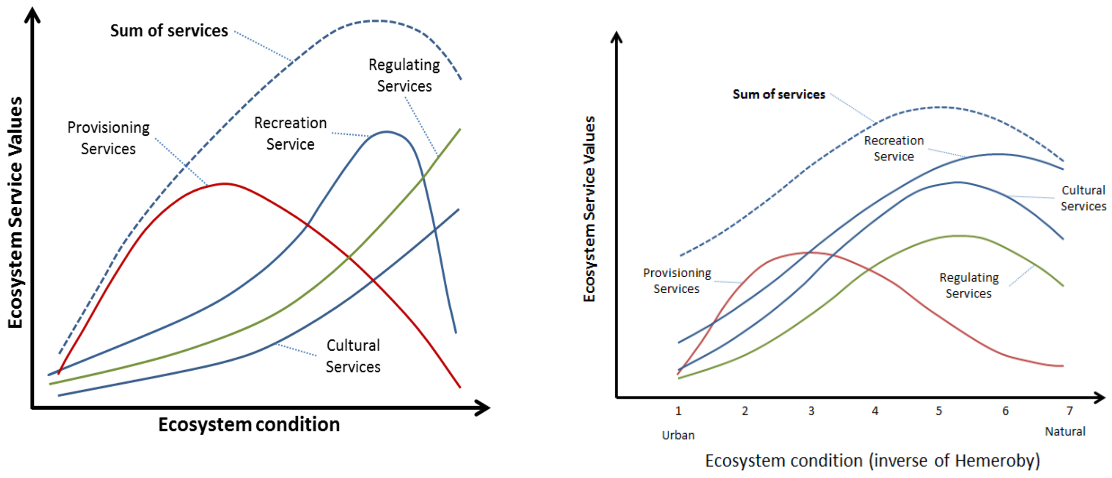

Figure 3.2.2: General Title: Relationship between ecosystem condition and ecosystem services ecosystem capacity.

Left graph: Theoretical relationships between ecosystem condition and ecosystem service values (adapted from Braat and Brink 2008. Cost of Policy Inaction). Right graph: adjusted curves of ES scores from Stoll et al. (2015) to CLC hemeroby values derived from Walz and Stein (2014) (unpublished results of Roche and Campagne).

3.2.6. References and calibrating ecosystem condition

When considering ecosystem condition assessment and monitoring, two broad options can be implemented. The first one is to identify relevant indicators, known to be related to ecosystem condition and monitor them in time and space in order to follow the indicators changes. If the values of the indicators increase, then the ecosystems condition improve (the reverse is also true). The indicators make sense based on their changes. It is the approach proposed by SEEA and MAES. The second option is to benchmark the indicators values to reference systems through observations or modelling. We will present some guidelines regarding the second option, the first one being quite explicit.

3.2.6.1 Reference conditions

Benchmarking the ecosystem condition could be done with regards to ES capacity if the focus is on delivery capacity or by using references based on the ecosystems past conditions or comparison with modern analogs (Vogiatzakis et al., 2015). The notion of reference conditions is well used in restoration ecology and it has been defined by WWF/IUCN 2000 as "*model for planning an ecological restoration project, and later serving in the evaluation of that project*" (Dufour and Piégay, 2009; p2). But, the notion can refer to many and contradictory concepts depending on the application. Stoddard et al. (2006) distinguish several references conditions for running waters that could be used for evaluating the conditions of a large range of ecosystems. We propose here to resume references conditions and relate them to expected states expressing societal targets (i.e. the ecosystem quality concept). The reference conditions are presented in Figure 3.2.3 in a gradient of "ecological integrity" (as a general concept) and in an increase of human impacts. The societal targets are classified as desirable, acceptable, attainable or unacceptable states. Like the ecosystem quality concept, the societal expectations related to an ecological integrity depend on the society and its ethical value attached to nature (Manuel-Navarrete et al., 2004).

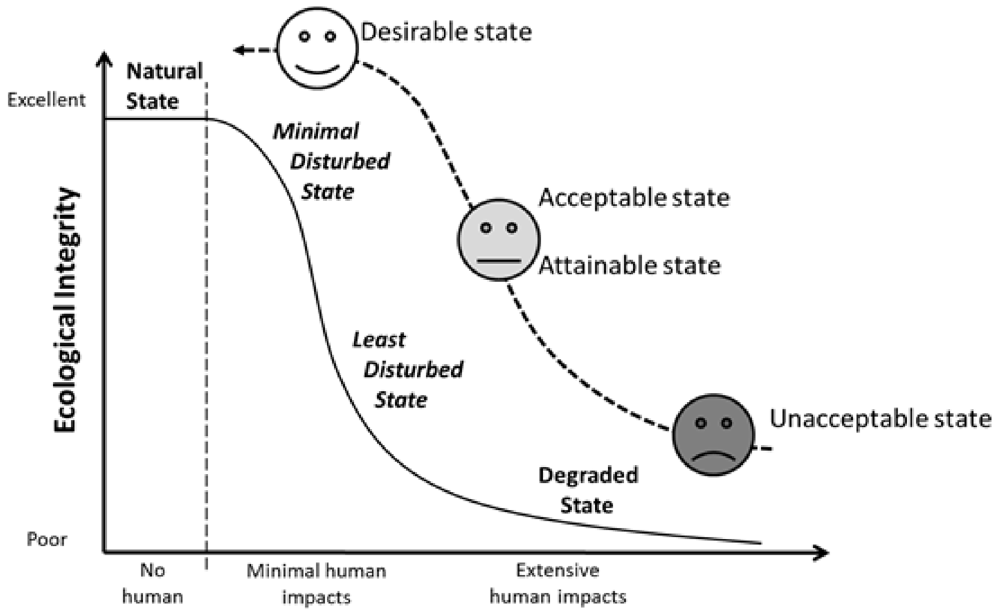

Figure 3.2.3: References conditions and expected states (adapted from Stoddard et al., 2006)

With no human impacts and the best integrity is the natural state. Stoddard et al. (2006) define it as Reference Condition for Biological Integrity (RCBI) "*for naturalness even though we might only approximate it in most parts of the world because of the pervasiveness of human disturbances*" [...] "*as a definitive benchmark to capture the original intent of efforts to maintain and/or restore biological condition to some state of naturalness*". Linked to an ethic of integrity as a foundational value (Manuel-Navarrete et al., 2004), this reference condition is related to the desirable state (i.e. ideal conditions in Jungwirth et al., 2002) in order to achieve the absolute state of an ecosystem (i.e. pristine ecosystems in Manuel-Navarrete et al., 2004).

Stoddard et al. (2006) define the minimally disturbed condition (MDC) as the "*absence of significant (or slight signs of) human disturbance".* For this condition the reference site would have minimal disturbance criteria like, for example, in protected areas (Andreasen et al., 2001; Stoddard et al., 2006). Depending on the social expectation, this reference condition can illustrate the desirable state or an acceptable state. For example, in a protected area the desirable state would be a natural state, but the human impact/ global change only allows the achievement of a MDC which would be an acceptable state (Andreasen, et al., 2001). Acceptable state "*establishes the minimum criteria for identifying a conservation target as conserved*" (Parrish et al., 2003).

Then the least disturbed condition (LDC) (i.e. "least impacted situation" (Jungwirth et al., 2002) is defined as the "*lowest signs of human disturbance in an area with extensive human disturbance*", also qualify as "*the best available physical, chemical, and biological habitat conditions given today's state of the landscape*" (Stoddard et al., 2006). A reference site of LDC would be sites with the best existing condition or sites with lowest stressors regime (Stoddard et al., 2006). This reference condition illustrates the acceptable state because the intensity of the human impacts doesn't allow reaching the desirable state. Moreover, it's also relatable to the attainable state, named and defined by Stoddard et al. (2006) as the "best attainable condition" (BAC): "*a state that is better than any in existence in a heavily modified region, but differs from either MDC or RCBI) because those states might not be achievable."*

The distinction between the acceptable state and the attainable state (BAC for Stoddard et al., 2006) is also marked by the feasibility. Indeed, in a restoration process, the desirable or acceptable state can't always be reached depending on the technological and ecological feasibility, the financial limits, etc. Finally, we would add the degraded reference conditions defined as the socially unacceptable state (Andreasen et al., 2001).

3.2.6.2 Time references

Depending on the references identified as appropriate and the data available, references values can come from different time periods. We propose to differentiate as followed in a human influence gradient. Based on the notion of natural state, the paleoecological references can provide reference from ecosystems without any or marginal human impacts (Jungwirth et al., 2002). Depending on the ecosystems sensibility to environmental change, the reference time period can fluctuate. Reif and Walentowski (2008) talk about the Atlantic period, ca 6000 to 8000 years b.p. for original natural forest. The pre-settlement period is very often referred to in North America (Andreasen et al., 2001) and Australia and pre-Columbian in South and Central America (Stoddard et al., 2006). In Europe, we can consider a tiny/slightly progressively increase of human influence in Stone Age to Iron ages (Czech, 2004). Indeed, human impacts have been showed on running water back to about 4000 years in Western Europe (Petts, 1996). The pre-industrial reference corresponds of an absence of large/major impact of human (Dufour and Piégay, 2009). Industrialization period is considered as a "*fundamental shift in the relationship of humans to their environment*" and some consider, after it, that "*no geographic area can be said to retain absolute ecological integrity*" because of global change (Czech, 2004). Stoddard et al. (2006) also consider a pre-intensive agriculture references with "*very low pressure without the effects of major industrialization, urbanization and intensification of agriculture, and with only very minor modification of physicochemistry, hydromorphology and biology*''. Even if it's understandable that global change and human activities have fundamentally modify natural trajectory, some made "*the distinction between historical and actual naturalness*" (Reif and Walentowski, 2008). Human is part of the ecosystem and many changes are irreversible so actual natural states have to be defined.

3.2.6.3 Spatial references

Data from time reference can be limited by the availability or can be inexistent depending on the ecosystem and because scientific knowledge has a relatively short history (Parrish et al., 2003). So reference values for the evaluated ecosystems can come from a reference site. Reference sites allow paired comparisons and give a baseline condition (Minshall, 1998). Natural geographic variabilities of ecosystems are quite important to consider for a reference site. In any case, we recommend in minima to have a reference site in the same biome (e.g. temperate, equatorial, etc.) as the case study. The same climatic region (in Europe: Mediterranean, Alpine, Continental, etc.) increases the precision. A reference site in the same location or in a really close patch of the study case is the best in order to have the most similar ecological conditions but it’s not always easy to be found.

Here, we discussed briefly the reference systems for indicators values of ecosystem conditions. The indicators have to be evaluated with some baseline through observations or modelling taking into account the reference conditions considering time and spatial references and related to the expected states. Clearly defined references conditions and expected states are important to identify conservation and protected actions. Another option would be to set up monitoring systems to assess the indicator values in time and to relate changes to the expected trends associated with ecosystem condition improvement or degradation.

3.2.7. Discussion and recommendation

Assessing and monitoring ecosystem condition is a key component of the evaluation of the ecosystems management and ecosystem services provision sustainability. The notion of ecosystem condition is used and related to a more anthropocentric vision of nature (MA, 2005; Kandziora et al., 2013), either as the state of the ecosystem in response to human pressures and disturbances or as the ability to continue to provide services to people. Seen from this perspective, this notion of ecosystem condition is compatible with human management and disturbances, since it clearly refers to the capacity of ecosystems to provide humans with services and resources over the long term (Czech, 2004; Mackey et al., 2010; Haines-Young et al., 2012; Hermoso and Clavero, 2013; Kandziora et al., 2013). However, as stated in Hull et al. (2003: p3) “*there also seems general agreement that human intervention can produce healthy and sustainable ecosystems, but that such systems are less likely to have integrity*”. Accordingly, in the most artificialized land covers such as urban and very intensive agricultural ecosystems where the ES are highly dependent on human capital (Jones et al., 2016), the notion of ecosystem condition may reach its limits. Nevertheless, it may provide some references to design nature-based solutions (i.e. favour biodiversity, resilience capacity, connectivity, etc.) to reach at least an acceptable state (see Figure 3.2.3). This also means that improved systems that could sustainably provide ecosystem services cannot be considered as having a high ecological integrity but a good ecosystem condition. This point is important for many agroecosystems and high-nature-value areas whose state and biodiversity result from strong and ancient human management. The focus is more on the sustainability of natural resources, environment and ecosystem services to people.

As a consequence, we recommend paying attention to the different aspects of ecosystem integrity and on the potential indicators associated with these different concepts. The ecosystem condition indicators have to be assessed and calibrated before using them as a proxy to evaluate the ecosystem condition in monitoring programs. This calibration could be based on different approaches and at different scales.

Ecosystem integrity and ecosystem condition are very important aspects of ecosystem assessment and should be a required complement to ES capacity in order to address conservation actions, management options and policy aimed at long term ecosystem sustainability. As proposed in the framework by Burkhard et al. (2018), as well as the ESMERALDA framework (see Chapter 2 of this Deliverable) ecosystem condition should be assessed in a complementary way to ES capacity, use and demand. Ecosystem condition and ecosystem services sustainability are two sides of the same coin if the goal is to promote meaningful and efficient environmental policies and resilient socio-ecological systems. Recently the 5th MAES report proposed a framework that represented ecosystem condition as the ecological "equivalent" of "human well-being" for social systems (Maes et al., 2018: p12). We partially agree with that proposition since ecosystem condition indeed is strongly related to what could be defined as "ecosystem wellbeing". Nevertheless, ecosystem condition is partly human focussed; as stated in Burkhard et al. (2018), besides the biotic and abiotic characteristics of an ecosystem that underpin notions of condition, it can also be considered to relate to the capacity to *provide* ES. We would therefore prefer to use the term 'ecosystem integrity' to indicate the state of 'ecosystem wellness' and ecosystem condition for the capacity to provide ES. However, contrary to Burkhard et al. (2018) and Maes et al. (2018), we propose that indicators related to policy targets and environmental legislation should be considered separately from ecosystem condition to allow independent assessment of ecosystem state, ecosystem status and policy efficiency.

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3.3. Mapping and Assessment of Flood Regulation Ecosystem Services in an urban environment

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3.3.1 Background

The EU Biodiversity Strategy to 2020 calls on the Member States to map and asses the state of ecosystems and their services in their national territories by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020 (EC, 2017). The Strategy defines mapping and assessment of Ecosystem Services (ES), as a comprehensive process that integrates various tasks to support sustainable development. The conceptual framework for implementation of the Strategy in EU countries was developed by the working group on Mapping and Assessment of Ecosystems and their Services (MAES), (Maes et al., 2013). ESMERALDA (Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking) project aims to deliver a flexible methodology for implementation of Action 5 of the BD Strategy, supporting the needs of assessments in relation to the requirements for planning, agriculture, climate, water and nature policy. "The ESMERALDA framework for an integrated ecosystem assessment (IEA) was developed to provide practitioners and decision makers with a tool that enables them to flexibly bring together different activities of existing ecosystem assessment frameworks in an integrative way" (Potschin-Young, 2018). In this sub-chapter we aim to present an example how the integrated ecosystem services assessment framework can be used to map and assess flood regulation ES provided by urban ecosystems using a case study from Bulgaria.

The institutionally coordinated process for implementation of the ES assessment and mapping in Bulgaria started in 2014 with preliminary mapping of ecosystems in NATURA 2000 zones. The assessment and mapping of urban areas was carried out through the TUNESinURB Project (Nedkov et al., 2018a in review). The process of concentration of population in towns and cities makes achievement of the Biodiversity Strategy goals in urban areas of great importance. Urban blue and green infrastructure provides important climate and flood regulation services, including services for mitigation and adaptation to climate change and related flood hazard. The European Commission has developed a Green Infrastructure Strategy which aims to make the green infrastructure "an integral part of spatial planning and territorial development (EC, 2013). The strategy supports natural water retention measures that aim to safeguard and enhance the water storage potential of landscape, soil, and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes (EC, 2016a; EC, 2016b). Implementation of ES assessment and mapping of flood regulation ecosystem services would contribute for better understanding of the capacity of nature and land use management to cope with urban flood hazard. Managing the capacity of ecosystems to provide flood regulating services is an important alternative for flood hazard mitigation and prevention. Implementation of the EU Flood Directives 60/2007/EC is key factor in the flood risk management, but it does not incorporate ecosystem services approach in the policy process for river basin management and flood risk reduction. However, the Flood Directive is open for regular updates and the mapping and assessment of flood regulation ES in the river basins may find place in it in the future. It would require better integration between implementation of the EU Directives 60/2000/EC, the EU Flood Directives 60/2007/EC and the goals of the EU Biodiversity Strategy and Green Infrastructure Strategy at European level.

The water management at national level is carried out in accordance with EU and national legislation such as Environment Protection Act, Water Act, regulations, national strategic and planning documents such as National Strategy for Management and Development of the Water Sector, Plans for River Basin Management, Plans of Flood Risk Management, Marine Strategy, national programs in the field of protection and sustainable development of waters. At local level an integration between land use management and site-specific nature-based solutions in accordance with the flood regulation ES assessment and mapping have to find place in the cities Flood Risk Management Plans. The main challenge in terms of regional environmental policies and territorial strategies is to successfully combine the protection of natural assets and landscapes with ecosystem services and sustainable territorial development (Nedkov et al., 2018a).

3.3.2 Flood regulation ecosystem services and CICES

According to the Common International Classification of Ecosystem Services (CICES)[1] v 4.3. typology the class "Flood protection" pertains to the group "Liquid flows", Division "Mediation of flows", section "Regulation and maintenance". While we are aware of the update of the Common International Ecosystem Service Classification version 5.1, in this case study we are still using version 4.3 as the bases for our investigation as set out in the DOA of ESMERADA (ESMERALDA DoA, 2015). In respect of water the difference is that water is included under abiotic outputs in CICES V5.1 "because hydrological cycles are mainly driven by geo-physical processes" (Haines-Young and Potschin, 2018). The interaction between biophysical and geo-physical processes determines potential capacity of natural capital to provide regulating and maintenance ecosystem services. In CICES V5.1. Regulating and maintenance ES are defined as "All the ways in which living organisms can mediate or moderate the ambient environment that affects human health, safety or comfort, together with abiotic equivalents". When the ES "Regulation and maintenance" do not provide a sufficient degree of ecosystem services, as for example in cities where the natural cycle of water is influenced by paved impervious surfaces, the risk of extreme fluctuations in river flow is bigger and can lead to water shortages or flooding. It depends on the capacity of the landscape to hold the exceed volume of water. The water flow can be influenced by a number of natural processes and functions of the ecosystems, which contribute to the absorption of water and therefore reduce surface runoff or vice versa. The main factors of the capacity for water retention are: the vegetation cover, soil structure and texture, the presence of bare land or water bodies, the slope and the land cover. In urban ecosystems "Flood protection" service depends on the proportion of the green infrastructure and the ratio in its spatial distribution in the different land use types.

3.3.4 Policy context

As noted in Chapter 2 of this deliverable "the final design of any integrated assessment is shaped through the questions which are being asked and the mandate provided for the assessment". An updated list of relevant ES policy questions (PQ) as developed in ESMERALDA is available from Maes et al. (2018). Practical application of ES knowledge enables the territorial integration of interests,

[1] See www.cices.eu (Haines-Young and Potschin, 2013)

activities, policies and overall governance. This, in turn, creates a basis for active management of ecosystems as service sources, while maintaining a sustained motivation of the local community and other stakeholders to cooperate in the process (Nedkov et al., 2018b). Formulating policy support question such as "How can ES be used to support disaster risk reduction?" and in particular flood risk we actually are seeking to integrate the answers from at least few additional technical questions: 1) To which level of the governance system the relevant question is addressed?; 2) "How can we better communicate the social benefits of nature-based solutions into decision making?" (13th MAES meeting); 3) "What kind of information will be recognized?; 4) "Which methods are available to map, quantify and assess specific ES"? How to communicate and disseminate final results to the relevant users? The expected long-term outcome is to achieve simultaneous results in the natural, social, cultural, political, and economic aspects of sustainable development in the respective area. It is a real challenge for the cities to implement such a balance without a long-term policy goals like SDG's, and science-based tools for implementation of nature-based solution to the environmental problems. One of the key impacts of the mapping and assessment of ES is that it is able to provide such a tool and to smooth the tensions that often arise between the different interest of the investors to the build and green infrastructure in the cities and public administrations which recognise the positive impact of the green environment and protected areas. A comprehensive identification and consideration of the dependence of the local population on the ES in the nearby areas makes valuation of the ES an important factor in sustainable landscape planning and territorial integration policy making (Borisova, 2013). Examples for implementation of ES assessment and mapping of flood regulating services could contribute for better understanding of the capacity of nature and land use management to cope with flood hazard at all levels – region, basin and settlement (Boyanova et al., 2014; Larondelle et al, 2014).

3.3.5 Case study area

Mapping and assessment of the urban ES requires integration of different methods and indicators for assessment of the state and services and different management policies which are illustrated here by the case study on assessment and mapping of flood regulating ES in town of Karlovo, Central Balkan area. The Central Balkan National Park occupies the higher parts of the mountain, ranging in altitude from 550 m to 2376 m. The Park is part of the PAN Parks network and is also one of the largest and the most valuable protected areas in Europe, ranked at category 2 by IUCN. The Central Balkan National Park belongs to the Rhodope montane mixed forests terrestrial ecoregion of the Palearctic temperate broadleaf and mixed forest. It is home of rare and endangered wildlife species and communities. Both cities and catchments situated in the frames of Central Balkan area depend on important regulating ecosystem services provided by this mountain area, like flood and climate regulating services. Climate extremes, heavy rains and floods are frequently observed phenomena in the study area. The choice of town of Karlovo as a case study example for implementation of IEA framework is due to its location in Central Balkan protected area. The close interaction between the urban ES and those in the surrounding protected area with rich biodiversity and variety of ES (Figure 3.3.1) on one hand and the flood prone territory of the town and the need to increase its resilience providing an ES based management alternative on the other.

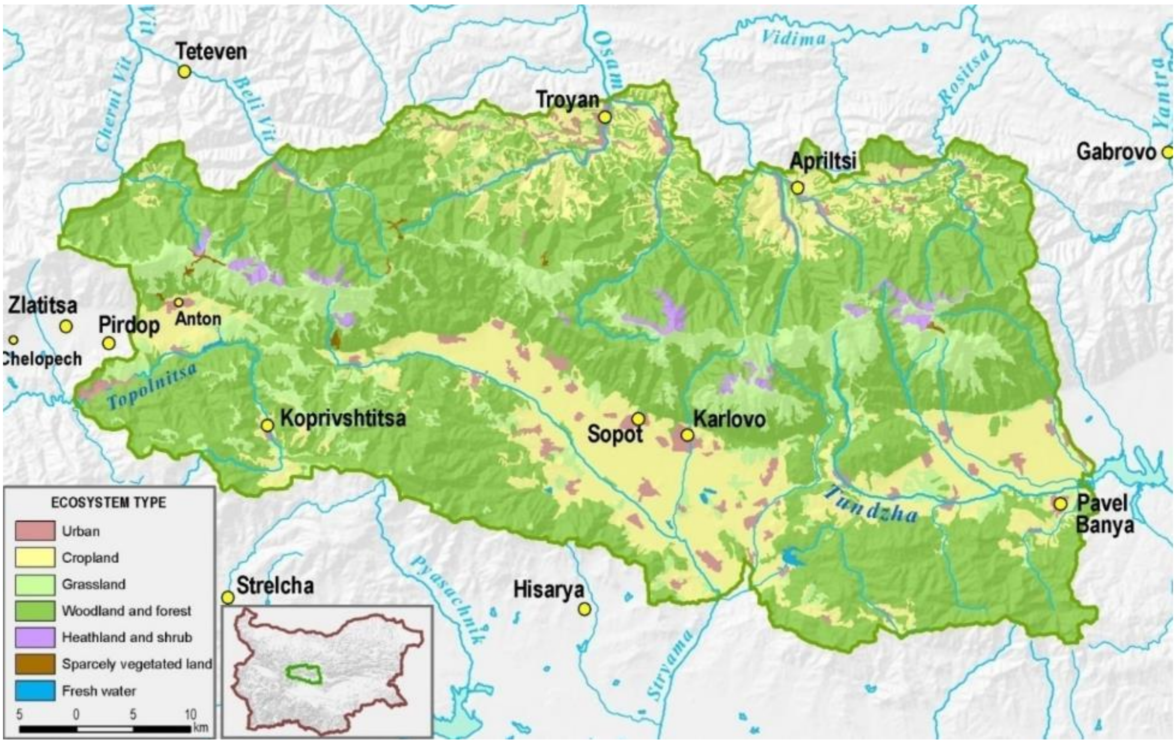

Figure 3.3.1. Ecosystem types in Central Balkan area

Karlovo (280 km²) is administrative centre of the municipality of Karlovo (1044 km²), situated in the Karlovo Plain (average altitude of 452 m) between the southern steep and rocky slopes of the Balkan mountain and the north forested slopes of the mountain Sarnena Gora. The mountain relief and precipitation extremes of up to 66.7 mm/24h contribute for the higher risk of flood events. Through the town flows the River Stara, left tributary of the River Stryama. River Stara rises in the area of peak Kochmara (1997.6 m) and passes through a steep valley to its entry in Karlovo plain below the Suchurum waterfall (15 m). On its way River Stara gathers the water of five small streams. The climate of the town of Karlovo is temperate-continental with average annual temperature of 11.4° C and annual amount of rainfall of 653 mm (Reference Book Precipitation in Bulgaria, 1990). Soils diversity is represented mainly by Fluvisoils, Chromic Cambisols, Chromic Luvisols, Distric Planosols, and Andosoils (Geography of Bulgaria, 1997). Forests are the predominant land cover in of the Central Balkan occupying 56% of its area. The natural vegetation of Oak and Oak-Hornbeam forests is replaced by cultivated land cover in the Karlovo Plain. Direct impacts on territorial development are strongly linked to the ongoing management of the protected areas and implementation of national policy in conservation. In recent years municipalities in the region of Central Balkan NP tried to include the enhancement of the ecotourism circuit and to improve quality of products and services, which are outlined in the municipality plans. At the local level, some municipalities and actors work on the promotion of sustainable tourism and infrastructures to valorise biodiversity, given that nature and cultural tourism is the key potential for development in the area. The municipality of Karlovo (30 340 inhabitant) has leading role in this process in close cooperation with the Central Balkan NP authorities. The water and natural hazards control (i.e. forest fires, soil erosion, flood, avalanches) and climate regulation through forests are crucial ecosystem services in the study area (Nedkov et al., 2018a). However, there are no any actions at city level towards implementation of ES approach to the flood risk management practices.

3.3.6 Methodology for mapping and assessment

The methodological framework developed and applied here is relevant to urban ecosystems in Bulgaria; it comprises the full cycle of assessment and mapping the capacity of these ecosystems to deliver ecosystem services.

3.3.6.1 Mapping of ecosystems

Identification and mapping of ecosystems are important parts of the IEA. Urban ecosystems are considered as "areas where most of the human population lives and it is also a class which is significantly affecting other ecosystem types" (Zhiyanski et al., 2017). For delineation of urban ecosystems, the typology of MAES (Maes et al., 2013) at first and second level (ecosystem types) was further developed at third level (ecosystem subtypes) for territory of Bulgaria. The regulation of water flow and flood hazard in the urban environment is a complex process that depends on extremely wide range of factors. Therefore, each ecosystem subtype has a particular role in this process and can be object to an assessment. The ecosystem subtypes presented in Karlovo and their role in flood regulation is given in Table 3.3.1.

Table 3.3.1. Urban ES subtypes with capacity to provide urban ecosystems service "Regulation of water flows and flood hazard" (after Zhiyanski et al., 2017)

Index	Subtype urban ecosystems	Role in providing the service "Regulation of water flows and flood hazard"
J1	Residential and public areas of cities and towns	Characterized by a different type of construction and ratio between the green and sealed areas. The larger share of green areas increases the capacity of the ecosystem to retain water.
J3	Residential and public low density areas	Sparsely populated areas are characterized by a smaller proportion of the sealed areas and respectively with better regulatory functions.
J5	Urban green areas (incl. sport and leisure facilities)	The role of green areas for the provision of the service is very important. It is expressed by the regulatory functions of the soils, to which these areas are linked, as well as the adjoining to them blue infrastructure.
J6	Industrial sites (incl. commercial sites)	Industrial zones can have different capacities to provide the service, depending on their nature and the type of construction.
J7	Transport networks and other constructed hard surfaced sites	Transportation network does not have a large capacity for regulation of water streams, but the adjoining vegetation surrounding roads can have such features.
J9	Waste deposits	The capacity of these ecosystems depends on the physical characteristics of the deposits (household or industrial waste).
J10	Highly artificial man made waters and associated structures	Because of the wide variety of these structures and their effects on the regulation of water streams can be omnidirectional.

The delineation of urban ecosystems at national level in Bulgaria was performed in two steps. First, the extent of urban ecosystems, which correspond to level 2 of the typology, was outlined and at the second step the resulting polygons were divided into ecosystems from more detailed classification at level 3. For delineation of the ecosystems at level 3, a flexible spatial approach was developed (Nedkov et al. 2016). It used multiple data sources such as digital cadastre of the cities, restored property plans, digital orthophoto map of Bulgaria and incorporates several GIS tools and analyses. The Digital Cadastre of the settlements in Bulgaria is the most useful spatial data source but it is available only for some big cities. For urban ecosystems in the cities with available digital cadastre they were delineated using the information for land use part of this database. The polygons were classified into ecosystems at level 3 and then they were aggregated in order to meet the requirement of the methodology. The cities and villages without digital cadastre were mapped using the Restored Property Plan database and Digital orthophoto map of Bulgaria as complementary sources. The output vector dataset containing the graphical representation of the ecosystem subtypes was prepared in scale 1:25,000 while the minimum mapping area was fixed at 0.25 ha. The spatial distribution of the relevant ecosystems subtypes in Karlovo is represented in Figure 3.3.2.

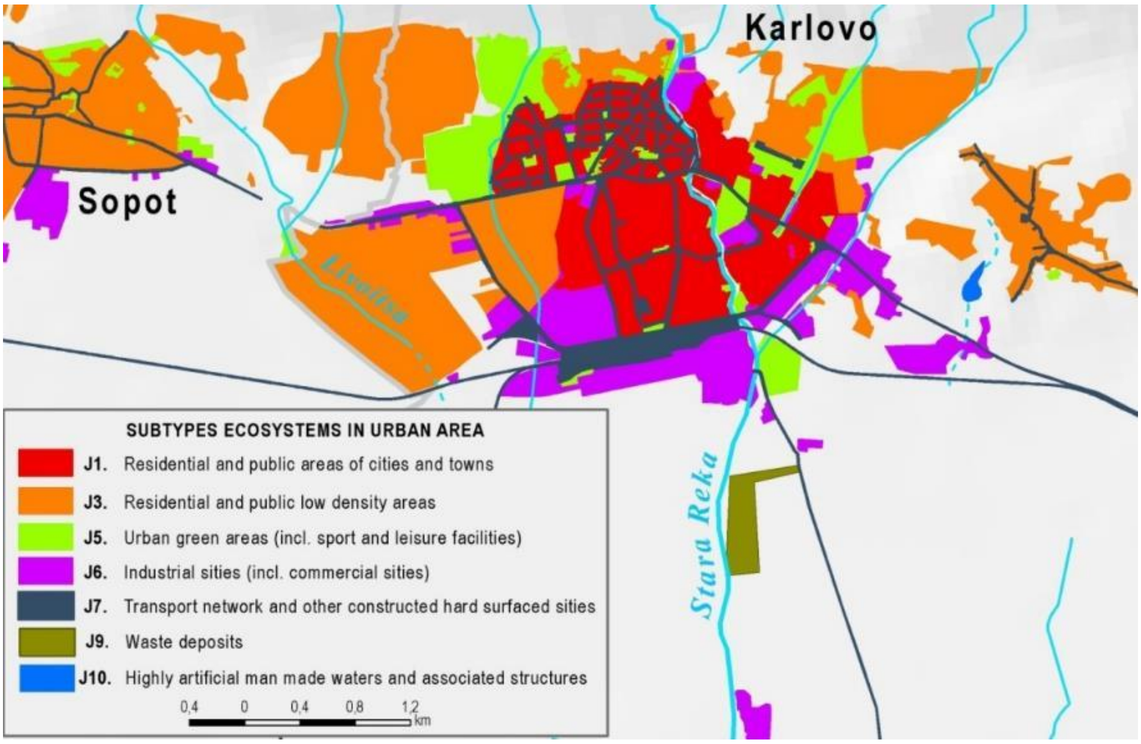

Figure 3.3.31. Urban ecosystem subtypes in the city of Karlovo

3.3.6.2 Assessment of ecosystem condition

The assessment of ecosystem condition is the second step in the MAES framework (Maes, 2013) and it is based on indicators that reflect the biophysical aspects of the ecosystem and relate to the ecological functions supporting a range of ecosystem services (Roche and Campagne, 2018). Therefore, the indicators for ecosystem condition can also be used in the ecosystem services assessment which is ensures integration between these elements of the framework. The condition of the ecosystems in the town of Karlovo was assessed within the study on national assessment of the urban ecosystems.

The assessment of ecosystem condition is measured by a set of indicators which are organized in a system based on the concept of ecosystem integrity. The indicators classification system is organized in four levels. At the first level there are two main categories - ecosystem structure and ecosystem processes which are divided at the second and third level as it is presented in Table 3.3.2. Each item from the third category was further divided to form an operational set of 37 indicators at the fourth level. Each indicator has its own parameter, measurement unit and measurement approach. The assessment scale for all indicators is unified in five-level scoring system: 1 – very bad; 2 – bad; 3 – moderate; 4 – good; 5 – very good (Zhiyanski et al., 2017). The scores were defined according to the analyses of measured parameters and were individual for each indicator.

Table 3.3.2: Indicators for ecosystem condition in Bulgaria based on the concepts of ecosystem integrity

ECOSYSTEM STRUCTURE	**Biotic heterogeneity**	Plant diversity	**ECOSYSTEM PROCESS**	**Energy budget**	Energy balance
		Animal diversity			Entropy
		Habitat diversity			Metabolic
		Invasive species			Other energy
		Other biotic		**Matter budget**	Matter balance
	Abiotic heterogeneity	Soil heterogeneity			Element
		Hydrological			Efficiency
		Air heterogeneity		**Water budget**	Water balance
		Geomorphological			Water storage
		Other abiotic			Other state
					Efficiency

For the assessment of flood regulation we used two indicators: vegetation cover and integrated index of spatial structure of urban ecosystems. The first one is part of plant diversity group and the second part of other abiotic indicators group. The vegetation cover of urban ecosystems is measured as the percentage of the total area of vegetation for particular ecosystem subtype (Zhiyanski et al., 2017). This is very important indicator because it reveals the role of the green infrastructure which is the main source of ecosystem services in urban areas. The regulation role of the vegetation cover for redistribution of water flows in an urban environment has been demonstrated in the form of absorption of soil moisture from the plants, transpiration and interception (the amount of precipitation that retain on vegetation). As a parameter which represents the regulation role of vegetation cover we use the parameter Area with vegetation cover (VC), represented as area with vegetation cover compared to the sealed surface of artificial ground in cities. The larger the percentage of vegetation cover, the more pronounced are the regulation functions of the ecosystem in terms of the flood hazard and regulation of water flows.

The integrated index of spatial structure of urban ecosystems is based on the classification of local climate zones for urban temperature studies developed by Steward and Oke (2012). The classification scheme consists of two main parts: built type and land cover type. There are 10 built types indicated by number from 1 to 10 and seven land cover types indicated by capital letters from A to G. The analyses of the ecosystems data revealed that within single polygon there are usually several land cover types and sometimes more than one built type. For the identification of the built type within a polygon we used an approach of dominance which means that the type predominant area will define the index of the polygon. Some ecosystem subtypes such as green urban areas (J5) or artificial water bodies (J10) have no buildings therefore we added complementary built type 11 (no buildings) which corresponds to areas without buildings. For land cover types we applied different approach by combination of the existing types within a polygon. For instance, the residential area with scattered trees (type B), grasslands (type D) and paved areas (type E) is defined as BDE. This combination is added to the ecosystem subtype and built type to for the integrated index of spatial structure. For instance, J15BE means residential and public areas of cities and towns (J1), open arrangement of midrise buildings (5), scattered trees (B) and paved areas (E). For the purposes of this study we used the land cover part of the index. In flood regulation assessment we used only land cover part of the index. The potential of each land cover type to regulate water flows and flood risk is defined by expert assessment (Table 3.3.3).

Table 3.3.3: Types of land cover in Karlovo (after Steward and Oke, 2012)

Index	Type	Definition	Capacity
A	Dense trees	The densely wooded landscape of deciduous or coniferous trees. This may be an urban forests, parks or nursery garden.	Very high
B	Scattered trees	Poorly forested landscapes of deciduous or coniferous trees. This may be an urban forests, parks or nursery garden. Low vegetation prevails.	High
C	Bushes	Dominating shrubland, low scrub or trees. In the land cover there are bare soils and sands or farmlands.	Medium
D	Low vegetation	The landscape is dominated by grass vegetation or crops with or without single trees. It may be natural grassland, agricultural land or city parks.	Low
E	Bare rocks or paved areas	The landscape function is as natural desert or urban transport system with few or no trees.	Very low
F	Bare land or sand	There are separate trees or bushes. It may be natural desert or bare land	Very low
G	Water	Water bodies like sea, lakes or rivers	Low

3.3.6.3 Assessment of ecosystem services

The identification of ecosystem services is based on CICES classification (Haines-Young and Potschin, 2013) by selection of those which are relevant to urban ecosystems and can be supported by appropriate dataset for the assessment. The selection led to identification of 25 services which have to be assessed by using appropriate indicators for their quantification. The methodological framework for ecosystem services assessment is based on the “matrix approach” proposed by Burkhard et al. (2014) with relative six-level scale ranging from 0 to 5. The assessment of flood regulation is carried out into four main steps: 1) identification of the urban ecosystems with potential to provide flood regulation; 2) selection of indicators for ES assessment; 3) quantification of the ES indicators; and, 4) assessment and mapping of flood regulating urban ecosystem services. The main factors that determine the capacity for water retention in the landscape are the character of the vegetation cover, soil structure and texture, presence of impervious surfaces and bodies of water, slope and type of land cover on the area. The proportion of green infrastructure and the ratio in its spatial distribution in the different types of land use and constructions have major impact on the capacity of urban ecosystems to provide this service.

The quantitative characteristics of the parameters are normalized using five qualitative categories defined by five ranging intervals from 1 to 5. The estimates presented in Table 3.3.4 relate to each of the indicators used to assess the capacity of the soil to retain water.

Table 3.3.4: Scale for assessment of parameters FC and FR

Parameter	1	2	3	4	5
FC (%)	20-25	26-30	31-35	36-40	> 40
FR(cm/s)	0,0001-0,0003	0,0004-0,0006	0,0007-0,0009	0,001-0,002	0,003-0,005

3.3.7 Integration of mapping and assessment

Mapping and assessment of ES, as it is defined in the Biodiversity strategy to 2020, is a comprehensive process that builds on various individual tasks and their systematic integration. Therefore, an integrated and operational framework is needed to support and coordinate these activities (Burkhard et al., 2018). The IEA has been developed through extensive consultation with ESMERALDA stakeholders and resulted in the final version of the IEA framework in ESMERALDA project where the core was placed within a wider assessment process (see Section 2.3 in this deliverable).

3.3.7.1 Integration of ecosystems, condition and services

Assessment of the capacity of urban ecosystems to regulate water flow and flood hazard is carried out by means of the proposed *Index of Capacity for Water Retention* (ICWR), which is derived on the basis of a quantitative assessment of the three main retention indicators: Water holding capacity, Vegetation cover and Land cover patterns. The approach chosen for the assessment is essentially quantitative evaluation based on aggregated information for the indicators within spatial units. Each indicator is evaluated quantitatively by means of data analysis for core parameters (Figure 3.3.3).

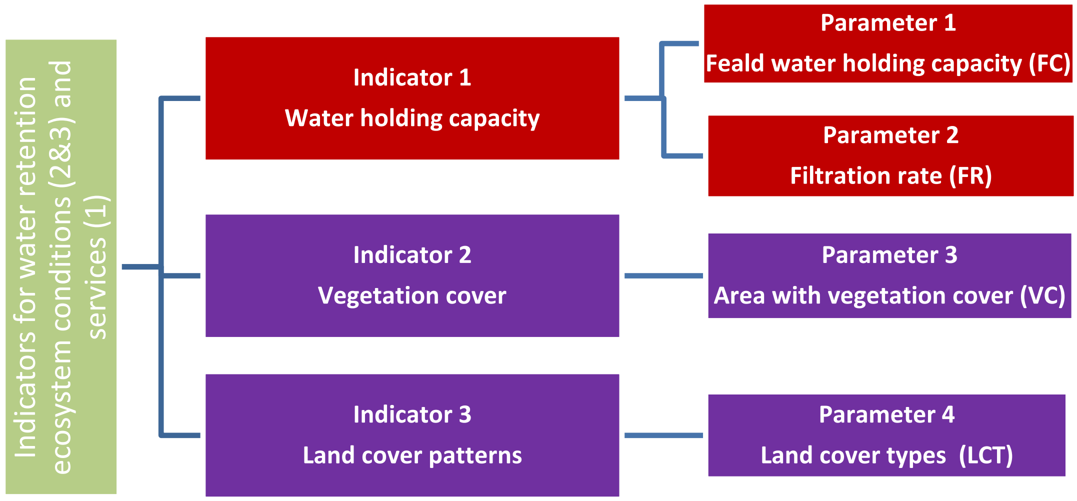

Figure 3.3.3. Indicators and parameters for evaluation of retenzion capacity of urban ecosystems

A quantitative evaluation, based on aggregated information for spatial units, was carried out for the parameters FC and FR. In addition, the percent of the VC in each spatial unit is represented as a coefficient (k) which values vary from 0 to 1. Value 1 corresponds to VC=100%, value 0 to VC=0%. The coefficient enables to estimate more precisely the filtration capacity within spatial units (FC*k) and FR (FR*k) in terms of the important role of vegetation in the regulation process. The results for the parameters were normalized to the 0 to 5 relative scale using natural brakes statistical (Table 3.3.5).

Table 3.3.5. Estimation of flood regulation capacity based on filtration capacity (FC) and filtration rate (FR)

	Scores	1	2	3	4	5
Indicator 1	Parameter 1 (FC), (%)	0-9	10-14	15-19	20-25	> 25
	Parameter 2 (FR), (cm/s)	0,0001-0,00014	0,00015-0,00020	0,00021-0,00024	0,00025-0,00032	0,0032-0,0004

The land cover in cities has some important characteristics. The paved surfaces and build-up areas are predominant. The green areas are unevenly distributed, both in spatial terms and compact size within the urban areas. The soils also have specific characteristics due to the anthropogenic impact. Therefore, it is necessary to search for the most appropriate land cover classification which is relevant to the conditions in the settlements and to the objectives of the study. The two types of land cover E (bare rocks and paved areas) and F (bare land or sand) have very low capacity to provide water flow regulation their score 1. The type A (dense trees) is characterize by highest capacity to provide flood regulation (Table 3.3.6).

Table 3.3.6. LCT assessment scale

LCT	Capacity	Scores	LCT	Capacity	Scores
A	Very high	5	**D**	Low	2
B	High	4	**E**	Very low	1
C	Medium	3	**F**	Very low	1
G	Low	2	**H**	Very low	1

The assessment of the combinations between main LCT types in frames of one polygon is defined as an average of the scores for each basic type. For example:

BCDE = (4 + 3 + 2 + 0)/4 = 2.25 (or the final evaluation is 2).

ICWR is derived based on the normalized scores ranging from 1 to 5, for the values of FCk, FRk and LCT:

ICWR = (FCk + FRk + LCT) / 3

Where:

FCk - normalized score of field water holding capacity
FRk - normalized score of soil filtration rate
LCT- normalized score of the land cover type

The expert-based assessment of the selected indicators was applied to each unit (GIS polygon) of the urban ecosystem subtypes. The flood regulation supply capacity in Karlovo was assessed by the ICWR for each spatial unit (ecosystem subtype) in the town. The assessment results for each one of the assessed urban ecosystem subtypes are mapped and spatially represented using GIS tools (Figure 3.3.4). It is represented by the average value of all polygons in each ecosystem subtype. The result show that the water retention capacity of the urban ecosystems in Karlovo is low to medium in ecosystem subtypes J1 (Residential and public areas), J3 (Residential and public low-density areas) and J6 (Industrial areas) and high to very high in J5 (Urban green areas) (see Figure 3.3.2).

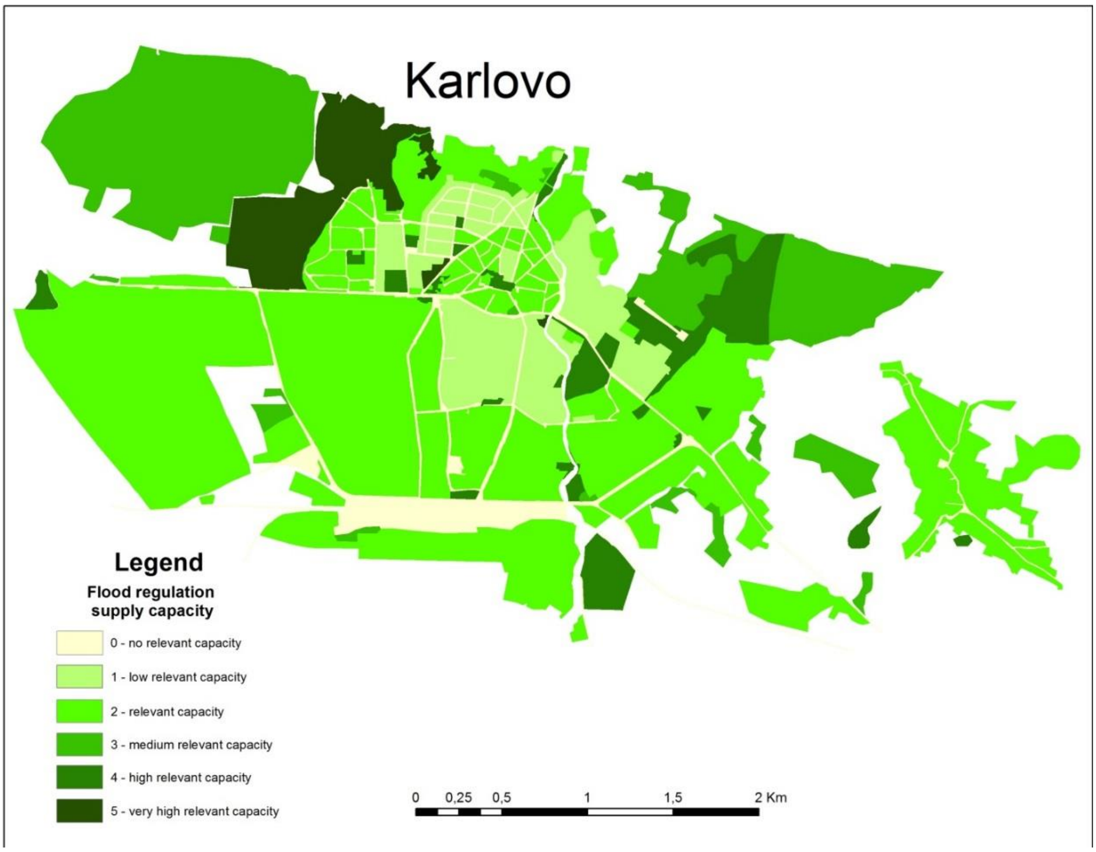

Figure 3.3.4. Capacity for flood regulation ES in Karlovo

3.3.8 Discussion

3.3.8.1 Integration between Policy Question and assessment methods

The results show that IEA framework supported the integration between MAES methodology for mapping and assessment of ES and the National Methodology for mapping and assessment of urban ES (Zhiyanski et al., 2017), and in particular for increasing urban resilience to flood hazard. Biophysical methods were used for assessment of ecosystem condition and flood regulating service. Identification and mapping of the urban ecosystems using the typology of urban ecosystems in Bulgaria (Zhianski et al. 2017) allowed spatial integration of the assessment results providing spatially explicit information about the capacity of ecosystems to contribute to the urban resilience to flood hazard**.**

The integration between parametric and nonparametric information and data for quantification of the ES indicators was accomplished by introducing normalized values for each parameter which enables to implement the Index of capacity for water retention (ICWR).

3.3.8.2 Challenges and problems

There is lack of data for the indicator "filtration rate” for some soil types in the country, in some cases it cannot be calculated using the index of capacity for water retention. Data for the parameter “field capacity” for anthropogenic soils (Andosols) were also not available and for the purposes of this study are used data for dominated soil type in the study area. Here we do not take into account the various types of vegetation, with their specific regulatory functions. Soil moisture is observed in a small number of stations all over the country and data do not always satisfy the requirements for representativeness because of the differences in the distribution of moisture in horizontal and vertical direction (Hristov, 2004). There is need of more specialized and much more detailed research on how these parameters behave in the urban areas.

Assessment of ecosystem condition is a key component of the assessment of ES capacity to provide ecosystem services. In this study the ecosystem condition and ecosystem services indicators have been tested in respect of their sensitivity and reliability to present the flood regulating capacity of the urban ES subtypes. The results show their reliability under the given conditions. They can be also used for monitoring of the historical and current changes which would extend their incorporation in the IEA framework.

Understanding of plausible futures is the next possible level of integration as far as in this particular case study it is of crucial importance to know the limits of the resilience of each ES subtype to provide flood regulating services in respect of the climate change pressure and the related extremes.

3.3.9 Conclusions

We consider that the proposed index correctly represents the capacity of the urban ecosystems to provide flood regulation services in the town of Karlovo. Although the applied approach is not within the IEA framework of ESMERALDA it demonstrates an opportunity to integrate ecosystem conditions and ecosystem services indicators using an *Index of Capacity for Water Retention* (ICWR). The assessment of flood regulation by the value of ICWR quantified for each urban ecosystem subtype enables the preparation of maps which ensure clear visualization of the spatial aspects of this service. It contributes significantly to the communication and dissemination of the results at different levels of management and public interests. The results also confirm the high relevance of green areas to the regulating ecosystem services and their capacity for implementation of NbS for flood hazard resilience in urban areas.

The implementation IEA in an urban environment using biophysical methods requires detailed data about the physical properties of the used indicators, which is not always available. The communication and dissemination of the ES assessment depends to some extent on the policy priorities of the public authorities, of the attitude and investment interest of stakeholders and of the general attitude of the citizens to the environmental problems.

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3.4 Using an Integrated Ecosystem Assessment approach for the EIA procedure under the Polish legal framework

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3.4.1 Introduction

Until now, the term "ecosystem services" (ES) has not been included in Polish legal acts. However, the current regulations allow for this approach to be taken into consideration to a significant extent (although not in a direct way) (Stępniewska et al., 2018; Mączka et al., 2016). Polish experts particularly favour of introducing the ES approach into the Environmental Impact Assessment (Stępniewska et al., 2017).

The main challenges for integrating the ES approach into the Environmental Impact Assessment (EIA) procedures are issues of scope, scale, ES trade-offs and indicators (see e.g. Geneletti, 2016). These challenges can be overcome by carrying out studies in a real decision-making context. Here, we investigate the possibility of using the Integrated Ecosystem Assessment approach as described in Chapter 2 of this report for the EIA procedure on an example of road investment, which influences many ES. We investigate how information contained in the EIA report drawn up for the planned investment can be used for understanding the values associated with ecosystems. Following Maes et al. (2018) we address the following policy questions in particular (Maes et al., 2018):

1. How can the ES approach be integrated into EIA processes?
2. How to integrate and use lessons from work on the concept and valuation of ES in practical management?

We believe that many of the findings could be interesting for other countries which in their own way implement the European Union law within the scope of the EIA

3.4.2 The bypass of Ostrów Wielkopolski as the case study

We tested the possibility of inclusion of the Integrated Ecosystem Assessment approach in the process of the EIA for planned investments using the example of the construction of the bypass of Ostrów Wielkopolski in the Greater Poland Province, Poland.

The designed bypass, 12.05 km long, will be located in the route of expressway S-11. The investment is located within the borders of Ostrów Wielkopolski (city populated by 72.5 thousand residents) as well as the Ostrów Wielkopolski and Przygodzice communes.

The designed road crosses mainly agricultural areas (farmlands, the areas of ruderal vegetation) and seminatural areas (meadows and pastures), as well as, to a lesser extent, woodlands, watercourses (River Barycz, Chynowski Channel, Leśna Struga trench, other drainage ditches) and small field ponds. The clusters of residential development are located in the northern part of the bypass within the borders of Ostrów Wielkopolski. Loose single-family dwellings with non-intrusive services and farmsteads are located along local roads that will be intersected by the planned road (EIA Report, 2016).

3.4.3 Mandate for ecosystem assessment

In Poland, EIA procedures are regulated by the Act on EIA (2008). The Act is a transposition of the European Union Environmental Impact Assessment Directive. According to the Act, the administrative permit for public and private projects that are likely to have significant effects on the environment should be granted only after prior assessment of the likely significant environmental effects of these projects (EIA procedure). The assessment has to take into account the influence of the project on human health, quality of life, the diversity of species and the reproductive capacity of the ecosystem as a basic resource for life.

The above-mentioned provisions have a significant potential for the introduction of the ES approach directly into the documentation drawn up within the EIA. It is possible to match the legal requirements for the EIA reports with concrete ES categories; e.g. identification of the impact on ecosystem components such as fauna, flora, soil, water and air can be related to the influence on the structure and level of a large number of provisioning and regulating ES. On the other hand, describing the impact on material assets, cultural heritage and the landscape is related to the cultural ES.

3.4.4 The scope of the assessment

An EIA was conducted for the purpose of quantitative and qualitative analysis of the forecasted impact of the planned road investment on the environment. The scope of the assessment results from the regulations contained in the Act on EIA (2008), as well as conditions specified in the environmental permit and arrangements with the environmental protection authorities, including Regional Directorate of Environmental Protection in Poznan. During the assessment, the investor also considered the regulation contained in strategic documents such as: National Development Strategy 2020, Transport Development Strategy until 2020, Program for National Roads Construction for the years 2011-2015, Program for National Roads Construction for the years 2014-2023, National Spatial Development Concept 2030, National Strategy of Regional Development 2010-2020, Report Poland 2030 as well as programmes and plans at regional and national level, including Development Strategy of Greater Poland Province up to the year 2020, Spatial Management Plan of Greater Poland Province, the studies of conditions and directions of spatial development of the communes and local spatial development plans.

The EIA included the following:

- the description of the investment and conditions of land use,
- the description of arrangements from issued administrative decisions,
- the impact of the planned road on the abiotic environment (air, noise, surface waters, groundwaters, soils, landscape, waste generation, monuments and cultural goods),
- the impact on the biotic environment (flora, fauna, protected areas, including Natura 2000),
- the description of accumulated impacts,
- the countering of serious accidents,
- the impact of electromagnetic radiation,
- analysis of potential social conflicts,
- the impact on human health,
- potential cross-border effects,
- the impact of the investment on climatic conditions, and
- monitoring of the impact of the investment at the stage of construction and exploitation.

The impact of land reclamation has not been considered in the EIA Report due to the permanent character of the planned investment. The phase of liquidation due to the permanent character of the planned investment has not been analysed in the EIA Report.

3.4.5 Mapping and assessment of relevant ecosystem condition aspects

An inventory of the resources and values of the natural environment from the component perspective was made within EIA. However, the types of ecosystems have not been identified; basic types of land use, taking plant communities and species of animals and mushrooms occurring on this area into account, were described only in an indirect way. As a result, there are no maps in the report that show the spatial distribution of the ecosystems on the area covered by the planned investment. Creating them would be essential for a deeper recognition of the values associated with ecosystems. An instrument supporting the recognition of the types of ecosystems on the area covered by the assessment can be the EUNIS habitat classification with spatial database of resolution 100 m (https://eunis.eea.europa.eu/). Due to the character of the investment and the requirements of detailed consideration of its impact on the environment, the use of only EUNIS data, due to their inadequate resolution, would not be sufficient. However, they can be used as a reference material in the field work related to mapping of natural habitats and particular ecosystems.

Based on information contained in the EIA report, we identify the potential indicators that could be used for the assessment of relevant ecosystem condition aspects on the area covered by the planned investment (Table 3.4.1). We regarded as relevant those ecosystem condition aspects in which the Act on EIA (2008) requires to be determined in terms of the impact of an investment on them. The indicators proposed are embedded in information about abiotic and biotic components, collected during the field and in-house research that preceded the preparation of the EIA Report.

Table 3.4.1. Indicators for ecosystem condition assessment on the area covered by the planned investment.

Indicator included in EIA Report	**Indicator quantification**
Plants	
Identified species, including legally protected, rare and endangered	• 258 species of vascular plants, including 1 under legal protection. • 48 species of bryophytes, including 7 under legal protection. • 72 species of lichens, including 10 under legal protection.
Identified plant communities, including legally protected, rare and endangered	Forest and brush, aquatic and rush, clearing, grasslands.
Animals	
Identified species, including legally protected, rare and endangered	• The mammals typical of southern Greater Poland, including 6 species under legal protection. • 11 species of bats. • 99 species of breeding birds, including 9 from the Annex I of the Birds Directive, 18 from the Annex II of the Bologna Convention, 61 from the Annex II of the Bern Convention and 4 from the IUCN Red List of Threatened Species.

The places of increased activity of the animals	• 11 species of amphibians and 4 species of reptiles (all under legal protection). • 6 species of fish, including 2 under legal protection. • 47 species of insects, including 6 under legal protection • Hoofed mammals: from about 409.0 km till the end of the investment. • The routes of flights and feeding grounds of the bats: 403.0 km, 407.1 km, 410.3 km, 411.0 km to 412.0 km. • Avifauna: Przygodzice Meadows and forest areas in southern and northern part of the planned road. • 5 areas of increased seasonal activity of the amphibians (migration routes, summer feeding grounds and winter habitats).
Mushrooms	
Identified species, including legally protected, rare and endangered	1 species under legal protection
Natural habitats	
The types of habitats from the Annex I of the Habitats Directive	Alluvial forests with Alnus glutinosa and Fraxinus excelsior; Galio-Carpinetum oak-hornbeam forests.
Surface water and groundwater	
The quality of groundwaters	The waters in Body of Groundwater no. 74 are of satisfactory quality, and in Body of Groundwater no. 77 - of unsatisfactory quality.
The quality of surface waters	The investment will affect the Bodies of Surface Water: Ołobok to Niedźwiady, Ołobok from Niedźwiady to the mouth, Barycz from the source to Dąbrówka and Gniła Barycz. Three first are strongly changed bodies of waters, and their state is bad. Gniła Barycz is a natural body of waters and its state is moderate.
Protection zones of water intakes	The road on the length of about 1,6 km runs through the area of indirect protection of municipal intake of groundwater for Ostrów Wielkopolski.
Air and noise	
Air pollution	In the area of the planned road, the level of air pollution is within the norms permissible by the law (benzene, nitrogen dioxide, nitrogen oxides, sulphur dioxide, lead, particulate matter PM2,5, particulate matter PM10, carbon monoxide).
Surface of the earth, soil	
Types of soil	Mainly acid brown soils, peat and muck soils. There are pieces of podsols and black earths.
Mineral deposits	Designed road on the section from 406.5 km to 408.2 km intersects the area of the exploitation of natural gas.
Nature conservation	
The forms of nature conservation	From 406.5 km till the end of the investment (that is, 412.05 km), the road runs within the borders of Protected Landscape Areas "Ostrzeszów Hills" and "Odolanowska Valley". Moreover, in the close proximity of the planned investment, there are also: Barycz Valley Landscape Park, Wydymacz Reserve, Natura 2000 areas: "Barycz Valley" Special Protection Area, "Ostoja nad Baryczą" Special Area of Conservation.
Ecological corridors	The road intersects: national corridors KPdC-8A and KPdC-16B; regional corridor GKPdc-17 Stawy Milickie.
Monuments and cultural landscape	
Cultural goods covered by existing documentation	The road intersects: the areas of occurrence of the archaeological sites, connected with the settlement of the river basin of Ołobok and Barycz; the zone of archaeological protection in the area of Wysocko Wielkie.

Source: Own elaboration based on EIA Report

3.4.6 Mapping and assessment of ecosystem services delivered by ecosystems

In the next stage we explored the links between the impact on ecosystems in the phase of construction and the exploitation of the bypass and ecosystem services (Tab. 3.4.2). We used the categorization of ES provided by the Common International Classification of Ecosystem Services (CICES V4.3) (Haines-Young & Potschin, 2018).

The results show that the investment will affect all three categories of ES, but especially regulating and provisioning services. The highest impact on ES will occur as a result of the road occupying surface and the elimination of many semi-natural ecosystems. The changes in aquatic ecosystems, especially in small field ponds, will also have a considerable impact on ES. Discharge of water from sealed surfaces will change both hydrographic and topoclimatic conditions, affect flora, fauna and landscape. Deforestation and occupation of the arable land and small ponds will result in a reduction of the level of ES provisioning. It will also limit the possibilities of taking mushrooms and fish. Mushrooming and angling are amongst the most popular outdoor hobbies in Poland; therefore, these services are important in terms of both the provisioning and cultural dimensions of ecosystem services. A decreased possibility for walking, especially in forests and meadows, will be also important. The impact on aesthetic experience is another important aspect, arising by acoustic screens partially obscuring the view.

The EIA procedure for planned road investment provided much information that was useful for the valuation of ES. However, as indicated in Table 3.4.2, the EIA Report contents allowed for the analysis of only part of the ES change indicators; for many specified ES the formulation of such indicators still poses a challenge. The fact, that there are no maps of ecosystem and natural habitats, makes mapping of ES much more difficult. The lowest possibility of ES mapping and assessment on the basis of existing data is with reference to cultural ES. There is no recognised assessment path for this aspect within the EIA procedure. The only elements addressed by the document are monuments and landscape, but based on the EIA report, there are no criteria for their objective assessment.

Table 3.4.2. Affected ecosystem services and ES change indicators for selected ecosystem condition aspects.

Impact on ecosystems	ES affected (codes CICES V5.1 biotic for groups)			ES change indicator included in EIA Report
	Provisioning	**Regulation & Maintenance**	**Cultural**	
Surface of the earth, soil				
1. The changes in the structure of soil and its physical, chemical and biological properties. 2. The changes in filtering properties of soil. 3. Soil pollution (heavy metals).	1.1. Cultivated terrestrial plants, materials or energy. Wild plants and animals (terrestrial and aquatic) for nutrition, materials or energy. 1.2. Genetic material from organisms.	2.1. Mediation of wastes or toxic substances of anthropogenic origin by living processes. Mediation of nuisances of anthropogenic origin. 2.2. Regulation of baseline flows and extreme events. Lifecycle maintenance, habitat and gene pool protection. Pest and disease control. Regulation of soil quality. Water conditions. Atmospheric composition and conditions.	3.1. Physical and experiential interactions with natural environment, Intellectual and representative interactions with natural environment. 3.2. Spiritual, symbolic and other interactions with natural environment.	High-quality soil surface.
Air and noise				
1. The use of biologically active surface and the impact on microclimate. 2. Pollination and emission of pollutants to the air.	2.2. Lifecycle maintenance, habitat and gene pool protection.	2.1. Mediation of wastes or toxic substances of anthropogenic origin by living processes, mediation of nuisances of anthropogenic origin.	3.1. Physical and experiential interactions with natural environment. Intellectual and representative interactions with natural environment. Intellectual and	1. Air pollution. 2. Noise level.

3. Noise affecting human health, animal world, and recreational values.		2.2. Regulation of baseline flows and extreme events. Lifecycle maintenance, habitat and gene pool protection. Pest and disease control. Regulation of soil quality. Water conditions. Atmospheric composition and conditions.	representative interactions with natural environment. 3.2. Spiritual, symbolic and other interactions with natural environment.	
Surface waters and groundwaters				
1. The use of biologically active surface for road and the changes in the level of groundwaters. 2. The change in the flows of groundwaters as a result of formation of the embankments and excavations. 3. The changes in the route of watercourse, the changes in the riversides. 4. Pollution of surface waters during exploitation of the road as a result of the surface run-off. 5. The pollution with rubbish thrown away by the road users. 6. The pollution with hazardous substances as a result of the serious accidents.	1.1. Wild plants and animals (terrestrial and aquatic) for nutrition, materials or energy. 1.2. Genetic material from organisms.	2.1. Mediation of wastes or toxic substances of anthropogenic origin by living processes. Mediation of nuisances of anthropogenic origin. 2.2. Regulation of baseline flows and extreme events. Lifecycle maintenance, habitat and gene pool protection. Pest and disease control. Regulation of soil quality. Water conditions. Atmospheric composition and conditions.	3.1. Physical and experiential interactions with natural environment, Intellectual and representative interactions with natural environment 3.2. Spiritual, symbolic and other interactions with natural environment	1. The quality of groundwaters. 2. The quality of surface waters. 3. Protection zones of water intakes.

Landscape				
1. The changes or liquidation of freshwater bodies, the changes in the route of watercourse. 2. Movement of earth masses, ground levelling. 3. Deforestation. 4. The conversions of agricultural landscape. 5. Building acoustic screens limiting the visibility.			3.1. Physical and experiential interactions with natural environment, Intellectual and representative interactions with natural environment. 3.2. Spiritual, symbolic and other interactions with natural environment.	Cultural goods covered by existing documentation.
Flora and fauna				
1. The rips of ecological corridors, the changes in the habitats. 2. Noise and vibrations scaring animals off. 3. The pollution of water and air changing species composition of flora and fauna.	1.1. Wild plants and animals (terrestrial and aquatic) for nutrition, materials or energy. 1.2. Genetic material from organisms.	2.1. Mediation of wastes or toxic substances of anthropogenic origin by living processes. 2.2. Lifecycle maintenance, habitat and gene pool protection. Pest and disease control.	3.1. Physical and experiential interactions with natural environment, Intellectual and representative interactions with natural environment. 3.2. Spiritual, symbolic and other interactions with natural environment.	1. Identified animal and plant species, including legally protected, rare and endangered. 2. The presence of the forms of nature conservation. 3. The intersections of ecological corridors. 4. The types of habitats from the Annex I of the Habitats Directive.

Source: Own elaboration based on EIA Report

3.4.7 Understanding plausible futures (Scenarios)

The development of scenarios predicting the effects of the implementation of the variants of a given investment is the key element in the EIA process. In our case study a preferred location alternative was selected in the previous administrative procedure; therefore, three technological variants were assessed within the scope of the analysed EIA Report:

1. **Failure to investment.** The decision not to construct the beltway would involve a continuation of directing car traffic through Ostrów Wielkopolski, the street system of which is not efficient. The consequences would include: extending the time of travel through the city and congestion, increased acoustic nuisance without technical capabilities of introducing devices protecting against noise, increasing the flow of pollutants to surface waters and to the ground as a result of defective dehydration of existing national road no. 11 and observed growth of traffic intensity. A failure to invest would result in the degradation of water and water dependent ecosystems, located nearby current traffic arteries, as well as a reduction of supply of their services.
2. **Making the investment – the variant with a concrete road surface.** This technological variant would help to eliminate or limit negative effects mentioned above, and bring benefits for the stakeholders, especially inhabitants of Ostrów Wielkopolski. However, building the concrete road surface requires for it to be made very precisely. The use of road salt in winter is also potentially problematic, because it has a negative impact on the concrete, speeding up its erosion. Moreover, concrete surfaces are less effective in the reduction of the noise level and they are characterised by a lower adhesion in comparison with asphalt pavements.
3. **Making the investment – the variant with an asphalt road surface.** Taking the risks connected with the variants no. 1 and 2, building the beltway with the use of an asphalt was indicated as the most effective solution both for the environment as well as technologically and economically.

Taking potential social benefits into account, the decision not to invest would be an inadequate response of the decision-makers to the identified needs of the local community. In such a context, EIA seeks to minimise the negative impact of the planned investment on the environment, including the supply of benefits provided by local ecosystems; an analysis of plausible scenarios allows one to understand the key threats and benefits from the execution of particular investment variants. The information obtained may play an important role in the decision-making process, contributing to the reconciliation of interests of various social groups (trade-offs, optimisation) and ensuring provision of key ES.

3.4.8 Discussion

Our results suggest that the information contained in the EIA report is a sufficient source for the assessment of relevant ecosystem condition aspects. However, it applies more to information about environmental quality than about ecosystem attributes such as forest fragmentation and connectivity or farmland bird indicator. Although the indicators of ecosystem condition considered usually meet the requirements described by Maes et al. (2018), many of them are not policy relevant, i.e. they cannot link ecosystem condition and ES with policy objectives. Roche and Campagne (2018) emphasize the importance of identification links between the potential indicators, the nature of what is supposed to be indicated (indicandus) and the goals of use. From an investor perspective, considering ecosystem condition from the perspective of understanding how they support a wide range of ES will require additional resources. The advantage of identification of links between investment pressure, ecosystem condition and ES will be a greater capacity to address specific policy questions related to the use and the protection of natural capital.

In our case study, we used the ESMERALDA IEA framework for linking ecosystems with socio-economics system through the flow of ES. As opposed to framework developed by Maes et al. (2013)**,** the operational character of the IEA framework allows for translation of scientific findings into practical knowledge. The flexible structure of IEA framework enables the choice of entry point of MAES analysis depending on specific questions faced by potential end-users. Thus, it facilities the scoping and planning the MAES activities according to needs and requirements of planners and decision-makers. In turn, conceptual character framework developed by Maes et al. (2013) makes it valid for use in conceptual discussions, but to a limited extent supports instrumental decision-making.

Similarly the IEA**,** framework presented by Burkhard et al. (2018) can guide the user step by step through the MAES analysis according to particular empirical or policy questions being investigated. Regarding differences, we see Burkhard et al. (2018) framework as a guideline on how to carry out a particular MAES study, and the IEA framework as described in Chapter 2 of this deliverable as a guideline how to develop a MAES process. It is due the fact that the IEA framework **is** stronger in terms of including the preconditions of MAES analysis, as well as a role ES information received for natural capital management (e.g. understanding plausible futures, societal responses to assessments findings).

Making general recommendations for the MAES community on which framework to use is difficult. No single framework is a panacea; the choice depends heavily on the contexts in which the ES information is intended to be used and on its specific function. A demand analysis should be a first step toward choosing the framework which allow for preparing and providing ES information that is relevant and useful for end-users.

3.4.9 Conclusions

Legal regulations regarding the EIA required that the investor undertook a broad consideration of the impact of the planned investment on the relevant aspects of ecosystem condition. The scope of the considered impact is regulated by national law; in addition, as a result of consultations with the regional and local authorities governing the EIA procedure, this scope was elaborated, taking the specificity of the investment into consideration.

Therefore, the analysed EIA report contains many qualitative and quantitative data, obtained both from field inventories and numerous secondary sources, including expert reports and statistical information. This information allows to diagnose the state of the ecosystems on the area covered by the planned investment and expected changes of this state as a result of its realisation.

Taking another analytical step, that is, an identification of the affected ecosystem services, allow to move from the assessment of the impact on the ecosystems to the assessment of the impact on the structure and level of benefits from them for a human. In the first case, the full effects of the execution of the investment may be barely visible and intelligible for the community and decision-makers, especially in a longer period of time. In the second case, it shows a clear relation between changes in the ecosystems and human well-being.

From the social and political point of view, the recognition of ecosystem services within EIA procedure provides information for the communication and discussion of various interested stakeholders while solving dilemmas related to the use of environment during the execution, exploitation and restoration of the investment. Understanding the relationship between the investment and the ES response can help to more effectively reach the optimal scenario. Recognizing the most important actual and desired ES, as well as trade-offs between different scenarios, provides premises for the response to policy questions concerning the priorities and preferences (Maes et al., 2018). Moreover, the recognition of the service role of the ecosystems impacted by the investment supports the arguments for expenditure to reduce the pressure on the ecosystems by the aspect of notable benefits for society.

Currently, the ES concept is not a part of Polish legal framework concerning EIA. Since the regulations do not limit the methodology for analysing the impact of the investment on the environment, a voluntary consideration of the ES approach is possible. Our study showed that IEA framework can fruitfully support the ES analysis carried out in an EIA context, due to its comprehensive, but still practical and flexible structure. A compendium of biophysical, socio-cultural and economic methods, which can be applied for mapping and assessment of ecosystem and their services in the EIA procedure, was provided by other ESMERALDA project outcomes (ESMERALDA Deliverable 3.1, 3.2, 3.3). However, from the perspective of the investor, it would require additional costs related to a higher and "excessive" scope of the assessment. Moreover, many Polish experts indicate the lack of formal, specialist guidelines related to the application of the ES approach in the decision-making process (Stępniewska et al., 2017). Therefore, it is unlikely for ES approach to be considered in EIA procedures in an operational way. The most effective and complex solution is to make efforts to include the ES approach in national legislation concerning EIA. Further inclusion of the ES approach in law and strategic documents of the European Union, as well as interactions between the European Commission and national authorities, are of motivating importance for the administration. Legislative actions should be associated with education and training because many practitioners indicate a deficit of knowledge on the practical way of using the ES approach.

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3.5 Integrated ES assessment at national level - the Hungarian MAES

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3.5.1 Introduction

The second target of the EU Biodiversity Strategy to 2020 (European Commission, 2011) requires EU Member States to assess and map their ecosystem services (ES) and integrate these results into policy decisions. Started in 2016 with the leadership of the Ministry of Agriculture, an EU-financed project entitled "Strategic investigations on the long-term preservation and development of natural heritage of community importance and on the implementation of the EU Biodiversity Strategy 2020 objective" aims to build up spatial databases of ecosystems and their services in Hungary (MAES-HU), and to assess them using biophysical, economic and social indicators (Kovács-Hostyánszki et al., 2018). To ensure broad scale scientific, policy and social credibility, the project applies an integrated approach putting high emphasis on participatory planning and stakeholder involvement. At the time of writing, the project is ongoing; it will be completed at the end of 2020. The work plan consists of several distinct tasks organised in a logical and temporal sequence building on previous results. Figure 3.5.1 shows the sequence of tasks in MAES-HU. In the following paragraphs, the identification and prioritization of ES is described in detail, while the rest of the already executed tasks as well as the remaining tasks are described in brief. In the second part of this sub-chapter we are assessing whether MAES-HU allows integration where necessary and if it is consistent with the framework of an integrated ecosystem assessment as developed within ESMERALDA (see Chapter 2). In addition we also try to use the MAES-HU case for comparing the ESMERALDA framework - with its additional components - to former frameworks (European Commission, 2014; Burkhard et al., 2018) and assess if, in this particular case, applying the ESMERALDA framework can bring benefits in the future work in MAES-HU.

3.5.2 Identification and prioritization of ES

Determining the range of relevant services is a fundamental task before any MAES exercise, taking into account the ecosystem types and socio-cultural conditions of the area in focus. Being a country with diverse forms of land cover including agricultural fields, forests, grasslands as well as water-based ecosystems, there is a large number of ES supplied within the territory of Hungary. However, for an optimal efficiency in allocation of time and human resources, it was necessary to select a shortlist of ES which are most relevant for the society at national level, and which reflect the perception of a wide representation of stakeholders as well as the knowledge of sectoral experts. Beside nature conservation and socio-economic considerations, a clear conceptual framework had to be followed which is consistent with the recommendations of the EU MAES guidelines (Maes et al., 2013). This includes, among others, the compatibility of the selected ES with the recommended classification system, which was, at the time the exercise was performed, Version 4.3 of the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2013). The selected ES were the mapped and assessed in the MAES-HU project. Selection of ES was undertaken through a three-step process, as described below.

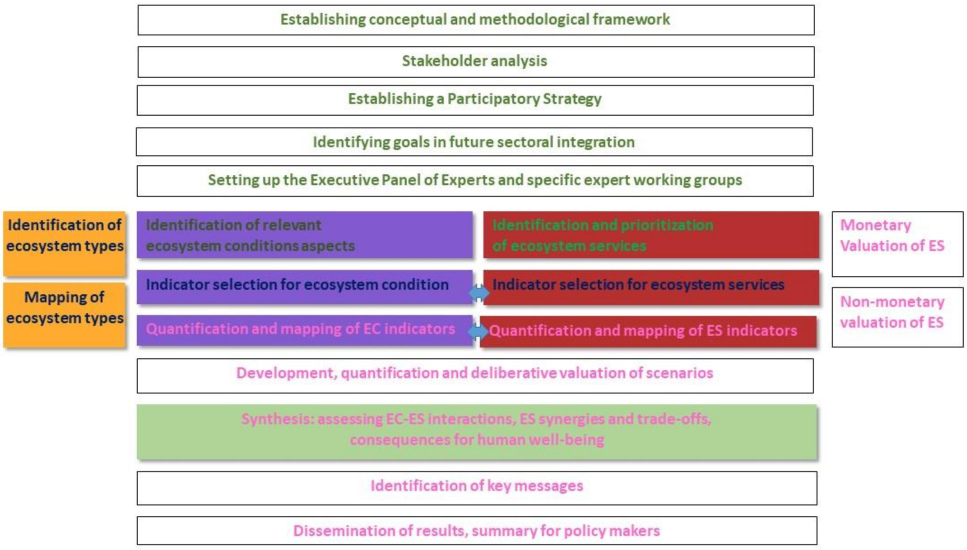

Figure 3.5.1. Overview of the main blocks of MAES-HU, font colour indicating executed (green), ongoing (blue) and future (pink) tasks. Box colours follow the coding of the ESMERALDA framework.

3.5.2.1 Compilation of preliminary ES list based on stakeholder interviews

A preliminary list of ES was made up from the results of stakeholder analysis (see textbox below). Between November and December 2016, semi-structured interviews were made with representatives of selected stakeholder groups concerned (23 people), using pre-defined topics and questions. The following sectors were represented: nature conservation, forestry and hunting, agriculture, angling/fishing, water management, spatial planning, transport and infrastructure, tourism, industry. In addition, representing a diversity of sectors, we also aimed to represent various institutional structures within each sectors, including administrative bodies, state and private companies, NGOs and research institutions, with companies and NGOs delivering the highest number of respondents. During the interviews, a distinct issue was the question of what kind of "broad ecosystem contributions" (whatever might potentially be perceived as ES in a broad sense) were mentioned by the respondents, which contributions they considered important during their work or in which contributions they saw opportunities. In addition, desktop research has been carried out exploring the available documents of the interviewed organizations (websites of organizations, information materials, policies and other written documents). Through the analysis of interview summaries and background research materials, 73 broad ecosystem contributions were identified.

Stakeholder analysis

The overall aim of the stakeholder analysis for MAES-HU was to get a general overview of the most relevant stakeholders at national level, and to get acquainted with their responsibilities, interests and activities in relation to ecosystems and ecosystem services. In addition, it was also intended to provide the basis for the strategic approach of stakeholder involvement during the implementation of MAES-HU. The specific objectives of the analysis were as follows: (1) to identify a wide range of stakeholders relevant to MAES-HU; (2) to structure the most important (primary) stakeholders in MAES-HU and the relations (cooperation, conflicts) between them, as well as (3) to define the possible ways of their involvement in the project; and (4) to establish the basis of further tasks, such as the selection of ES for mapping and assessment, and the possible future uptake of the results and outputs.

3.5.2.2 Adaptation of CICES to Hungarian ecosystems (CICES-HU)

The CICES classification system covers a wide range of ecosystem services provided by European ecosystems. However, each Member State has significantly different habitat characteristics, hence different types of services can be put to the fore in different countries. CICES was designed to be a comprehensive yet adaptable tool, which is able to support the needs of the user community (Haines-Young et al. 2016), in this case users and decision makers at national level in Hungary. On the other hand, the preliminary list of 73 ES (sensu lato), derived from the sectoral interviews and desktop research of the stakeholder analysis, is a bottom-up list of items not following any existing classification system. Accordingly, the preliminary list also had to be made consistent with the CICES classes. As CICES uses the cascade concept, the national ES priority list also had to follow that logic.

The first step during the adaptation of CICES to Hungary was the Hungarian translation of the complete category system along with ES definitions and examples of CICES 4.3. Then, items of the preliminary ES list were positioned in this system. This allowed identification of ‘empty categories’, when a specific CICES class was not relevant for Hungary. At the class level only one such category was found, namely, chemical condition of salt water (2.3.4.2). This class was deleted, since there is no marine ecosystems in Hungary. Most items of the preliminary list were below CICES class level, in other words, individual CICES classes were represented by multiple items of the preliminary ES list. Related items were then grouped at the class level and became examples. In some cases, items of the preliminary list could not be positioned in CICES as they were not consistent with some criteria embedded in the CICES concept (Potschin and Haines-Young, 2011; see also Czúcz and Arany, 2016), e.g.

- items that referred to ecosystem condition (e.g. biodiversity),
- items that represented benefits beyond the production boundary (items originating in the socio-economic system instead of the natural system, e.g. processed products), or,
- items highlighting services of solely abiotic origin (e.g. mineral water).

Even though such items were excluded from CICES-HU, an effort was made to identify a corresponding ES which could be included instead. Finally, after consulting the Executive Panel of Experts (see textbox below), the list of services was complemented with a few additional examples for ES still missing from the preliminary list, but judged important by the Panel. This resulted in a consensus version of Hungarian adaptation of CICES (CICES-HU v1.0) in February 2017.

Executive Panel of Experts - a permanent advisory body of MAES-HU

The Executive Panel of Experts (EPE) is a group of experts from different sectors who assist in the execution of MAES-HU throughout the whole project implementation time. The Panel was brought to life with a mandate to assist the ES assessment with their experience and knowledge, to support the specific evaluation processes and to support sectoral integration of results. During the first (preparatory) year of the project, the EPE consisted of 18 people and met three times. As there was a consensus that further sectors and fields of expertise need to be integrated, some changes in the composition of the panel are expected. The renewed EPE is expected to meet 2-3 times every year during the remaining 3 years of the MAES-HU project implementation.

3.5.2.3 Discussing CICES-HU with expert groups to select priority ES

The prioritization of the ES was organized in a participatory way, involving a broad range of sectors and stakeholders into the process. Experts representing their sector were invited into a structured discussion process organized in five thematic groups along five major ecosystem types: forests, water-based ecosystems (water bodies and wetlands), grasslands, arable fields and urban ecosystems. The prioritization work allowed the participation of a higher number of experts (users, managers, researchers, policy makers etc.) with in-depth knowledge on the given ecosystem type (8 to 14 experts per ecosystem type), and to prioritize ecosystem services in more detailed way.

In each group the selected experts received the list of ecosystem services (CICES-HU), the definition and examples of each ES, and the background documents that described the project and its objectives. Based on these materials they were invited to an online preparatory exercise, during which they were asked to score the societal importance of each ecosystem service on a five-grade scale (0 = not important, 4 = very important). It was made clear, that 'important' means long term societal needs for the continuity of a certain ES in the given major habitat type. Participants were instructed that in each of the three ecosystem services groups (provisioning, regulation and maintenance, and cultural services) there should be at least one, but no more than the third of the eligible ES that can receive the highest score (4, "very important"). Based on these individual expert scores, a pre-prioritized list was prepared for the workshops.

Following these preparatory consultations, a series of 4 workshops was held in March-April 2017 (grasslands and arable fields were discussed in a joint workshop). The aim of the workshops was to select 8-10 ecosystem services for each major habitat type that were considered the most important as a result of a joint discussion and consensus. The preliminary online prioritization only served to direct the focus of the workshop discussions on the services that had been already highlighted, helping to carry out efficient and focused work during the limited time. Services that had received lower scores were also discussed, and in some cases, the discussion and a more precise definition of certain services that had previously been scored low were eventually scored higher, leading to changes in the previously set priority lists. After careful evaluation of the five priority lists, a cumulative priority list of 13 ES (see Table 3.5.1) was constructed for mapping and assessment during the remaining three years of the MAES-HU project, which runs until the end of 2020.

Table 3.5.1: Priority ES selected for MAES-HU and the major ecosystem categories where they were considered important

Selected ES (corresponding CICES 4.3 class)	Relevant broad ecosystem types
Provisioning	
Cultivated crops for nutrition (1.1.1.1)	Arable fields, grasslands, urban
Reared animals for nutrition (1.1.1.2)	Arable fields, grasslands, water-based, urban
Cultivated plants for energy resources (1.3.1.1)	Arable fields, forests
Regulation & Maintenance	
Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)	Arable fields, forests, urban
Mediation of smell/noise/visual impacts (2.1.2.3)	Urban
Mitigation of surface degradation and erosion control (2.2.1.1)	Arable fields, forests, grasslands
Hydrological cycle and water flow maintenance (2.2.2.1)	Arable fields, forests, grasslands, water-based, urban
Flood control and management of rainwater (2.2.2.2)	Forests, urban
Pollination and seed dispersal (2.3.1.1)	Arable fields, grasslands
Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	Arable fields, forests, urban
Micro and regional climate regulation (2.3.5.2)	Forests, grasslands, urban
Cultural	
Use of nature for recreation (3.1.1.1, 3.1.1.2)	Forests, water-based, urban
Cultural heritage (3.1.2.3)	Arable fields, forests, grasslands, water-based

3.5.2.4 Mapping of ecosystem types

The mapping of ecosystem types (ET) in the MAES-HU project is based on a habitat classification created specifically for this purpose. The categories are established so that they can be matched with those of the National Habitat Classification System "ÁNÉR" (Bölöni et al., 2011), which is widely used in Hungary. The primary data sources are partly EU databases such as Copernicus high resolution layers, partly national level data such as agricultural, forestry and soil databases. The existing datasets are complemented with information from remote sensing, mainly different indices derived from Sentinel satellite data. A first version of the map containing more detailed classes is currently being validated. Once the so created ecosystem types are mapped, it will be possible to develop simple matrix models (Burkhard et al., 2010; Jacobs et al., 2015) to map ES capacities. Such models, with the ET map being their only spatial input, are no more than simple 'lookup tables' which link the ecosystem types to indicator scores.

3.5.2.5 Next steps: mapping and assessment of the selected ES

The methodology of the assessment is built on the guidelines of the EU MAES working group (Maes et al., 2013) and technical reports of former national assessments of several EU Member States. The assessment will last two years and will be conducted along the four levels of the cascade model: 1) map and condition of ecosystems; 2) capacity (potential supply) of the selected ES; 3) actual use of the selected ES; and, 4) contributions to human wellbeing.

In MAES-HU, three to five ecosystem condition indicators are required to be assessed and mapped for the whole country area: naturalness, habitat diversity and soil fertility (mainly based on soil organic carbon content and soil depth). The more complex of these (especially naturalness) allow the integration of several related EC indicators, also further indicators can still be added to the list. This work is ongoing, the decision is to be made by the end of summer 2018.

The evaluation of the selected ES (their capacity and actual use) will be performed in the frame of six dedicated technical working groups (TWG). To form the TWGs the 13 selected ES from CICES-HU were clustered into thematic groups (alimentation/food production, climate and energy, urban, hydrology, pollination, cultural) according to the expertise needed for assessing them. Each TWG consists 5-15 experts from different fields (there are altogether 48 experts in the 5 TWGs), and has a well-defined mandate in terms of ES. The main goal of each TWG is to develop rule-based models (Tier 2, see ESMERALDA method application card 'Spatial proxy methods (rule-based matrix model)'), which are highly refined extensions to simple matrix models that identify additional relevant spatial input data and including them into map calculations. TWGs are expected to integrate the ecosystem condition indicators into these rule-based model, wherever feasible, thus establishing a coherence between the different layers on the MAES-HU assessment.

Economic evaluation is also planned for some ES, while valuation of some ES is being made on other (non-monetary) aspects of human well-being. In the last year of the project, planning of different future scenarios will be developed. The results of the MAES-HU project are expected to contribute to the sustainable management of environmental resources, enhance the development of green-infrastructure and improve incorporation of the results into sectoral policies. In the following we will analyse how different components are integrated in this work and how the work would change taking the integrated ecosystem assessment framework as developed in ESMERALDA (see Chapter 2) into account.

3.5.3 Aspects of integration

An ES assessment can be considered integrated if it allows analyses across the biophysical, social and economic (monetary) domains to be linked up, and cross-scale issues to be addressed. Various components of an ecosystem assessment can and should be subject of integration, some of which occur at an early phase of the MAES process, while others arise later. In Hungary the process is still ongoing, with the ES prioritization and selection, being a determinant phase of the whole MAES process, already completed, while indicator development and mapping of ES are on their way, followed by monetary and non-monetary valuations, scenario development and the synthesis of results during the next two years. Below we attempt to analyse whether the MAES-HU project complies, focusing primarily on what is already completed but also with an outlook to ongoing and planned work.

3.5.3.1 Integration of ecosystem types

One layer of the integration of ecosystem types is the cross-compliance between different habitat classification systems, so that the interpretation of ES capacities is, at least to a certain extent, not restricted to the actual system which was used for mapping. The ET system of MAES-HU is compliant, as minimum requirement for any national level ES mapping, with the MAES ecosystem types (classification level 2 in Maes et al., 2013). As far as it can be seen at present, the refined thematic classes planned in MAES-HU will be made compliant with the 2nd and 3rd levels of the European Nature Information System (EUNIS home) by means of an appropriate crosswalk.

A second layer of ET integration can arise during the assessment of ES provided by the complexity of a landscape, resulting from interactions between the individual ET. Such integration is seldom included in the matrix-type ES models due to the nature of this approach. In MAES-HU, landscape level integration of ET is planned in a more general way: incorporating "habitat diversity" or "landscape diversity" among the EC dimensions. Interaction between ET might also take place if we consider "source" and "sink" habitats - this is basically a binary scoring that reflects diverging functions of ET (relevant for example for water purification/filtering of anthropogenic emissions).

Although ES assessments use the current ET and EC stock as their basis, integration of ET at a temporal scale – considering also the historical set of habitat types – might provide useful information, for example in analysing trends of landscape change, developing scenarios or planning long term land use strategies of an area. In MAES-HU, the multilayer estimation of the Potential Vegetation of Hungary (Somodi et al., 2017) is available for such purpose, where the probability of the occurrence of natural habitats is estimated at a resolution of 700 m, using several abiotic background variables.

3.5.3.2 Integration of ecosystem condition

A crucial and central question of all ES assessments is how ecosystem condition (EC) relates to service provision. This is important because, according to the cascade logic, ES supply relies on the proper condition of ecosystems, which is a prerequisite for any ES to be enjoyed by people. However, individual ES (or, more often, groups of them) are different in their dependence on certain aspects of condition, and the actual use of ES can have a strong feedback on the condition itself (Harrison et al., 2014; Smith et al., 2017). EC can be integrated at the level of individual ES maps, i.e. incorporated into the ES model calculations, and also at an aggregated level of the assessment, identifying ES bundles, trade-offs and thresholds for sustainable ES use. Chapter 3.2 (Ecosystem Condition and its role in an integrated ecosystem assessment) of this document provides more information on the relations between ecosystem condition and ecosystem services.

In MAES-HU the 3 pre-chosen EC aspects mentioned in Chapter 1.5 will be incorporated into some of the specific ES models at the level of ES capacity (cascade level 2), in the form of relevant input layers/modifying factors, but they can also be used for the assessment of trade-offs, synergies and questions related to sustainability. Besides, integration of further EC aspects happens at the individual ES level (development of rule-based models) as specific rules, some of which are or could be actually EC indicators. Due to the rule-based model approach, the EC-ES integration happens not only at the synthesis phase of the project but EC aspects are in most cases already integrated in each individual ES maps.

3.5.3.3 Integration of stakeholder perspectives

Integration of the perspectives of different stakeholders and experts is a strong element of the MAES-HU project. As described in the first part of this chapter, identification of ES was based on an initial stakeholder analysis. ES prioritization was done by the help of experts, and so is the development of ES models. Selecting indicators for EC and ES is going to be done by dedicated groups of sectoral experts involved in the entire implementation period of the project. The transparency and intuitiveness of the rule-based matrix models can facilitate expert involvement in an iterative process. If experts are used for setting the rules and verifying the model outputs then the resulting models can also be called expert models (Wainger and Mazzotta, 2011). The project allows integration between the thematic expert groups as well both occasionally - for the more exact identification of rules in certain ES models - and systematically - when it comes to the evaluation of sustainable land use, synergies, trade-offs and the development of future scenarios.

Scenario development and valuation will be executed by a group representing all relevant stakeholders. However, a wider public participation is not planned, as this would need more resources (e.g. questionnaires on more topics). Although inclusion of experts into the expert groups was based on the stakeholder analysis, expert groups might still not represent all relevant opinions in the country, as some were not available for the initial series of interviews due to existing sectoral conflicts.

3.5.3.4 Integration of scope and expected policy uptake

If we compare the structure of MAES-HU (Figure 3.5.1) to the ESMERALDA framework for integrated assessment, it is apparent that components at the synthesis phase are less detailed in MAES-HU. The same is, however, true for the previous frameworks (European Commission, 2014; Burkhard et al., 2018), which give detailed advice on how to integrate ecosystem maps and condition into mapping, but little on how to integrate the results of mapping into the wider context of policy, society and business. In MAES-HU, developing scenarios is a tool meant to achieve this, because the scenarios will, beyond future ecosystem condition and services, contain information about the wider societial context. The deliberative valuation of the preferred scenario will allow participants to identify actions leading to that, which can be formulated into actual policy recommendations, either long term and strategic or detailed and specific for a particular policy field.

What is eventually taken up from those policy recommendations - the societal responses elements of the ESMERALDA framework - is beyond the scope of the MAES-HU project. At the early phase of MAES-HU, however, a detailed list of potential (and suggested) future uptake of the results of the ES assessment in policy, application and governance was compiled, similar to the list of policy questions by Maes et al. (2018) at the EU level. It includes the following main directions: implementation of international and EU legislation, incorporating ES into national legislation and sectoral strategies, incorporating the results into statistical databases, assisting the authorities, establishing professional (strategic and long-term) planning inside and outside the nature conservation sector, establishing and monitoring of continuous activities (e.g. management) of nature conservation, providing a decision support tool for investments and developments, incorporating ES into support systems and subsidies, identifying research priorities, resolving conflicts of land use, and strengthening communication and advocacy for nature conservation.

While not being able to guarantee the actual uptake of results in this very ambitious list of fields, there are still two things which can be done within the scope of the MAES-HU project. One of them is the strategic role of the EPE members, being key transmitters in the future uptake of MAES-HU results into sectoral policies and having various sectoral leaders among its members familiar with and dedicated to the project. The other is laying in the fact that MAES-HU is only one component of the “Strategic investigations on the long-term preservation and development of natural heritage of community importance and on the implementation of the EU Biodiversity Strategy 2020 objective” project, with the other component being the development of Green Infrastructure (GI) in Hungary. Results of ES mapping will be incorporated into GI and spatial planning regulations in Hungary, but the technical details of that is still unknown at the time this document is being written.

3.5.4 Conclusions

Having a strong participatory element and working along the cascade with every cascade level described by (a set of) indicators (as suggested by Czúcz and Arany, 2016) ensures that biophysical, social, and for some ES also economic aspects are integrated in MAES-HU. However, as already written in chapter 2.5, key contribution that the notion of integrated assessment provides should be the ability to consider the synergies and trade-offs of a range of ecosystem services associated with one or more ecosystems. For that, ES indicators need to be comparable with each other at a certain scale. In MAES-HU, the quantification of ES indicators is not always possible in terms of biophysical units, mapping of some ES will show only relative capacity scores. This will limit the possibilities for comparison or aggregation of ES maps is limited.

Despite – or in parallel to - several existing dimensions of inter-sectoral cooperation, some conflicts still exist between certain sectors, which might be an obstacle to a real efficient use of the results. Since the assessment of ecosystem services is, by definition, a transdisciplinary exercise, cooperation is indispensable both for the good quality of results and for any real future effect (Albert et al., 2017). What we hope is that the strong emphasis on the participatory approach during the whole project, including the permanent board, will help stakeholders understand the ES concept, and earn enough credibility and legitimacy for the results so that they will incorporate them in their own sectoral decisions.

Applying the ESMERALDA IEA framework for the remaining two years of project implementation would likely help achieve a more efficient integration of results by putting emphasis on each key elements of integration especially at the synthesis phase. To enable a sensible policy uptake in the future, results of MAES-HU will also need to be regularly updated after the project has finished, and the realized uptake will need to be assessed and monitored as a regular follow-up in the future.

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3.6. Ecosystem based management as a transdisciplinary approach in the Lower Danube River System

By **Cristian Mihai Adamescu and Constantin Cazacu (UNIBUC)**

3.6.1 Introduction

We combined an ecosystem-based management approach with a transdisciplinarity and ecosystem services perspective in an attempt to explain the dynamics of management decision over more than 60 years in the 'Lower Danube River System' (LDRS).

Land use change has impacted many areas in Europe. Among the most impacted ecosystem types are the wetlands (European Commission, 1995), with a 2/3 loss in the total surface. The remaining areas are, however, under constant pressures, leading to a significant reduction of size and connectivity. In the LDRS the change from natural systems and transformation into human-made and human-dominated systems occurred due to misuse or lack of understanding and knowledge (or all of the above) regarding the benefits that wetlands can provide to local communities as well as the littoral zone of the Black Sea.

At the time of the decision making about the important land use changes there was no consideration of the local people (despite the fact that all the changes were done in their name- but without really a consultation and a dialog with the local communities). The decision-making process was based on skewed scientific knowledge (taking into consideration only the production capacity of the systems and neglecting all other ES) and also not based on the interactions with local communities. The estimation of wetland benefits relied on the productive capacity of the system ,neglecting other types of services like for e.g. the regulation capacity of the wetlands. The consequences were very important for the local people (less benefits, more concentration to certain people, and generalised poverty despite huge available resources) but also for the biodiversity conservation (changes in the land use, reduction of wetlands surface, impact on species and communities) and in general a lower capacity of the system to adapt to future changes. In the last 20 years new scientific interdisciplinary knowledge integration occurred and based on the specific frameworks (the emergence of protection areas like e.g. biosphere reserves, Natura 2000 sites) the approach had changed to be more inclusive. A different approach in which people are actively involved in the decision system and in formulating the questions is needed. This chapter addresses the management situation in the Lower Danube River System and examines what influence an Integrated Ecosystem Assessment (like the one developed in ESMERALDA) could have had on the present situation if such a conceptual framework had been used. Such an integrated approach although more complicated could have saved (at least in theory) the area (and other similar areas) from changing from natural systems into anthropic systems.

3.6.2 Conceptual framework

Identification and assessment of the services supplied by natural and semi-natural ecosystem relies on the "hierarchic model" (Potschin and Haines-Young, 2011) that integrates the perceptions of stakeholders regarding the capacity of ecosystems to supply various goods and services.

According to the recommendations from the project ESMERALDA working towards the MAES initiative (Maes et al., 2014) the typology to be used for ecosystem services is specific to *"The Common International Classification of Ecosystem Services"* (CICES http://cices.eu). We consider that the integrative view on the ES is based, and should be based, on a deep understating of the ecosystems, their structure and functioning; and that we need also to involve the stakeholders all along the evaluation and assessment process from the beginning of the process.

In the case study discussed here, the purpose of assessing ecosystem services was a practical one, meant to serve the operationalization of the concept of ecosystem services and the development of practical applications. The elements that we used to assess the ES for this area are to be found at the convergence of science and politics, focusing also on the need to develop a terminology that would be easily accessible to the decision makers and to the various stakeholders, precisely for the purpose of expressing the plurality of ecosystem values for the various stakeholders involved.

Developing practical approaches that deals with assessment of ES in protected areas has to do more with a utilitarian and pragmatic one (“it is in our best interest to preserve nature”) than to a normative one (“we should protect the nature”). This is also dealing with a social dimension that in fact imply that the evaluation of ecosystem services should be grounded on a participatory, inclusive and deliberative approach allowing community members to discover, explore, share and build consensus on benefits provided by a specific ecosystem.

Any assessment of ecosystem services must start from recognising that such services are socially defined. Stakeholders define what represents a benefit, as well as the relevance or the value of any benefit. Thus, the value of ecosystem services is relative, rather than absolute. It is relative because both the range of services recognised socially, and their value are subject to the system of attitudes and values of the players evaluating them. Ecosystem services and their value vary in time and space depending on how the benefits generated by the ecosystem resources are defined at a social level. The same ecosystem resource may have one value to the local community and a totally different value to the scientific community or to people from outside the local communities. Identification of the existence of a certain type of ecosystem service can change over time, both as a result of changes in how informed people are regarding the benefits of the ecosystems, and as a result of changes in their system of attitudes and values regarding such services.

To include the social dimension of ecosystem services, we used different methodological approaches (see also Figure 3.6.1):

1. Participative approach – identification and assessment of the relevance of ecosystem services must take into account the diversity of value systems at the level of local communities and capture, rather than the views of an expert, the views of all the local, regional and national social stakeholders;
2. Inclusive approach - based on mobilizing the representatives of all groups of stakeholders at local, regional and national level. Thus, the evaluation of ecosystem services requires an initial process of segmenting the stakeholders and involving them in the process of identifying and ranking the social services; and,
3. Deliberative approach - focused on public/group debates on ecosystem services. The deliberative approach generates multiple effects at an individual and group level, and it contributes to: a) generating awareness on the different perceptions regarding the number and relevance of ecosystem services; b) deeper individual understanding of the multitude of ecosystem services and their relevance; and, c) building shared, negotiated understanding on the most relevant ecosystem services.

3.6.3 Transition towards transdisciplinarity

There is a continuous process transitioning from our way of thinking towards transdisciplinarity, meaning in fact working with different disciplines and with stakeholders for the co-production of knowledge, including knowledge related to ecosystem services (Figure 3.6.1). Such an approach is requiring disciplinary understandings, and integrating and a move beyond disciplinary and interdisciplinary research. It includes also all relevant data about policies; socio-economic data and trends; ecosystems and biodiversity related research. At the same it is addressing ecosystem services as a mean of integration and co-creation between stakeholders and decision makers.

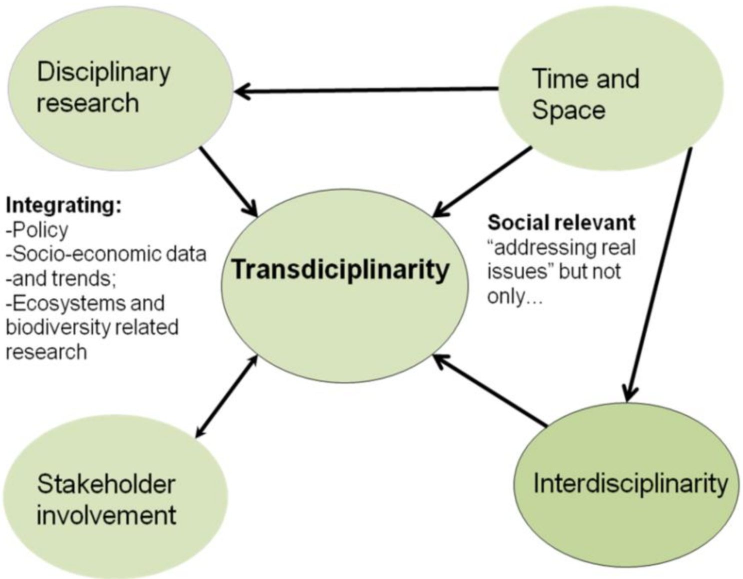

Figure 3.6.1 Conceptual framework for transdisciplinary approach in Lower Danube Floodplain (Braila Islands)

3.6.4 Case study area

"Braila Islands" site with a total surface of over 2,600 km^2 is situated in the South-East of Romania, and corresponds to a 78 km long Danube sector that stretches between the cities of Harsova and Braila. This socio-ecological system is inhabited by near 300,000 people and comprises heavily modified ecosystems (e.g. Big Island of Braila, former wetland transformed into agricultural land) but also systems under a natural functional regime (e.g. Small Islands of Braila), being of a crucial natural and socio-economical value. The Danube river along the Braila Islands section has been ranked as a heavily modified water body according to criteria 2.1 (embankment works) due to the hydro-technical works on more than 79% of the river stretch sector and a candidate for "heavily modified", according with the WFD criteria 2.2 (regulation works) as a result of dredging of 21% of the river bed for intensive navigation.

The main remnant of the natural floodplains consists in the wetlands from the Small Island of Braila Natural Park with a total surface of 210 km^2 and the floodplains between the riverbanks and dikes of almost 93 km^2.

3.6.5 Policy context

A debate started during the 60's (but even earlier see Antipa, 1910) about the need to transform a wetland area with "no use or very little use" into a highly productive systems (agricultural systems, fish farms. forest plantation).

The transformation took place (due to inappropriate conceptual framework and political will) and more than 80% of the former Lower Danube River floodplain was transformed into managed systems. There were immediate consequences at multiple temporal and spatial scale and for multiple stakeholders on one hand and on multiple ecosystems on the hand.

3.6.6 Data availability and methods

The approach proposed for assessing ecosystem services includes three distinct phases: a) identification of ecosystem services; b) assessing the social relevance of the ecosystem services and ranking of these services; and, c) determining the monetary value of the ecosystem services. Identification of the ESs requires an effort to become aware of the multitude of ecosystems services supplied by the natural areas. For this purpose, the approach needs to be participative and based on the different social actors, so that all the social perceptions regarding the advantages can be identified and recorded.

On top of this we have used historical maps (reference condition) to identify past ecosystem structure and derive ecosystem services. We compared then the ecosystem services with the actual ecosystem services and we have linked this with the changes in political situation (Figure 3.6.2.).

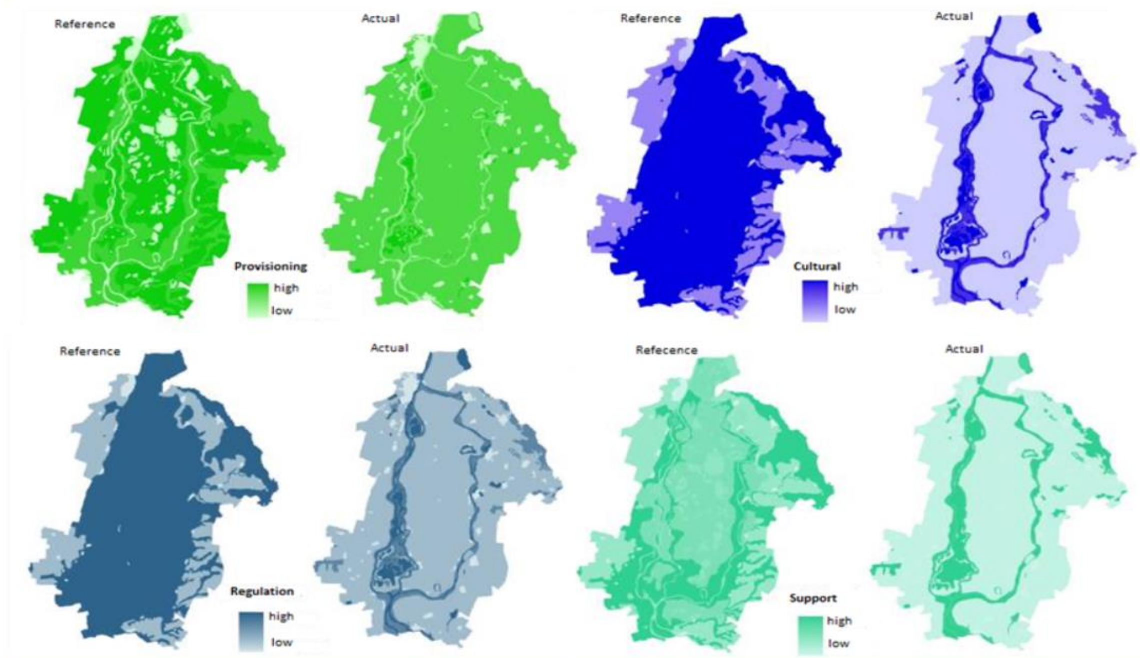

Figure 3.6.2 Ecosystem services (provisioning, cultural regulation and support) for LTSER Braila for the reference condition (prior to damming) and in actual condition

3.6.7 Mapping and assessment of ES in Braila Islands

3.6.7.1 ES identification

During our investigation we used three different methods to identify ES provided by a specific natural area:

i) Survey method - involving application on individual questionnaires with lists of ES and indication for subjects to indicate existence of services within a target area and their social importance,

ii) The list method (individuals where introduced to the CICES classification and asked to state which of these services are offered by the analysed area) allowed recognition of 22 different services while the brainstorming method (no detailed classification of ES) allowed identification of only 13 services. During a participatory workshop, individuals where introduced to the CICES classification and asked to state which of these services are offered by the analysed area. People were encouraged to share information on discussed ecosystems services.

iii) Brainstorming techniques used during focus group discussions. During the participatory workshops individuals were encouraged to think about benefits/services provided by a given area and indicate them during the group discussion (no detailed classification of ES provided to participants). **Ranking ES**

The overall aim of this stage was to establish a robust significance indicator for the identified ES. The first challenge was to select the 10 most significant or defining services for the analysed ecosystem and the second challenge was to establish a numeric correlation between these 10 services reflecting the significance of these services within the overall or cumulative value of the ecosystem. An **ES significance coefficient** was established for each identified ES reflecting its relative importance and contribution to the overall or cumulative value of the services provided by the analysed ecosystem.

Table 3.6.1: Methods used for identifying and ranking ecosystem services

Method	Comments
Face-to-face interview with the stakeholders	The attendants do not acquire an overall image regarding the collective perception. There is no debate or social dialogue between the stakeholders.
Group interview with stakeholders	Allows stakeholders to become aware of other views that shape the collective mind. Is allowing social learning.
Survey	Can include several types of questions: either open-end questions (*what are the benefits that nature offers?*), or closed-end questions (*which of the benefits below are supplied by the natural area we are analysing?*). Requires co-ordination by a specialist, both at the stage of creating the samples and at the stage of analysing the recorded data.
The Delphi method – a group of experts determining the services	The method is similar to the face-to-face or group interview, with the only difference that the social actors involved are experts. It usually generates a large list of possible ecosystem services.

3.6.7.2 Monetary valuation

In general, a set of methods are used in establishing the monetary value, as an expression of an integrated approach, of a particular protected area depending on the nature of the services analysed/identified in that protected area. The solution proposed for determining the value of ecosystem services is a mix of methods, techniques and hypotheses that enable monetary valuation of the area of interest. We used the following methodology in establishing the monetary value for a specific area:

a) Selecting the reference ecosystem service

A reference ecosystem service (RES) was identified. The RES was used as a benchmark for inferring the monetary value of all the other ecosystem services identified in the area. This is the only service for which an accurate measuring of the monetary value will be conducted, as this value will become a benchmark point in the inductive process that will result in approximating the value of the other services.

b) Determining the monetary value of the reference ecosystem service

A rigorous research on the monetary value of the reference ecosystem service (RES) is required in order to establish this.

c) Consumer surplus pertaining to the reference ecosystem service

The consumer surplus is the additional amount (in addition to the market price) that the consumer would be willing to pay for the same amount of an ecosystem service, without diminishing their material wellbeing.

d) Use value of the reference ecosystem service

The exploitation use value (UV) of the RES is calculated by adding the market price to the consumer surplus:

UV = MV+ CS

where: UV= exploitation use value; MV = market value; CS = consumer surplus

e) Non-use value of the reference ecosystem service

f) Total value for the reference ecosystem service

The total economic value is obtained by adding the two components – the use value and the non-use value of the ecosystem services.

g) Determining the value, the non- value and the total value of all the identified ecosystem services

The total value of all the ecosystem services identified is determined using the importance coefficients (calculated as a weighted mean of the local, regional and national coefficients, using a weighting system selected according to the majority rule).

h) Determining the amount/surfaces of manifestation of the ecosystem services

i) Determining the monetary value at site level

The monetary value at site level is determined by multiplying the unit value for each type of service and ecosystem with its surface.

3.6.7.3 Results integration

Based on existing date for the total surface of about 2,600 km^2 of natural and semi-natural ecosystems the area was able to identify a huge array of different ecosystem services with respect of reference conditions (Figure 3.6.3): a) Annual fish catches of 5-7 ktons; b) > 125 ktons of reed and reed mace; c) Up to $5*10^4$ cubic meters of wood; d) ~37 ktons of crops & animal products. At the same time, the system was able to support regulation ecosystem services: a) a flood retention capacity of more than $7km^3$; a nitrogen retention capacity between 84 up to 100 ktons*y^{-1}; and a phosphorous retention capacity of 4to 6 ktons*y^{-1};

Unfortunately, almost 60 years ago nobody considered that nitrogen and phosphorus retention, as well as flood detention capacity, could be an important aspect to be considered when designing management plans for the area. Based on ecosystem valuation the decision taken was to increase the provision of production provided, with no consideration on these other services. In the LTSER Braila Island, large enclosures for agriculture substituting the natural and semi-natural wetland ecosystems with intensive crop, livestock, fish farm and tree plantations (especially Canadian poplar) were built.

All of these changes occurred at a huge cost of over 2 billion USD and over more than a decade. The system transformed from a complex system with a balanced structure that is providing multiple ecosystem services to communities into a very simplified system with an unbalanced structure that is focusing on providing provisioning services.

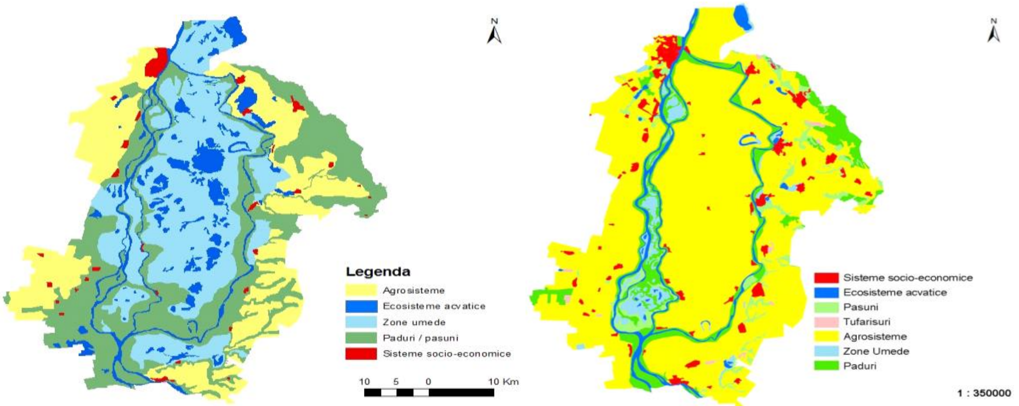

Figure 3.6.3 Braila Island reference condition (a) and actual condition (b)

As a result, there were many **unforeseen negative impacts** at local scale and also far away (in North Western Black Sea) from: a) changes in the land use; b) changes in the capacity of the floodplain to regulate the **microclimate;** c) changes of the flood detention capacity; d) Changes in the nitrogen retention capacity; e) Changes in the phosphorous retention capacity; and, f) Changes at longer distance – Danube Delta and NW Black Sea.

3.6.8 Discussion and Conclusion

Human well-being is linked with the ecosystem condition (MA, chapter 3 Corvalan et al., 2005) and therefore better environmental management could also have real impact on the human society. In many cases having a win-win situation (better environmental management-better ecosystem conditions - increased human well-being) is a very difficult task because it requires having a very clear understanding of coupled human environment system and also taking care of the systems characteristics (dynamics, non-linearity, complexity). This is also linked with the definition of ES and also with the usefulness of ES in management of ecosystems and sustainable development and the need to move conservation (and by inclusion, the ES) from being considered as opposing the development of society because of the competing goals (social, economic and ecological) towards being a necessary ingredient of the sustainable development.

Understanding the way the systems are working and providing the ecosystem services has proved, in too many cases, a very difficult endeavour. In too many cases decision making process using a faulty conceptual framework and a poor decision-making system had important consequences for numerous ecosystem services and finally on the human health and resilience of socio-economic systems.

The work on assessing the ES and the impact of different management policies on the Danube floodplain is the basis for building future scenarios, including those dealing with restoration, and also to raise concerns about the role of scientific community in decision making.

Having a system to evaluate in an integrated way the Ecosystem Services (like the one developed in ESMERALDA) could have most probable saved or could contributed into a greater extent to conserve or protect the area (and other similar areas) from changing from natural systems into anthropic systems.

3.6.9 Selected references:

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3.7 Applying the Integrated Ecosystem Service Assessment Framework in a European small island state

By **Mario V Balzan (MCAST)**

3.7.1 Introduction

Globally small islands are characterised by a diverse range of conditions, but they are recognised as a special case for sustainable development because of their relatively small populations, highly sensitive economies, limited natural resources, restricted usable land area, isolation from and yet dependence on external market, high susceptibility to climate change, and constrained adaptation capacity and development options (Nurse et al., 2001). The SAMOA Pathway (2014), which sets out objectives and strategies for the sustainable development of Small Island Developing States (SIDS), recognises the extraordinary biodiversity of SIDS, its value in providing ecosystem services and the acting pressures and strongly supports efforts to conserve biodiversity and ensure its sustainable use. Similarly, the important contribution of ecosystems to human well-being in small islands has been recognised by the Millennium Ecosystem Assessment, which assessed the important contribution of island systems to human well-being (Wong et al., 2005).

The limited availability of spatial data at the local scale (Balzan et al., 2018a) together with the challenges of integrating environmental objectives in decision-making processes and of ensuring horizontal coherence across sectoral policies (Hirano, 2008; Roberts, 2010) may limit the implementation of ecosystem service approaches in small islands environments. In a recent review aimed at exploring the knowledge landscape about island ecosystem services it was shown that most of studies focused on the management of island ecosystems and ecosystem services, and the pressures acting on these because of human drivers (Balzan et al., 2018b). Few studies carried out a biophysical quantification of ecosystem services, investigated their spatial variation, arising synergies and trade-offs, or assessed the socio-cultural and economic value of island ecosystem services. This is also demonstrated by a reclassification of a first dataset of the papers retrieved by Balzan et al. (2018b), to fit the steps indicated in the cascade model (Figure 3.7.2). In this review, the papers focusing on the biophysical, social or economic assessment of ecosystem services and their benefits composed a small fraction of the studies, whilst most of the studies dealing with the benefit and value to local communities mostly dealt with cultural ecosystem services in the form of recreation and ecotourism.

Within this context of challenges faced by small islands, their contribution to global biodiversity, and the challenges faced by small islands in achieving sustainable development, this contribution presents an overview of results obtained from recent studies that assess, map or value ecosystem services in the small island state of Malta, the smallest member state of the European Union. Finally, the experience of the implementation of ecosystem and ecosystem service assessments and the results obtained is analysed in the context of the Integrated Ecosystem Assessment (IEA) framework as developed further by ESMERALDA (see Chapter 2)

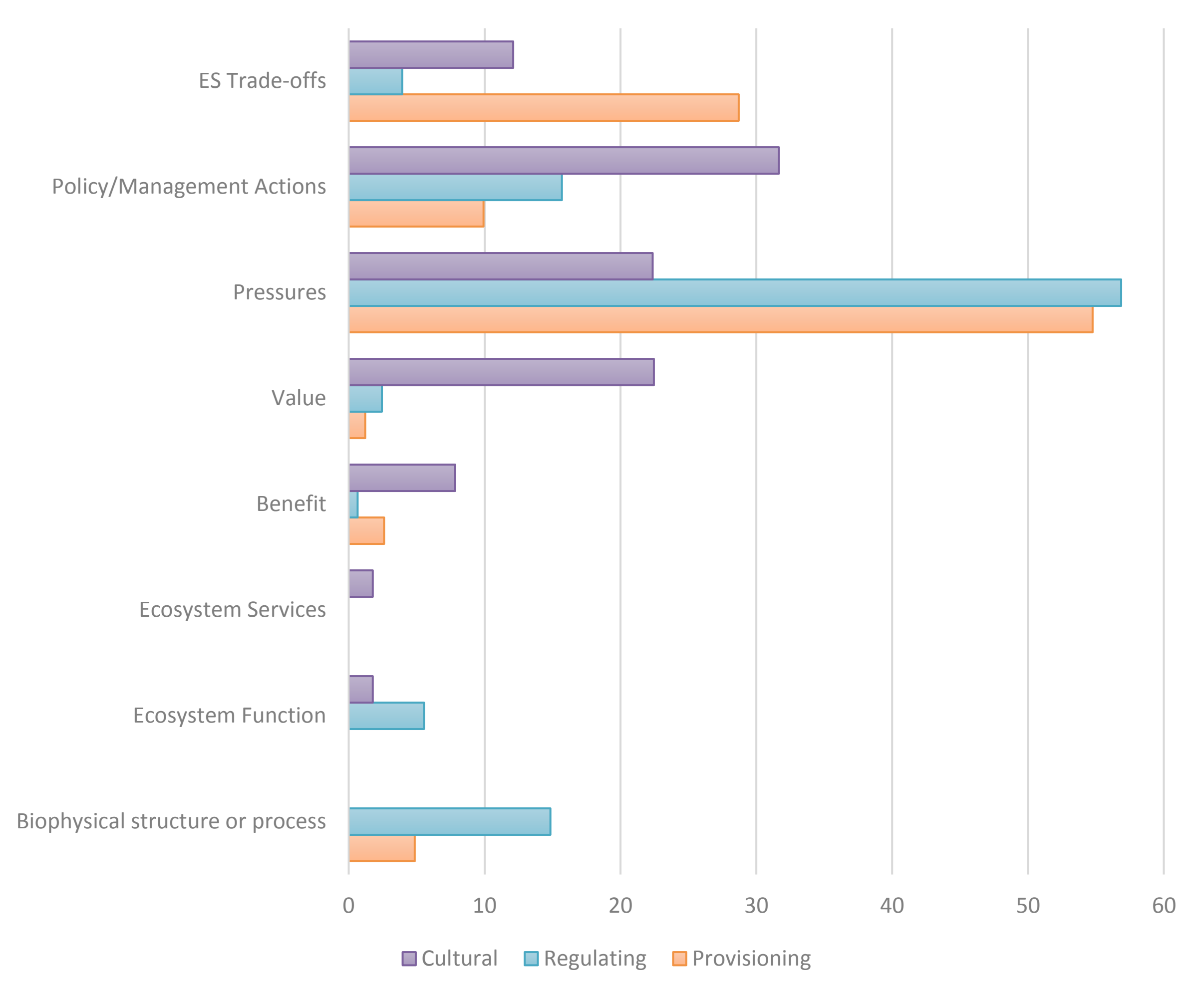

Figure 3.7.2: Literature about island ecosystems and their services were classified according to the stages of the ecosystem services cascade model described by Potschin and Haines-Young., 2011 (but including synergies and trade-offs which were included in the review by Balzan et al., 2018b).

3.7.2 Case-study area

The Maltese archipelago is a group of low-lying, small islands situated in the Central Mediterranean Sea at 96 km south of Sicily, almost 300 km east of Tunisia and some 350 km north of the Libyan coast. The archipelago is made up of three inhabited islands (Malta, Gozo and Comino) and several uninhabited islets, with a total land area of 316km^2. The Maltese Islands also have a long cultural history and the earliest evidence of settlement dates to around 7200 BP. With agriculture being as old as humankind's remote origins on the archipelago, the landscapes of the Maltese Islands have been highly modified over the millennia. The first settlements were associated with deforestation for agriculture, the introduction of livestock and grazing activities. In 2008 agricultural land cover occupied around 51% of the territory, whilst built-up, industrial and urban areas occupy more than 30% of the Maltese Islands (MEPA, 2010; Figure 3.7.2). Malta has a population density of 1,346 persons per km^2 in 2014 (NSO, 2016), the highest in the European Union, and a booming tourism industry the Maltese Islands' biodiversity creating substantial pressure on natural resources.

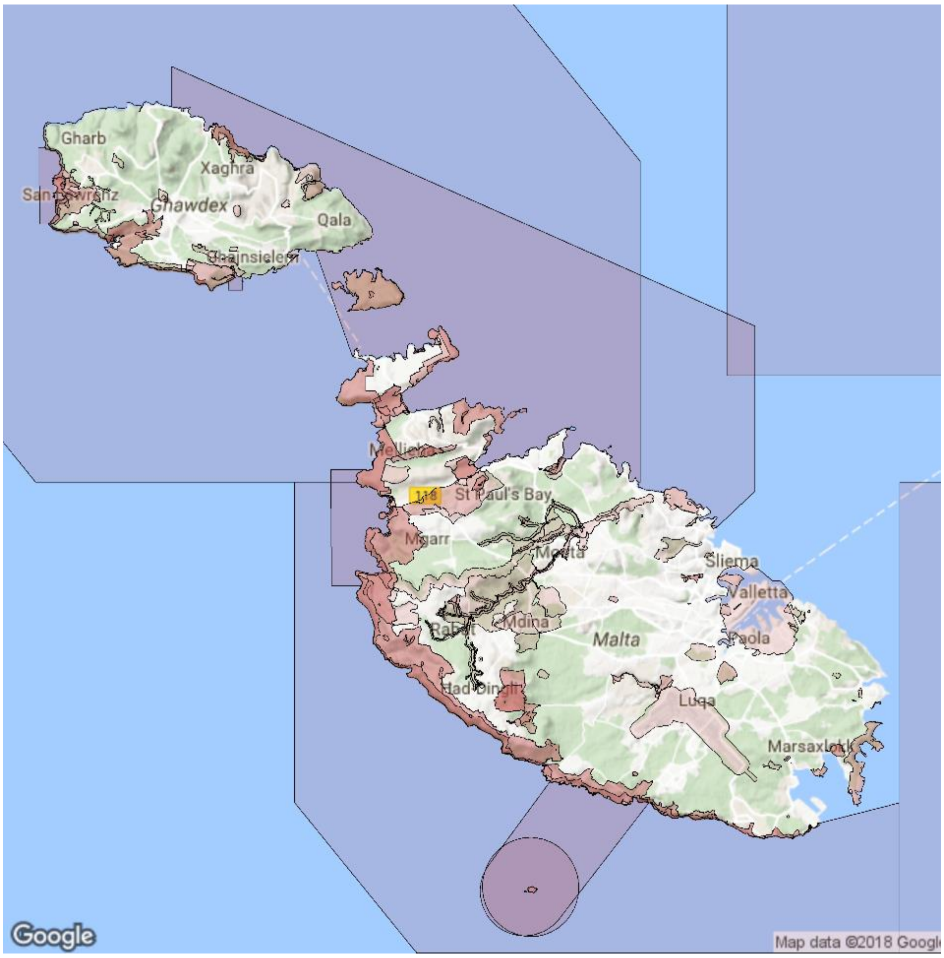

Figure 3.7.3: The Maltese Islands (grey areas indicate urban areas; green areas indicate agricultural and semi-natural habitats; overlaying polygons in red showing the nationally designated protected areas in 2017 with a focus on the terrestrial and coastal sites; source base map: Google, 2018).

3.7.3 Policy Context and Objectives

This work is particularly relevant to policy objectives of Malta's National Biodiversity Strategy and Action Plan (NBSAP)[2], which highlight the contribution of biodiversity to human well-being, set targets for the conservation and restoration of ecosystems providing key ES, and promote the mainstreaming of biodiversity concerns in relevant sectors and the recognition of the full range of values of biodiversity and ecosystem services. More specifically, the NBSAP aims to recognise the value of biodiversity and ecosystem services, and opportunities derived from their sustainable use, and to integrate these in national policies, as well as decision-making and planning processes (Target 2). At the same time, the NBSAP sets out a target for the restoration of at least 15% of degraded ecosystems and for the essential services provided vulnerable ecosystems to be safeguarded (Target 13), whilst also aiming to develop the knowledge base about biodiversity, its values, functioning, status and trends and the consequences of its loss (Target 18).

[2] https://www.cbd.int/doc/world/mt/mt-nbsap-01-en.pdf

3.7.4 Developing the science-policy interface

Malta has carried out a preliminary identification of key ecosystems and their services as part of Malta's Fifth National Report to the Convention on Biological Diversity (MEPA, 2014), and this forms the basis work that has commenced to implement the measures relating to the Mapping and Assessment of Ecosystem Services initiative in Malta's National Biodiversity Strategy and Action Plan 2012-2020. This work prioritises ecosystems and ecosystem services for mapping and assessment, has determined the level of detail best applicable to Malta and aims to identify available data/data sources that can be used, and data gaps that will need to be addressed; as well as identifying stakeholders/experts to be consulted in the process (BISE, 2018).

This contribution presents work carried out, amongst other, within the Horizon 2020 project ESMERALDA[3], the EC project EnRoute[4] assessing urban ecosystem services, and a number of other national or local scale studies. Within the ESMERALDA project, a case-study was carried out to test ecosystem services assessment and mapping methods in Malta. The case study is a first assessment of the capacity and flow of ecosystem services, and has analysed the spatial variation of ecosystems and their services to identify hotspots of ecosystem services, and to explore the impact of policies and developments on the ecosystems' capacity to deliver key ecosystem services (Geneletti et al., 2018).

3.7.5 Data availability and methods

3.7.5.1 Identification and mapping of ecosystem types

The assessment of ecosystem services in Malta, presents several challenges, mostly associated with the availability of land use and other spatial data at relevant scales, and the scale of the existing spatial data. Corine Land Cover (2006, 2012) is available for Malta but given the heterogeneity of the landscapes, the presence of small landscape units, and the coarse categorisation of agricultural areas that makes up almost half of Malta's land area, limit the usability of this land cover map for the mapping of ecosystem services. Given the limited availability of spatial data that covers the entire national terrestrial territory at the right resolution and scale, a land use land cover (LULC) map was developed using Sentinel 2 satellite images provided by Copernicus (Balzan et al., 2018a). These were converted to reflectance. Images were then processed and mapped by applying a supervised multispectral classification with the maximum likelihood method. The MAES typology of ecosystems was used as a reference (Maes et al., 2013) and has been adapted to the local land uses and cover in the study area. The final classification consisted of a LULC map with 13 classes (Balzan et al., 2018a; Table 3.7.1).

[3] http://esmeralda-project.eu

[4] http://oppla.eu/enroute

Table 3.7.1: Terrestrial ecosystems identified within the land use land cover map. The MAES initiative typology of ecosystems used in Maes et al. (2013) has been utilised as a reference and is adapted to the local land uses and cover in this study (Balzan et al., 2018a)

MAES (Maes et al. 2013) code	Terrestrial Ecosystems in MAES	Adapted LULC Code	Terrestrial Ecosystems in LULC map for Malta
A.1	Urban ecosystems	A.1.A	Urban areas
		A.1.B	Roads
A.2	Cropland	A.2.A	Non-irrigated arable land and bare soil cover
		A.2.B	Irrigated arable land
		A.2.C	Orchard and shrub communities
		A.2.D	Vineyards
		A.2.E	Greenhouses
		A.2.F	Golf course
A.3	Grassland	A.3	Steppe communities
A.4	Woodland and forest areas	A.4	Woodland
A.5	Heathland and shrub areas	A.5	Schlerophyllous vegetation
A.6	Sparsely or unvegetated land	A.6	Sparsely or un-vegetated rock cover
A.7	Inland wetlands	A.7	Wetlands

3.7.5.2 Methods for ecosystem services assessment and mapping

Ecosystem condition is for the purposes of the MAES initiative defined as the physical, chemical and biological condition of an ecosystem at a point in time. The assessment of ecosystem condition has been carried out using various indicators and measures, including through:

1. the described LULC map, which characterises the landscapes in terms of the ecological successional stages recorded in Malta, hence providing a proxy of the habitat and species characteristics and the pressures and disturbances acting on ecosystems.
2. distribution data of species and habitats of conservation value (Art.17, Habitats Directive);
3. ecological data that has been used to characterise the relationship between landscape composition and biodiversity (e.g. plant and pollinator diversity);
4. assessment of shrub and tree cover in different ecosystem types (including gardens, agroecosystems, shrubland and woodland) using satellite data; and through
5. assessments of intra-annual and long-term changes in vegetation cover using satellite-derived data.

The assessments and mapping of ecosystems carried out within the study area have included a diverse range of indicators and methods (Table 3.7.2). Indicators shown here represent the capacity and flow of ecosystem services, with the former being defined as the potential of ecosystems to provide services. The ecosystem service flow is defined as the actual use of the service, which can be measured directly as the amount of a services delivered or indirectly as the number of beneficiaries served (Villamagna et al., 2013).

Table 3.7.2: Indicators used for the assessment and mapping of ecosystem services and based on previous contributions (Balzan and Debono, 2018; Balzan, 2017; Balzan et al., 2018a; Zammit and Balzan, 2016).

Ecosystem Service (CICES 4.3)	Indicator	Capacity/Flow
Cultivated crops	Downscaled crop production (ton/Km^2)	Capacity/Flow
Reared animals and their outputs	Beekeepers' Habitat Preference (Frequency of responses)	Capacity
Reared animals and their outputs	Number of hives/Km^2	Flow
Materials from plants, algae and animals for agricultural use	Rainfed agricultural land (Fodder production potential)	Capacity
Materials from plants, algae and animals for agricultural use	Livestock (number of Cattle, Sheep, Goats)/Km^2	Flow
Pollination and seed dispersal	Pollinator visitation probability	Capacity
Pollination and seed dispersal	Crop pollinator dependency	Flow
Dilution by atmosphere, freshwater and marine ecosystems	NO_2 deposition velocity (mm/s)	Capacity
Dilution by atmosphere, freshwater and marine ecosystems	NO_2 removal flux (ton/ha/year)	Flow
Physical use of land- /seascapes in different environmental settings	Number of habitats of community importance	Capacity
Physical use of land- /seascapes in different environmental settings	Visitation to sites and urban green areas for recreational activities	Flow
Physical use of land- /seascapes in different environmental settings	Geocaching point location	Capacity
Physical use of land- /seascapes in different environmental settings	Number of geocache quests/favourites	Flow
Aesthetic	Preference Assessment with locals (Frequency of responses)	Flow

In the case of recreational ecosystem services, the flow has been characterised through the measurement of visitation either through questionnaires or the use of geotagged data obtained from geocaching activities (Balzan and Debono, 2018; Balzan et al., 2018a), and this data is shown in **Figure 3.7.4**.

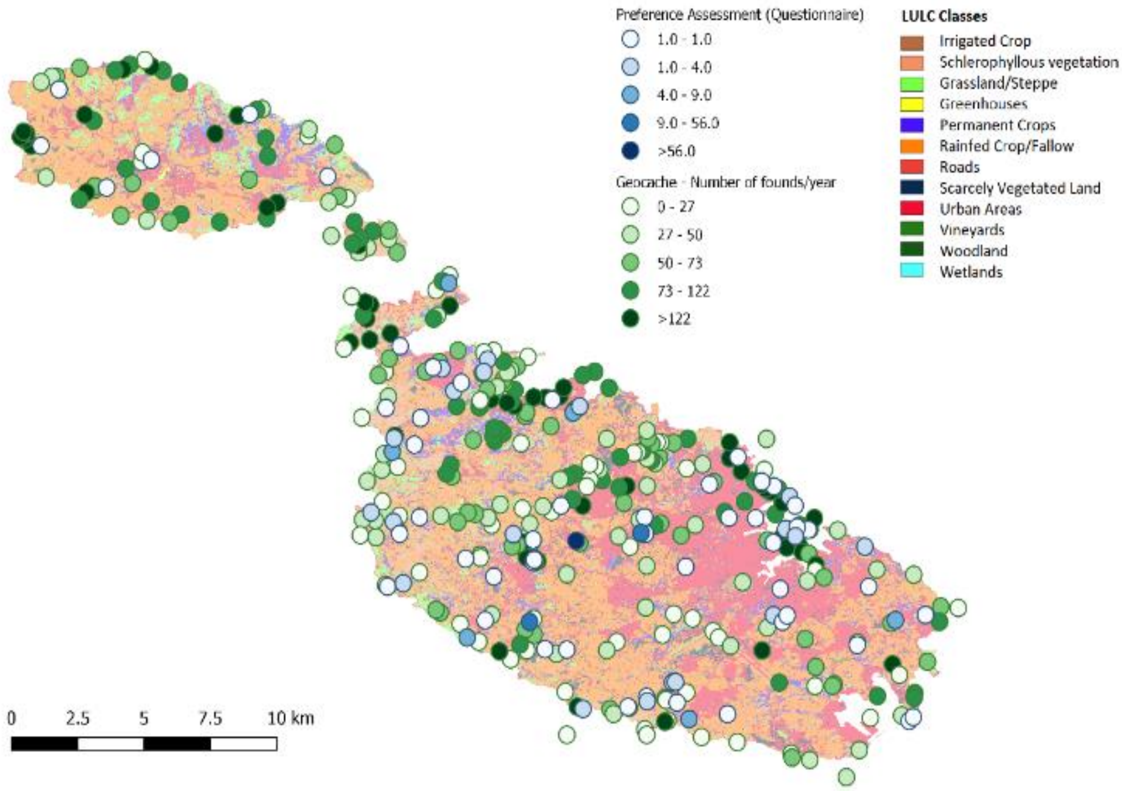

Figure 3.7.4: Mapping recreational ecosystem services. Different approaches have been used given that often the data available does not provide a complete overview of the use of ecosystems for recreation. The map shown here includes two datasets on the use of ecosystems for recreation (1) from a questionnaire with 283 residents and (2) using geocache data (base map: Balzan et al., 2018a).

The ecosystem flow depends on the ecosystem services demand, which is defined as the expression of the beneficiaries' preferences for specific ecosystem services attributes, such as biophysical characteristics, location and timing of availability, and associated opportunity costs of use (Schröter et al., 2014). This can be demonstrated for air quality regulation ecosystem services which were mapped for Malta (**Error! Reference source not found.**). Using air quality models and the capacity of e cosystems to remove pollutants, the removal flux of NO_2 (flow) was calculated for the Maltese Islands (Balzan et al., 2018a). A mismatch between the ecosystem services flow and demand for air quality regulation is indicated by the exceedance of air quality limit values in inhabited areas (e.g. average NO_2 concentration of 40 μg/m^3 over 1-year period according to the EC air quality standards[5]).

[5] http://ec.europa.eu/environment/air/quality/standards.htm

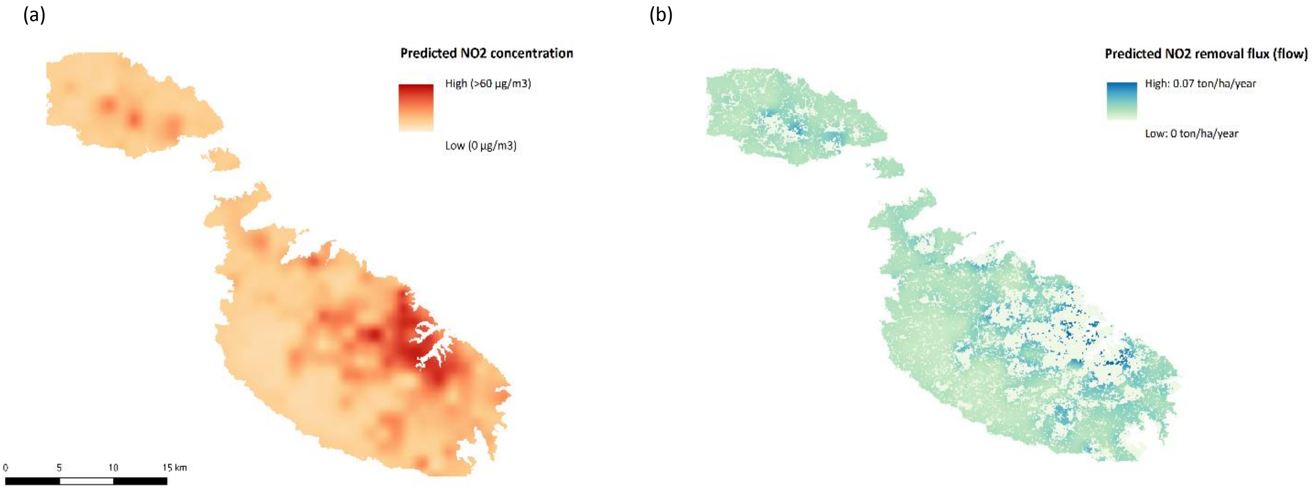

Figure 3.7.4: Mapping air quality regulation ecosystem services: (a) predicted atmospheric concentration of NO_2 and (b) removal flux of NO_2 based on the type of ecosystem and predicted NO_2 concentration according to data and models in Balzan et al., 2018a.

3.7.6 Results integration and societal responses to assessment findings

In the context of the MAES initiative, an IEA considers the condition of ecosystems as well as their capacity to deliver ecosystem services and their contribution to human well-being (Burkhard et al., 2018). The IEA framework was subsequently developed further in the ESMERALDA project, where it is considered as being an assessment that brings together data and information on the biophysical ecosystem with socio-economic system components and the societal and policy contexts in which they are embedded. Integration can be achieved through the assessment of biophysical aspects relating to the ecosystem condition or its capacity to supply ecosystem services but also through the assessment of the social and economic benefits arising from the flow of ecosystem services (Chapter 2). As discussed in the previous sections, results obtained from the studies discussed here, and carried out within the small island state of Malta, have collected first data about the ecosystem condition, and the capacity and flow of ecosystem services and hence the link to human well-being. In addition, statistical analyses have been used to analyse for the presence of potential synergies and trade-offs between the services, which is considered as being important for the identification and implementation of evidence-based policy responses.

The adoption of an integrated assessment approach provides a number of opportunities (Chapter 3). In the case of the work carried out in Malta, integration has been achieved through the adoption of interdisciplinary approaches that have assessed biophysical and socio-economic components of the ecosystem services cascade. This brings with it several advantages, as, amongst others, such interdisciplinary approaches (1) tend to foster dialogue between researchers, stakeholders and local communities, (2) offer opportunities for co-learning and knowledge sharing across disciplines and within communities, and can lead to (3) the collation of data and knowledge thus permitting for an improved validation of results and (4) to improved decision-making.

Through the scientific work carried out in the ESMERALDA case-study and in other ecosystem assessments carried out in Malta it has been possible to test methods and identify patterns in ecosystem services capacities and flows. Both of these aspects have implications for policy, namely (1) through the potential uptake and development of methods within national assessment of ecosystem services and (2) for improved landscape and urban planning that promotes targeted responses to maximise ecosystem service delivery and improved human well-being. It has been shown here that the application of IEA approaches is particularly important in insular environments, where strong links with the ecosystems and their services may exist but spatial data is often not available or not available at the right scale. In addition, past research in small islands has tended to focus on managing pressures or trade-offs to improve human well-being (e.g. through increased profit, food security, tourism and recreation opportunities, etc.; **Figure 3.7.2**) whilst few studies have assessed and mapped the important contributions of ecosystems, the perceptions of stakeholders or the cultural and economic benefits derived from particular ecosystem goods and services. These are all important aspects that are often ‘integrated’ in IEA approaches and which provide a stronger basis for policy and decision-making.

Some of the benefits arising from the adoption of an integrated approach in an island environment are apparent from the work done in Malta. Within the afore described studies integration is achieved through the assessment of different components of the ecosystem services cascade, through combining knowledge from diverse disciplines and the communication of results obtained to policy stakeholders. Recent studies within the study area indicate a strong dependence of cities on the capacity of rural landscapes, characterised by a matrix of agricultural land covers and semi-natural habitats, to deliver key ecosystem services (Balzan et al., 2018; Balzan, 2017). Results demonstrate that ecosystem services delivery in the landscapes of Malta is determined by land use intensity, and that highly urbanised areas are characterised with a low capacity of ecosystems to provide services, affecting human well-being. Urban areas associated with higher population densities had the lowest green infrastructure cover (**Error! Reference source not found.**b).

Figure 3.7.5: (a) Assessing the relationship between green infrastructure cover (GI) in each local council and average ES capacity. (b) Availability of green infrastructure decreases with increasing population density for local councils in Malta (source: Balzan, 2017).

This is leading to substantial difference in ecosystem services delivery between different regions but with the lowest values for ecosystem services capacity and flow obtained for the highly urbanised Northern Harbour District and Southern Harbour District (**Figure 3.7.6**).

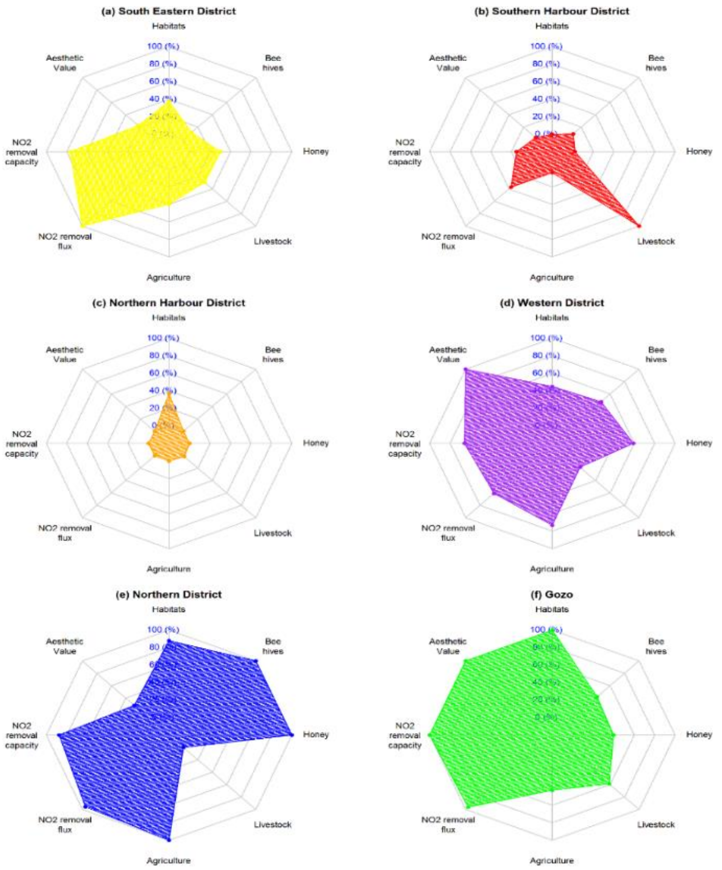

Figure 3.7.6: Assessing the capacity and flow of ecosystem services in different districts of the Maltese Islands (source: Balzan, 2017)

Results demonstrating gradients in ecosystem services supply and flow are particularly important to inform policy responses by identifying areas that would benefit, for example, from the addition of green infrastructure and may be used by local authorities to promote new public or private initiatives that improve the implementation of new (nature-based) solutions to develop green infrastructure in urban areas to support biodiversity and enhance ecosystem services delivery for human well-being. The dissemination of results obtained from the assessment and mapping of ecosystem services is therefore particularly important to provide opportunities for evidence-based decision-making. This is the final part in the iterative cycle of the integrated assessment of ecosystem services and focuses on the application of knowledge gained to inform management actions, planning, policy or legislation. Throughout this iterative cycle, the integrated approach combines knowledge from multiple disciplines, uses complementary data collection approaches to build-up the evidence-base to support decision-making and offers an opportunity to mainstream ecosystem services across different policy sectors with the aim of leading to improved social and economic benefits.

3.7.7 Conclusion

Small islands supporting small communities are often considered as a special case for sustainable development in international policy, as even though this group is rather diverse, they are often characterised with limited natural resources and land area, limited development options, high dependence on external markets and often vulnerability to anthropogenic pressures, natural disasters and climate change. In terms of biodiversity, islands often support a high level of endemism and contribute to human well-being through the delivery of a continuum of terrestrial, coastal and marine ecosystem services. However, recent research has shown that most of studies carried out in small island environments about ecosystems and their services investigate the management of island ecosystems and ecosystem services, and the pressures acting on these because of human drivers. Few studies have carried out a biophysical quantification of ecosystem services, investigated their spatial variation, arising synergies and trade-offs, or assessed the socio-cultural and economic value of island ecosystem services. The case of Malta, a small island state and the smallest member state of the European Union is here presented to analyse spatial variation of ecosystem services and identify the implications arising from studies that assess and map ecosystems and their services in a small island state. The integration of results from the assessment of different ecosystem services demonstrates several significant positive interactions (synergies) between ecosystem services within the study area. In general, semi-natural habitats, agricultural and urban green spaces had a significant positive impact on ecosystem service delivery. These results are described in further detail and recommendations for improved relevance to decision-making are made within this contribution. The importance of dissemination of results with policy-makers, planners and practitioners is identified as being critical in order to inform management actions in what is considered as an iterative cycle favouring evidence-based decision making for human well-being and sustainable development in a small island environment.

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3.8 Reasoning biodiversity and nature conservation policies using economic valuation and ecosystem services mapping: the case study of the natural park of Serra de S. Mamede (Alentejo, Portugal)

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3.8.1 Introduction

Biodiversity and nature conservation policies worldwide have been marked by different paradigms ranging from the original “wilderness” paradigm (strict protection) to other new models that clearly recognize the role of locals and of the maintenance of their practices as fundamental to preserve the inherent features of the area (e.g., biodiversity, landscape scenery, water for drinking and other purposes), or in different words, to preserve the benefits that society derive and desire to protect from spoiling or injury (Mace, 2014). In Europe, and despite the co-existence of both models, a significant part of the nature conservation public spending has been directed at preserving human dominated landscapes shaped by low intensity agriculture and forestry, which are often called multifunctional as they provide to society many other benefits apart from food and fibre. For instance, the Common Agricultural Policy (PAC), since the 1999 reform, encompasses many measures devoted to preserve biodiversity but also to preserve rural landscape multifunctionality, representing a significant part of the ERFD (European Rural Development Fund). Despite the contributions of PAC and other EU (European Union) sectoral policies to biodiversity conservation, the expected impacts are often unclear and there is increasing concern over the efficiency and effectiveness of such policies and associated public investment. Indeed, and despite environmental policy developments, many ecosystems are being degraded within the EU. The 2020 EU Biodiversity Strategy congregates a set of targets and actions seeking to halt biodiversity loss and the degradation of ecosystems services. Although ambitious the strategy implementation poses many challenges, some of which are addressed along this document by using the Natural Park of Serra S. Mamede (Portugal) as a case study (Marta-Pedroso et al., 2018). The focus of the case study presented hereafter is on economic mapping and assessment and is presented as a contribution to fine tune the ESMERALDA flexible methodology for integrated mapping and assessment of ecosystem services. The meaning of integration and its relevance in ecosystem services assessments is brought into discussion by highlighting the importance of linking biophysical and economic mapping in the context of economic assessment (as defined in the deliverable D3.2, i.e., an economic assessment involves the structuring and integration of value information into decision making and the design of policy instruments).

The remaining of this sub-chapter are organized as follows: in the next section, we refer to the 2020 EU Biodiversity Strategy to review its goals and to frame our contribution in its context. In the third section, we present our arguments for adopting an ecosystem services-based framework as a tool to evaluate biodiversity and nature conservation plans, programs or policies. In section 4, we contextualize the common challenges posed by the case of protected areas management and EU 2020 Biodiversity Strategy implementation. Section 5 presents the case study and in the last section (section 6) a set of final remarks and recommendations regarding the use of integrated ecosystem services assessment is provided.

3.8.2 The 2020 EU Biodiversity Strategy

The EU has committed itself to halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020. The 2020 EU Biodiversity Strategy (COM 2011) is built around six mutually supportive and inter-dependent targets which address the main drivers of biodiversity loss. They aim to reduce key pressures on nature and ecosystem services in the EU by setting up efforts to fully implement existing EU nature legislation, anchoring biodiversity objectives into key sectoral policies, and closing important policy gaps. Each target is accompanied by a set of focused, time-bound actions to ensure these ambitions are fully realized. Here we specifically address Target 2 of the strategy ("*By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems*") by taking the challenges imposed by its actions 5 and 7a), i.e., *"Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020" and In collaboration with the Member States, the Commission will develop a methodology for assessing the impact of EU funded projects, plans and programmes on biodiversity by 2014". While the first one is known as MAES (mapping and assessment ecosystem services) action the second one refers to "biodiversity proofing".* Efforts are therefore needed to ensure, on the one hand, that knowledge on ecosystem types, their state, which and where ecosystem services are being provided and how much they are worth is collected and, on the other hand, that the EU budget has no negative impacts on biodiversity, and additionally, that spending under the EU budget is overall supportive to achieving these biodiversity targets. Inventory and dissemination of existing knowledge and experience across EU Member States regarding mapping and assessment of ecosystem services was a major achievement of the ESMERALDA project, as it allowed, on the one hand, to share such experience and, on the other hand, to use such experience as a building block of the ESMERALDA flexible methodology. The work presented in this chapter illustrates the approach carried out by Portugal for mapping and assessment of ecosystem services in the context of EU 2020 Biodiversity Strategy and illustrates how to bring such approach in the context of decision making, namely in the context of reasoning nature conservation policies.

3.8.3 Ecosystem Services Framework

Different initiatives, among which MA (Millennium Ecosystem Assessment) and the TEEB (The Economics of Ecosystems and Biodiversity) have increased awareness of the importance of biodiversity and ecosystems in contributing to human well-being and therefore have called for their inclusion not only in policy making but also into business and individual spheres. Recently, and leveraged by the above-mentioned initiatives, the MAES (Mapping and Assessment of Ecosystem Services in Europe) initiative brings the need to account for the linkage between biodiversity, ecosystems services, and wellbeing as a fundamental pillar of the EU Biodiversity Strategy to 2020. From a methodological point of view, the work presented here adopted an ecosystem services framework, aligned with the above-mentioned initiatives ("cascade model"; Potschin and Haines-Young, 2011).

Although we recognize the plurality of values of ecosystem services, the particular focus of our work is on generating economic values and taking their spatial dimensions into the policy cycle evaluation, including biodiversity proofing through cost-benefit analysis (CBA) – (Medarova-Bergstrom, 2014). Due to the heterogeneity of ecosystems, linking biophysical and economic mapping and assessment is pivotal to fully understand the impacts of projects, plans or policies. Since many of these impacts do vary spatially, due to the heterogeneity of ecosystems, linking biophysical and economic mapping and assessment is pivotal for nature conservation as for the implementation of the EU 2020 Biodiversity Strategy.

3.8.4 Using Protect Areas management to inform the EU biodiversity strategy challenges

Nature conservation policies, including the establishment of protected areas (PA), represent costs to society and are implemented by governments acting as representatives of society preferences. In this regard, the efficiency and effectiveness of such public spending should be evaluated. PA establishment is not always a straightforward process, featuring a resource allocation problem often marked by conflicts among stakeholders and different opportunity costs. In a nutshell, defining the establishment of a PA implies the selection of geographical boundaries given protection goals, which levels of protection are adequate, should they be different within the protected area, which resources are needed, and how to optimally allocate them.

Demonstrating economic benefits generated by protected areas is often pointed out as pivotal for supporting decision-making, and the concept of ecosystem services (ES), defined as the benefits humans derive from ecosystems, provides a consistent framework to approach this issue as it links ecosystem functioning and benefits, including benefits with economic value.

3.8.5 The case study of the Natural Park of Serra de S. Mamede

The Natural Park of Serra de São Mamede (PNSSM) is located in the inner-central part of Portugal, within the Alentejo NUTS II region. In its current definition, the PNSSM covers an area of 56 021ha, embracing the Municipalities of Arronches, Castelo de Vide, Marvão and Portalegre being limited to the East by Badajoz province (Extremadura, Spain) – (Figure 3.8.1)

The land use/cover (LUC) within the park, based on the most recent available land use/cover national cartography (COS 2007) is dominated by Forests, open forests and shrubland, which represents respectively 22% and 38% of the park's area (Figure 3.8.1).

The PNSSM includes the mountain ridge called "Serra de São Mamede", which is the only range south of the River Tagus with climatic conditions that allow the presence of Atlantic plants and therefore contributes to the variety of remarkable habitat and plant diversity within the PNSSM. Indeed, the PNSSM is completely confined within the São Mamede Natura 2000 Site of Community Interest (SIC) - PTCON0007, established by the Council Ministers' Decision No. 142/97 of 28 August, representing around 45% of the site's area (Figure 3.8.1).

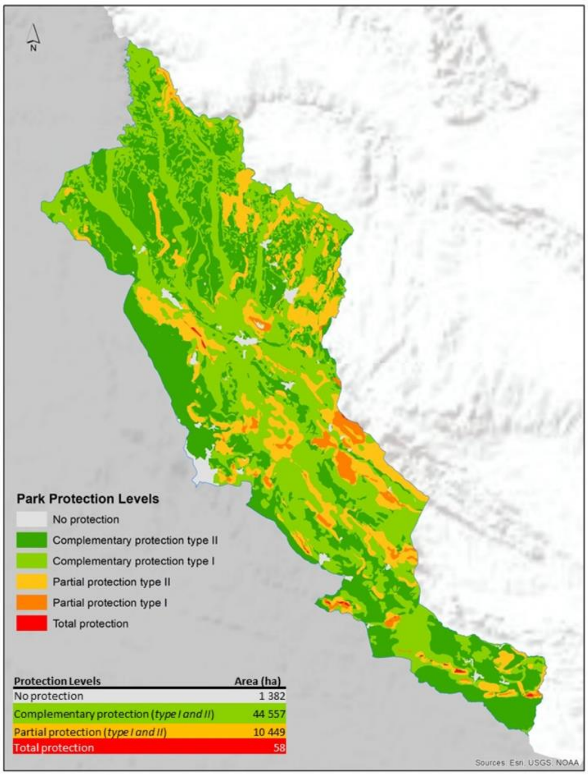

Figure 3.8.1: Location and Land use/cover (LULC) of PNSSM following national cartography (COS 2007 level 2)

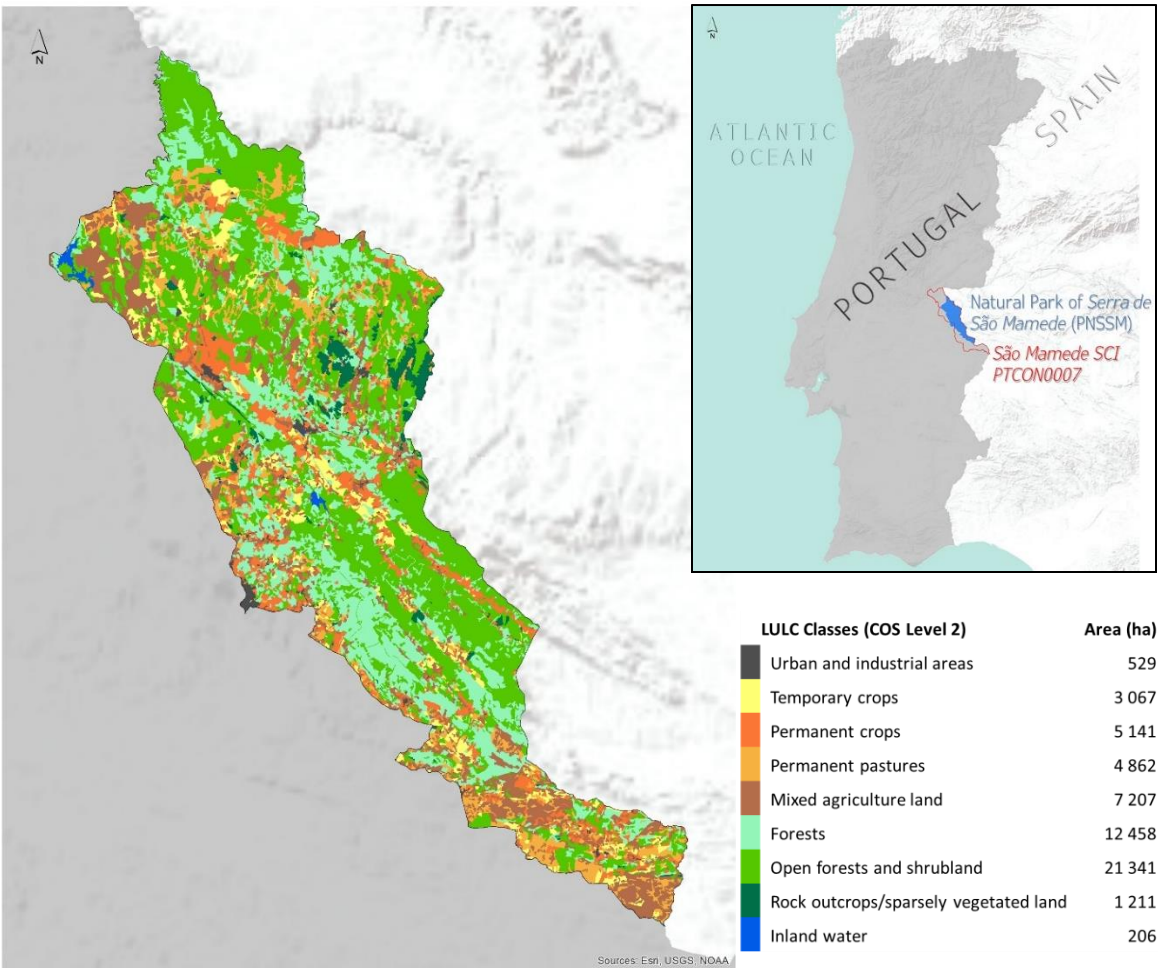

Figure 3.8.2 Location and Land use/cover (LULC) of PNSSM following national cartography (COS 2007 level 2)

The actual zoning of the PNSSM, defined by the Council of Ministers' decision 77/2005 of 21st, distinguishes fives zones regarding the protection/conditioning level imposed (Figure 3.8.2), which we list hereafter in descending order of protection level:

a) Areas of Total Protection – areas with predominance of recognized high natural and landscape values, including geological, landscape and ecological formations, with a high degree of naturalness, and which, taken as a whole, are of exceptionally high ecological sensitivity;

b) Areas of partial protection (Type I) - areas that contain natural and landscape values whose meaning and importance, from the point of view of nature conservation, are taken together as relevant or, in the case of exceptional natural values, have a moderate sensitivity;

c) Areas of partial protection (Type II) - areas containing natural and landscape values whose significance and importance, from the point of view of nature conservation, are taken together as relevant, which contain natural values that depend on the uses of soil, water and traditional agricultural and/or forestry systems, and which act as buffer or transition zones of the total protection areas and the partial type I protection areas, and may also contain structuring elements of the landscape;

d) Areas of complementary protection (Type I) - areas where the values of nature conservation and the physical structure of the territory are aligned and where it is intended to reconcile the current use of the soil with the natural and landscape values;

e) Areas of complementary protection (Type II) - remaining areas of less value for nature conservation, which correspond to areas of more intensive land use of where it is intended to reconcile human intervention and local social and economic development with natural and landscape values and objectives of nature conservation.

3.8.5.1 Objectives

We used the case study of PNSSM to provide evidence on how to bring the economic value of protected areas to the decision-making process and contributing to extend current EU Member States experience in mapping and assessing the economic value of ecosystem services (ES) in the context of the EU Biodiversity Strategy to 2020 (Action 5) and while opening the way to use CBA in biodiversity proofing (Action 7).

3.8.5.2 Methodology

We followed a three-step approach to pursue our goals (**Error! Reference source not found.**), entailing local s takeholders' engagement in selecting relevant ES (through a participatory workshop), biophysical mapping of ES flows (based on a multi-tiered approach depending on data availability), and spatial economic estimation of such flows (using value transfer, willingness-to-pay, and market price methods). One should notice that our approach presents an induced selection of ES, in the sense that it may be the case that only some of the ES identified as relevant by stakeholders are considered for economic valuation (and mapping). Information availability and its readiness for the purpose of mapping economic values of ES delivered by the PNSSM, and perceived by local stakeholders, were the major determinant of the final suite of ES for which we have estimated and mapped the economic value.

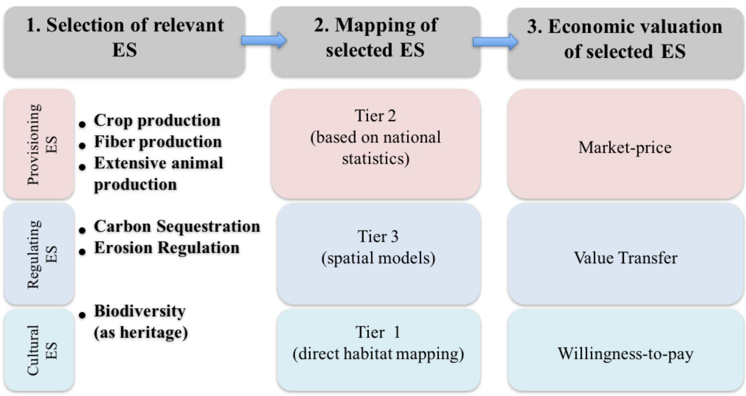

Figure 3.8.3: The three-step analytical framework

3.8.5.3 Mapping and economic valuation of ES

Economic methods for mapping and assessing ecosystem services principally involve measuring, and accounting for the spatial variation in the economic value of ecosystem services and structuring this information to support decision making and the design of policy instruments. If we refer to the cascade model (Potschin and Haines-Young, 2011), economic methods operate on the right side of the ecosystem services cascade model to quantify the benefits to humans. Any economic mapping or assessment therefore fundamentally relies on biophysical data and methods to quantify the capacity of ecosystems to supply ecosystem services (i.e. the left side of the cascade model).

3.8.5.4 Mapping Biophysical flows of ES

Biophysical mapping was mainly based on land-use/ land-cover (LULC), which was obtained with the most recent available national land cover cartography (COS 2007), at its lowest hierarchical level (level 5), hereafter referred to as COSN5.

Although the Common International Classification of Ecosystem Services (CICES) was originally developed by Haines-Young and Potschin (2013) as part of the work on the revision of the System of Environmental and Economic Accounting (SEEA) led by the United Nations Statistical Division (UNSD) since its release it has been widely used in ecosystem services research for identifying and communicating specific services, and thus for structuring ES mapping, assessment and valuation studies (Czúcz et al., 2018). CICES differs from other existing classification systems especially in making the distinction between services and benefits clearer. The fact that CICES is conceptually based on the cascade model contributes to such feature and supports our decision in adopting the CICES (v5.1)[6] in this study (Haines-Young and Potschin, 2018).

The methods applied for quantifying and mapping each ecosystem service biophysical flow are summarized in Table 3.8.1 and their choice is based on Marta-Pedroso et al. (2014a). Data collection and processing was guided by availability and readiness of its use for our purpose. Mapping options comprised tier one approaches (biodiversity), tier 2 approaches (statistics-based) to more complex ones such as model-based (e.g., soil erosion avoidance and carbon sequestration). Adoption of tiered approaches for mapping have been largely advocated as it provide consistent but flexible ecosystem services mapping (Grêt-Regamey et al., 2015; Maes et al., 2016; Grêt-Regamey at al., 2018).

Table 3.8.1: Final selection of ES (classification following CICES and specifications for this study) and brief description of biophysical mapping methods used.

Selected ES					Biophysical Mapping
ES classification following CICES (v5.1)			Specifications		
Section	Section	Class [code]	ES designation	Indicator unit	Description
Provisioning	Biomass	Cultivated crops [1.1.1.1]	**Crop production (CP)**	$ton.ha^{-1}.yr^{-1}$	Crop production was mapped based on total annual production of main cultures present within the study area. Information obtained per municipality, based on official national agriculture statistics (Instituto Nacional de Estatística, INE). Spatialization of this information was possible based on harmonization of culture classes with LULC classes.
		Reared animals and their outputs [1.1.1.2]	**Extensive Animal production (AP)**	$LU.ha^{-1}.yr^{-1}$	Extensive animal production was mapped based on effective support capacity of extensive pastures, considering average livestock header (LH) within the study area. Information obtained per municipality, based on official national agriculture statistics (Instituto Nacional de Estatística, INE). Spatialization of this information was possible based on harmonization of pasture classes with LULC classes

[6] www.cices.eu, also see ESMERALDA Deliverable 4.2 (Haines-Young et al., 2018)

Selected ES					Biophysical Mapping
ES classification following CICES (v5.1)			Specifications		
Section	Section	Class [code]	ES designation	Indicator unit	Description
		Fibers and other materials for direct use or processing [1.2.1.1]	**Fiber production (FP)**	$m^3.ha^{-1}.yr^{-1}$	Fiber production mapping was based on yearly biomass increments per species, as reported in the Portuguese National Greenhouse Gases Inventory Report (NIR), according to its land use typology (Kyoto Protocol Classes, hereon KP. Classes of species considered were: *Pinus pinaster*, *Pinus pinea*, *Quercus* spp, *Quercus suber*, *Quercus rotundifolia*, *Eucalyptus* spp, mixed broadleaves forests, and mixed coniferous forests. Average biomass losses due to natural mortality were discounted. Spatialization of this information was possible based on harmonization of KP classes legend with LULC classes from national cartography.
Regulating	Regulation of physical, chemical, biological conditions	Global climate regulation by reduction of greenhouse gas concentrations [2.3.5.1]	**Carbon sequestration (CS)**	$tonCO_2.ha^{-1}.yr^{-1}$	Carbon Sequestration mapping was based on input/output balances in biomass (above and below ground). Annual emission and retention coefficients for each land-use change (considering changes observed in a 17-year period) were estimated based on the National Inventory Report results (NIR). Spatialization of this information was possible based on harmonization of KP classes legend with LULC classes from national cartography.
		Stabilisation and control of erosion rates [2.2.1.1]	**Erosion regulation (ER)**	$ton.ha^{-1}.yr^{-1}$	Erosion Prevention was modelled and mapped based on the Universal Soil Loss Equation (USLE), integrated in a GIS platform, which allowed determining the difference between erosion rates in the current scenario (i.e., erosion rates given actual land cover type) and erosion rates for a worst-case scenario (considering a maximum erosion cover type), as first suggested by (Guerra et al. 2014)
Cultural	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Heritage, cultural [3.1.2.3]	**Biodiversity (as heritage) (BH)**	ha	Biodiversity (as heritage) was mapped based on presence (area) of protected habitats listed under the Annex I of the Council Directive 92/43/EEC.

3.8.5.5 Estimation and mapping of economic values of ES

Since the 1960s economists have developed a variety of methods for quantifying the economic value of ES, namely regarding those not priced and traded in markets to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment (Brander, 2013). An important distinction exists between methods that produce new or original information generally using primary data (primary valuation methods) and those that use existing information in new policy contexts (value transfer methods). The ES considered in the analysis and the economic valuation methods used are in **Error! Reference source not found.**. ES were valued based on their annual flow or utilization in common m onetary units, €/year, inflation-adjusted to 2014 euros. In particular, the provisioning services were evaluated using market valuation (price-based), heritage value of biodiversity based on inferred Willingness-to Pay (WTP) (although primary data to estimate WTP have not been collected the approach

Table 3.8.2: Economic value estimation methods

Mapped ES		**Economic Value Mapping ($€.ha^{-1}.yr^{-1}$)**	
ES Specification	Indicator unit	Valuation Method	Description
Crops production (CP)	$ton.ha^{-1}.yr^{-1}$	Market Price	Standard Gross margin (SGM) of each crop. SGM for each land use class was estimated as $SGM_{LUC\ j} = \Sigma A_i SGM_i / \Sigma A_i$,, where Ai represents the area of crop $_i$ in the land use class (LUC) $_j$. SGM_i and A_i were obtained from official statistics.
Extensive Animal production (AP)	$LU.ha^{-1}.yr^{-1}$	Market Price	Standard Gross margin (SGM) of pastures typologies. An average LU (livestock unit) for each different type of pasture was considered.
Fiber production (FP)	$m^3.ha^{-1}.yr^{-1}$	Market Price	ANPV (Annualized Net Present Value) of timber given the Investment Return Analysis for the species of interest provided by Machado and Louro 2009. For mixed LULC classes (i.e., when more than one forest species was present), the value was weighted according to an estimated cover percentage per species.
Carbon sequestration (CS)	$tonCO_2.ha^{-1}.yr^{-1}$	Value transfer	Unit Value: 79,5€/ton based on Stern (2006) social cost of carbon estimations. Amount of carbon sequestered/emitted estimated in each pixel by considering the land use transitions observed between 1990-2006 was multiplied by the unit value.
Erosion regulation (ER)	$ton.ha^{-1}.yr^{-1}$	Value Transfer	Unit value: (4.75 €. $ton^{-1}.yr^{-1}$) based on Marta-Pedroso et al. 2007. The avoided erosion value estimated in each pixel was multiplied by the unit value.
Biodiversity (as heritage) (BH)	ha	Inferred WTP	Compensatory payments given to farmers to carry out actions aimed at preserving the habitats listed under Annex I of the Council Directive 92/43/EEC. As compensatory amounts varied per habitat considered and per council location, spatialization was possible by means of protected habitats' cartography provided by PNSSM management.

Notes: Economic values were adjusted using consumer price index when appropriate

used falls into the revealed preference economic valuation methods). Method selection was, at first, guided by the type of information available and by the cost efficiency of method application. Below we describe each of the three approaches applied. For a comprehensive description of economic valuation foundation and methods we direct the reader to publications devoted to depict and/or review the entire suite of economic valuation methods (see i.e., Bateman et al., 2010; TEEB, 2010; Marta-Pedroso et al., 2014b; Koetse et al., 2015). Specific guidance on the main economic methods for mapping and assessment of ecosystem services is provided in Brander et al (2018). Besides the theoretical foundations of economic valuation of ecosystem services, several examples of economic mapping of ecosystem services are presented with respect to the MAES process and the ESMERALDA case studies.

Price-based market valuation approaches relies on the use of prevailing prices for goods and services traded in markets while value transfer uses economic information captured at one place and time to make inferences about the economic value of environmental goods and services at another place and time. Value transfer comprised different approaches, varying in level of detail and information adjustment made and hence accuracy of estimates obtained. In our case the unit value transfer was applied. In practice, unit value transfer uses values for ecosystem services obtained in a different location and/or context, expressed as a value per unit (e.g., per area), combined with information on the quantity of ecosystem service units delivered at the study area (in our case, PNSSM). Although unit values can be adjusted to reflect differences between the study and policy sites (e.g. income and price levels) we did not adjust the transferred values. In the case of biodiversity, heritage value estimation was based on farmers' compensatory payments for the ITI of Serra de São Mamede (MADRP, 2010). The ITIs were the main instrument within ProDeR (Rural Development Program for Portugal Mainland 2007-2013) for action in Natura 2000 areas, consisting of a combined approach of various policy instruments consistently applied in a territory within an over-arching objective, the conservation of natural values. From the set of eligible interventions within the ITI of Serra de São Mamede we took the minimum and the maximum expected value (€/ha) that would be given to farmers as compensatory payment if action to preserve the habitats are taken. In a certain way, this range can be seen as societal WTP to preserve the biodiversity heritage as we assume that the public support is defined by governments as representative of society preferences.

Selection of valuation methods was dictated by budget and time constraints. Collection of primary data for economic valuation was not envisioned for those reasons hence, and in line with what ESMERALDA proposes in this regard, value transfer was chosen for valuing monetary non-marketed ecosystem services.

3.8.6 Results and discussion

Below we present both the biophysical and economic value (Figure 3.8.4 to Figure 3.8.9) for each one of the six ES grouped by CICES section (provisioning, regulating, and cultural services). The designation of each ecosystem service was simplified for practical purposes, but we provide the CICES code in square brackets.

Provisioning Services

Crop Production *[1.1.1.1]*

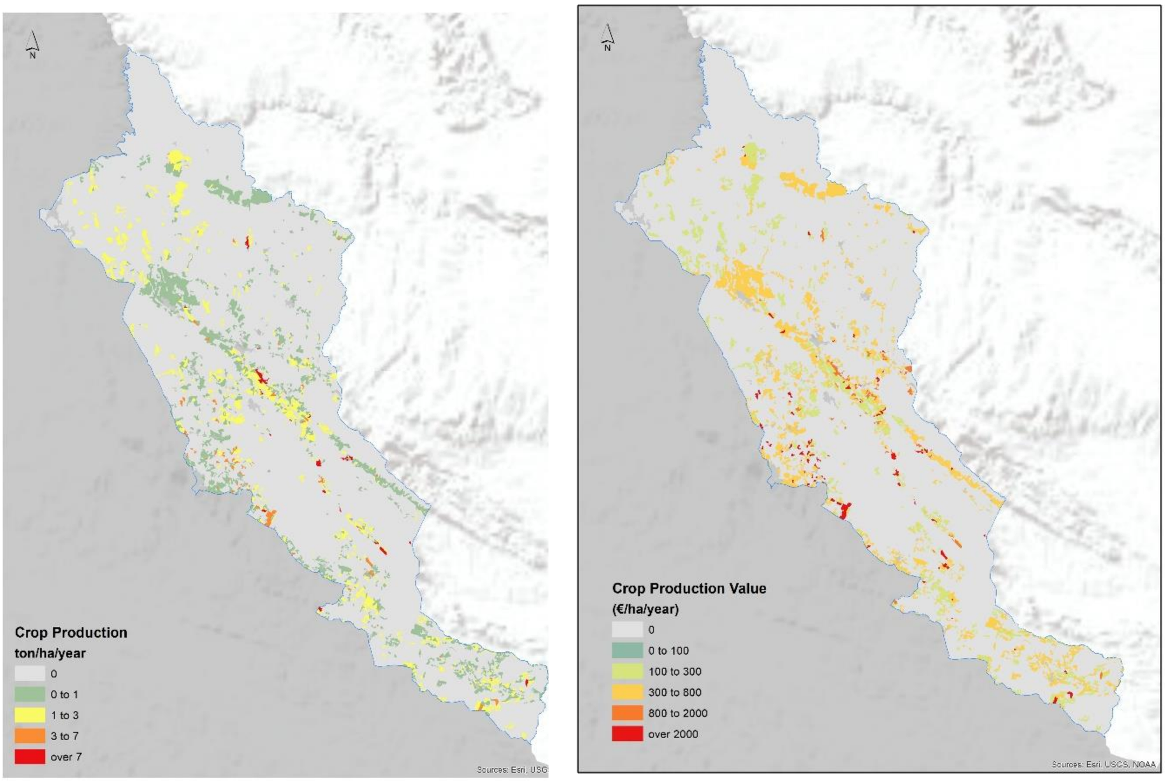

Figure 3.8.4: Spatial quantification (left) and economic valuation (right) of Crop Production within PNSSM

Extensive Animal production (AP) *[1.1.3.1]*

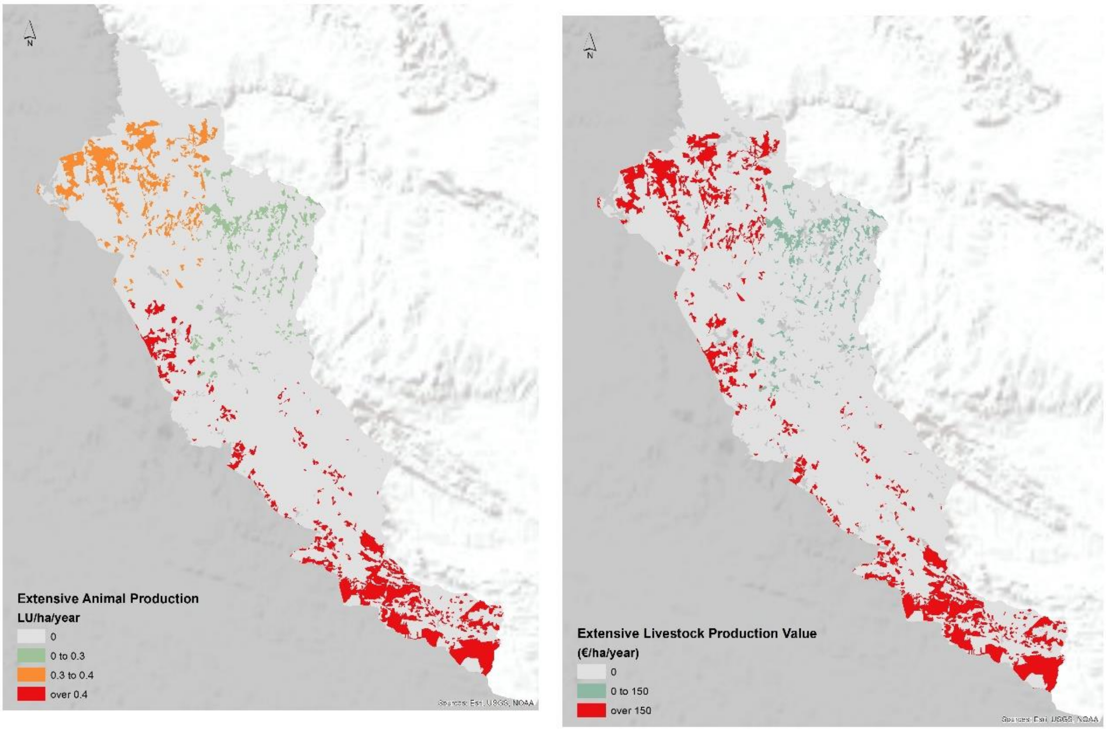

Figure 3.8.5: Spatial quantification (left) and economic valuation (right) of Extensive Animal Production within PNSSM

Fibre Production (FP) *[1.1.1.2]*

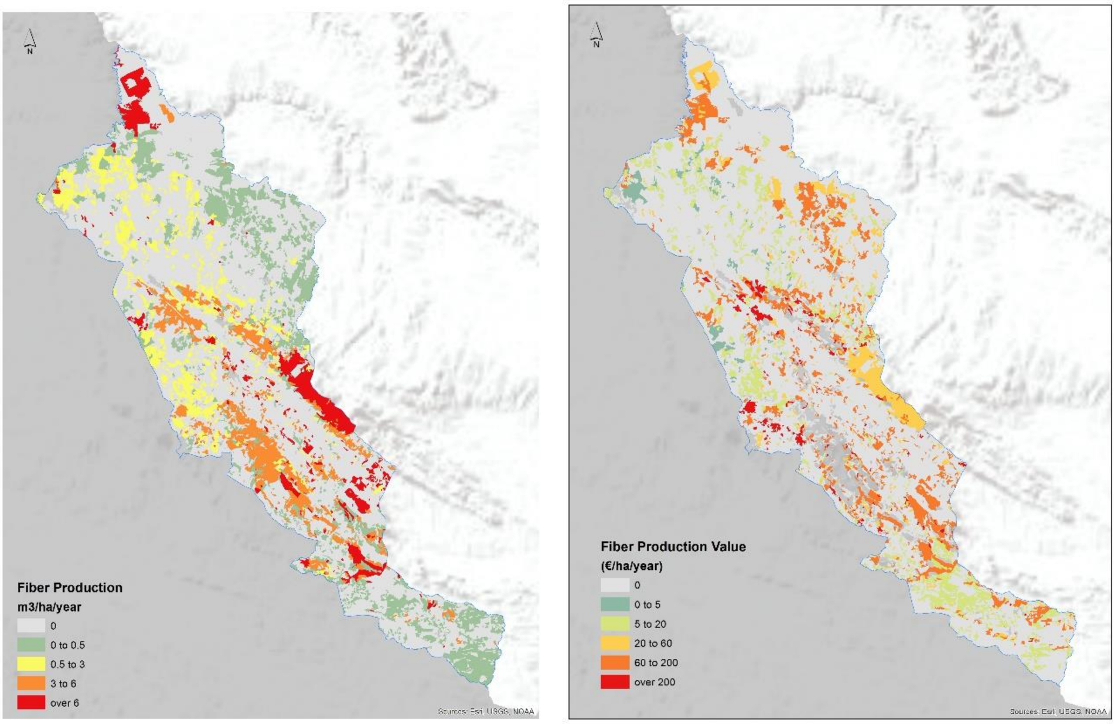

Figure 3.8 6: Spatial quantification (left) and economic valuation (right) of Fiber Production within PNSSM

Regulating Services

Carbon sequestration (CS) *[2.3.5.1]*

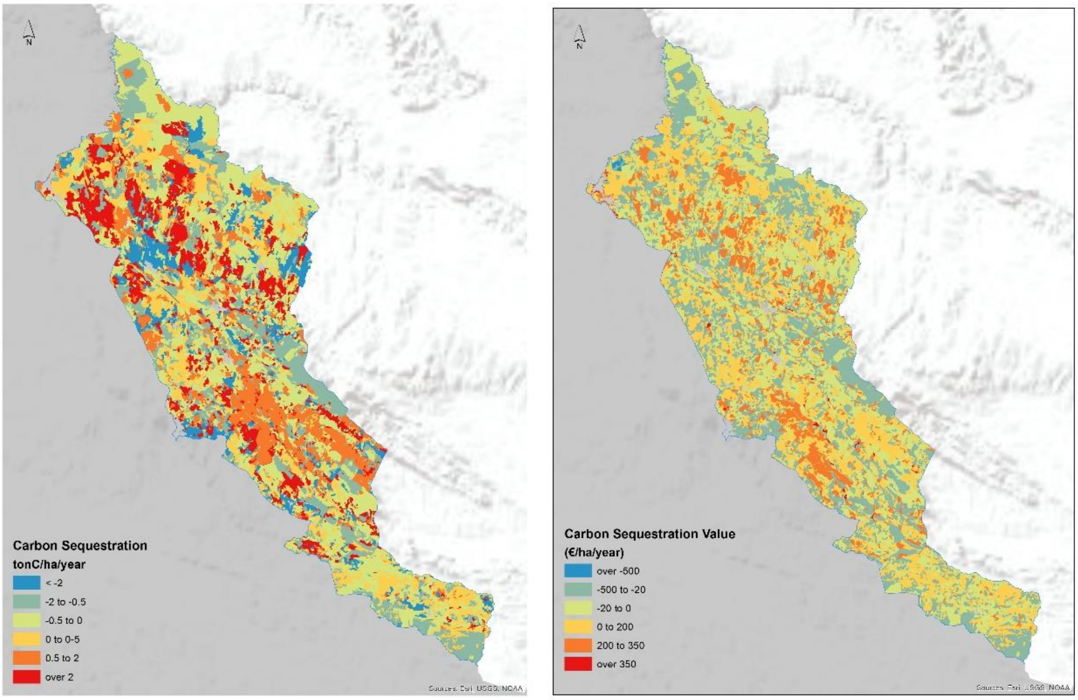

Figure 3.8.7: Spatial quantification (left) and economic valuation (right) of Carbon Sequestration within PNSSM

Erosion regulation (ER) *[2.2.1.1]*

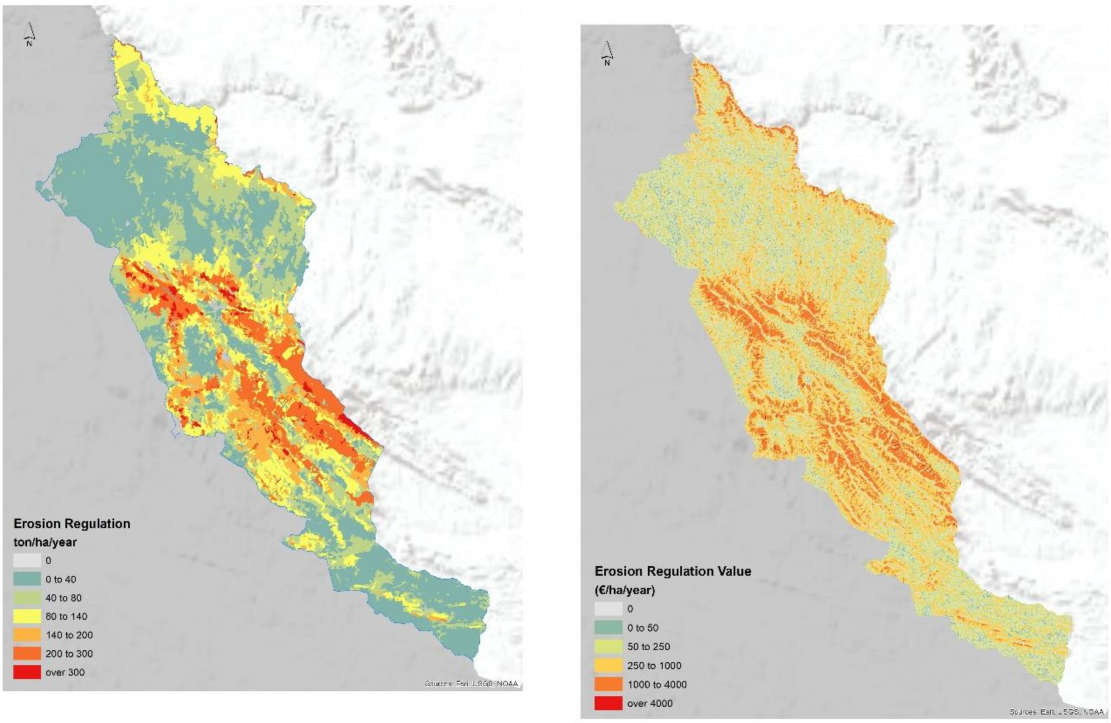

Figure 3.8.8: Spatial quantification (left) and economic valuation (right) of Erosion Regulation within PNSSM

Cultural Services

Biodiversity heritage (BH) *[3.1.2.3]*

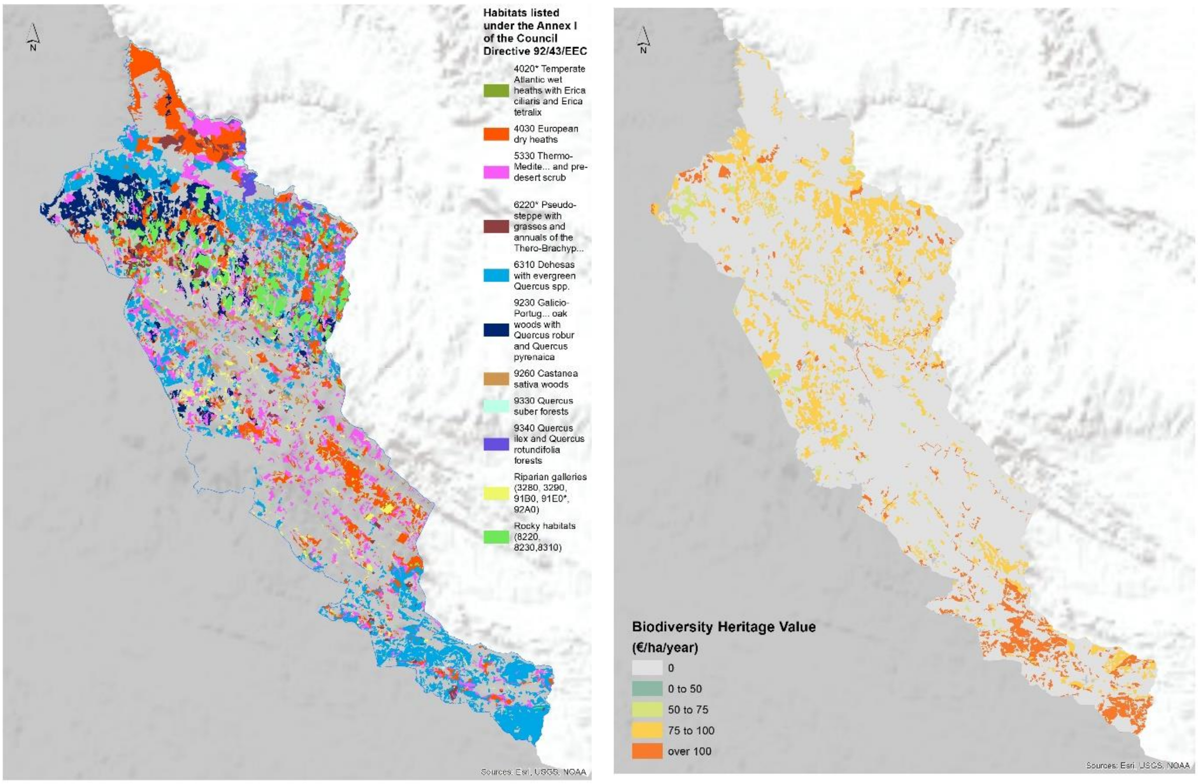

Figure 3.8.9: Spatial quantification (left) and economic valuation (right) of Biodiversity (as heritage) within PNSSM

3.8.7 How much is the Park worth annually?

By multiplying the annual economic value estimated for each ES (€/ha) by the area of each pixel, we obtained an aggregated value map for the park (Figure 3.8.10, left). A per hectare analysis, to compare the value of services delivered by different ecosystems present in the park (Figure 3.8.10, right), shows that permanent crops deliver higher value of provisioning services, whereas forests and shrubland ecosystems deliver higher value of regulating and cultural services and are the ecosystems contributing most to the park's annual economic value. we estimated the aggregate annual value of PNSSM at ranging from 11 to 33M€/year (representing 0.1 to 0.3% of the regional NUTSII Alentejo Gross Domestic Product).

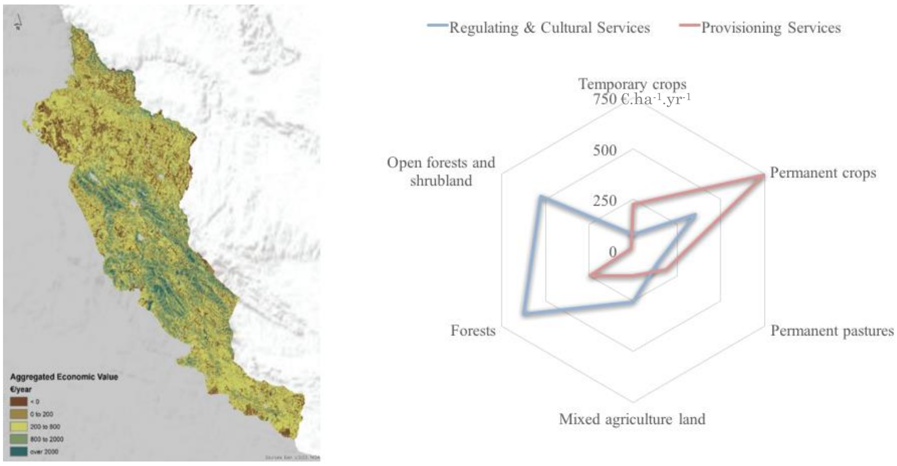

Figure 3.8.7: PNSSM value - Aggregate value map (left) and value per ecosystem typology (right)

3.8.8 Do high level protection areas match higher economic value occurrence?

We estimated the average economic value of each ES within park areas that have different protection levels (Figure 3.8.11), and showed that, on average, all ES have an increase in value when going from areas with no protection restriction to areas with protection restrictions - the exception being the Crop Production service (in red). Erosion regulation is not represented in Figure 3.8.11 due to scale fitting, as the estimated average value per hectare is significantly higher than the rest of ES, but it follows the same trend as Fiber Production.

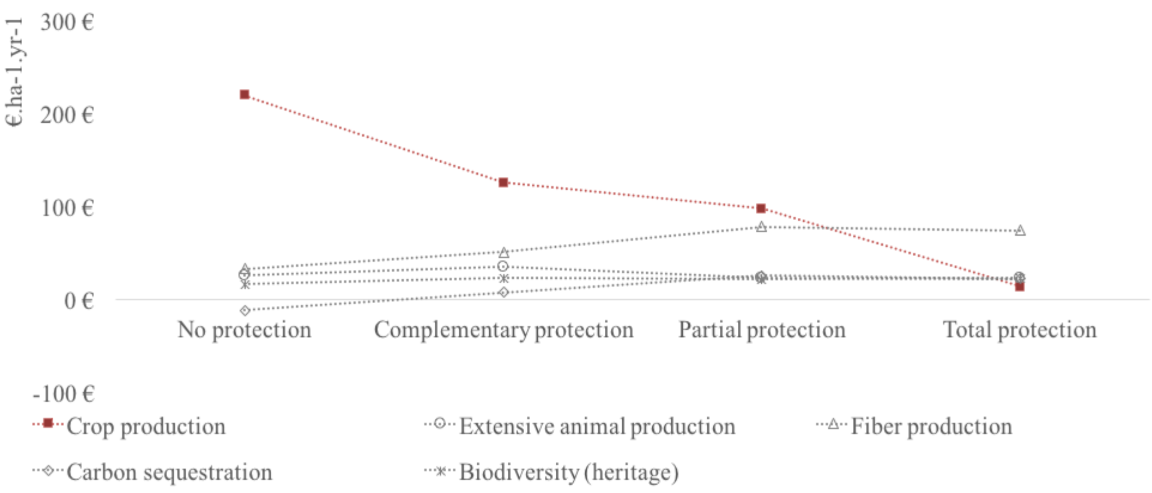

Figure 3.8.11: Average economic value of each ES inside different protection levels of PNSSM

3.8.9 Final Remarks on case study

The demand for timely monetary estimates of the economic value of ecosystem services (ES) is increasing in many countries and will also increase in Europe following the expected future integration of ES in appraisal of policies and projects that impact the environment. In this study, we tested a three-stage approach to map the economic value of the ES delivered using the Natural Park of Serra de S. Mamede (PNSSM) as case study. Our main purpose was to provide methodological guidance to integrate ES in protected area management while contributing to extend the current EU Member States experience in mapping and assessing economic value of ecosystem services in the context the EU Biodiversity Strategy to 2020 (Action 5 - and Action 9 – Biodiversity proofing), rather than to provide absolute value figures for the PNSSM. In fact, we recognize that, despite the potential of the methodological approach followed, our estimations should be regarded with caution, especially because the aggregated estimation of economic value does not include all the ES listed by local stakeholders as relevant (e.g. water availability and quality are not included in our estimation). Finally, as mentioned before, our estimations are based on non-primary data and therefore we are aware of possible bias introduced by that fact. These constraints reveal that, although the use of non-primary data is very appealing, namely in the presence of money and time restrictions, the outcomes of non-primary data-based valuation should be subject to sensitivity and uncertainty analysis. This gain particular relevance when CBA is envisioned more than just reveal economic value to raise awareness of the economic value of ecosystem services. These pitfalls should be taken into account when replicating the framework.

3.8.10 Integrated assessments: Lessons learned from the Natural Park of Serra S. Mamede case study

The nature of an assessment (biophysical, socio-cultural or economic) and the integration level brought into it is firstly determined by the mandate and objectives of the study. The case study presented here was developed as part of a regional study encompassing the NUTS II Alentejo commissioned by the ICNF, the Portuguese national authority for nature conservation and forests. The mandate was clear: at the NUTS II Alentejo level, the goal was mapping and assessment of ecosystems, their condition and mapping a set of ecosystem services (see Marta-Pedroso et al., 2014a). The economic valuation and assessment of ecosystem services was restricted to those provided by the Natural Park of the Serra S. Mamede (the case study presented before) as since the beginning the use of economic valuation in the context of nature conservation was pointed out as of interest to support decision-making. One could say that at regional level the biophysical domain was the focus and integration did not occur by incorporating different domains (biophysical, socio-cultural and economic) in a single framework but rather by linking the provision of ecosystem services with the ecosystems condition. This dimension of analysis ensured that sustainability of ES flows and ecological integrity of ecosystems were considered when measuring the flow of ES. For instance, a soil poor in organic matter brought into cultivation can supply high quantities of food and/or fibre but being that productivity dependent on the use of external outputs (e.g. fertilizers) and not due to the capacity of ecosystem in providing such ES flow levels.

In this regard, a biophysical assessment should always integrate the ecosystem condition assessment through the use of indicators that could be related to the ES flow measurement (e.g., organic matter for soil crop production, infiltration rate for water availability, etc.). The spatial dimension of the ES is another aspect largely discussed when referring to ES assessment. Our experience supports that mapping can be useful and should be part of an assessment whenever ecosystem heterogeneity can influence the analysis, either biophysical, socio-cultural or economic. Notwithstanding we argue that mapping should not be the first step or the focus of an assessment as often more expedite (e.g., a matrix based assessment) approaches can provide the answer to the question of interest without going into a possibly complex, time consuming and resource demanding spatial analysis. Going back to the case study presented here, and to the economic assessment as part of a broad (and integrated) assessment, a logical integration seems to be the inclusion of participatory approaches or others that would allow to bring preferences and the demand side of ES assessment into the equation. Although surrogate and proxies of preferences can be applied, involvement of relevant stakeholders is advisable to ensure that all the benefits are at least identified even if they cannot be quantitatively integrated into the assessment (Marta-Pedroso et al., 2018). Also, often some discussion is settled around the use of scenarios in performing an ES assessment. Again, the objectives would be a first factor shaping the decision regarding its inclusion. Nevertheless, the focus of economic valuation is estimating the value of change, and so scenarios are always involved in economic assessments. Therefore, one should bear in mind that the use of scenarios is not avoidable while performing economic assessments.

3.8.11 References

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4 Multifunctional assessment methods and the role of map analysis in an Integrated Ecosystem Assessment

By Roy Haines-Young (Fabis) and Marion Potschin-Young (Fabis)

4.1 Introduction

Action 5 of the EU Biodiversity Strategy 2020 sees mapping as a way of integrating biophysical, social and economic assessment techniques. The aim of this deliverable has therefore been to work this idea through, and to locate mapping with the wider conceptual thinking about what ecosystem assessments entail. Such a focus is especially helpful because one of the requirements for implementing the Biodiversity Strategy was seen to be the need to develop a flexible methodology to provide the building blocks for pan-European and regional assessments. In order to provide assistance to Member States in making such assessments, this Deliverable has sought to refine and test the initial conceptual thinking that was done within the context of MAES. The earlier part of this document presented a broad assessment framework, made comparisons with other assessment frameworks and gathered insights from practitioners on its usefulness for the kind of challenge they face. In this final part we make a critical reflection of the framework, and develop recommendations that can serve as guidelines for its future application and refinement.

4.2 The ESMERALDA Integrated Ecosystem Assessment (IEA) Framework: A Review

To support the EU Biodiversity Strategy ecosystem assessments must have a strong applied focus and be designed to answer the range of policy questions that are relevant to conserving biodiversity. As part of the work within ESMERALDA partners were invited (See Appendix C) to submit examples of what they saw such policy relevant questions to be within the context of implementing the EU Biodiversity Strategy. The ambition was to explore how such questions could be approached methodologically (see also Maes et al., 2018).

A key point to emerge from the material is that the questions identified cover a very wide range of issues indeed (Table 4.1). The analysis of the 82 questions submitted suggested that they fell into five broad groups, namely: knowledge or information requests, policy support questions, technical and methodological questions, questions about resources and the governance related to ecosystem service-based approaches, and applications of the ecosystem service approach. Such diversity poses a significant challenge for anyone seeking to identify a unifying conceptual framework that could address all these needs.

A recent, general discussion of the design and purpose of conceptual frameworks has been provided by Potschin-Young et al. (2018). Their goal was to examine and clarify the various roles of conceptual frameworks in operationalising and mainstreaming the idea of ecosystem services. The discussion which built on initial discussions from IPBES, suggested that conceptual frameworks could be used as:

- a tool that can help to make complex systems as simple as they need to be for their intended purpose;
- a device for structuring and prioritizing work;
- a way of clarifying and focusing thinking about complex relationships, thereby supporting communication across disciplines, knowledge systems, and between science and policy; and,
- a common reference point that encourages 'buy-in' from different participant groups.

Table 4.1: Typology of policy questions which drive the implementation of mapping and assessment of ecosystems and their services (See Appendix C and Maes et al., 2018).

- **Knowledge requests:** Questions for conceptual clarification and information needs. Examples are:
  - What are ecosystem services?
  - How are they linked to biodiversity and condition?
  - What are the trends of ecosystem services?
- **Policy support questions**: How ES can be used to support policy making and implementation.
  - Agricultural policy
  - Biodiversity policy
  - Spatial planning
  - Impact assessment
  - Disaster risk reduction
  - Economic policy
- **Technical and methodological questions**: Questions for specific technical details of mapping ecosystem services:
  - Spatial scale:
    - How to use data which collected at other spatial scales than the scale of assessment?
  - Uncertainty:
    - How to address conceptual and scientific uncertainty (e.g. role of biodiversity in providing ecosystem services)?
    - How to address data uncertainty?
  - Priority and preferences:
    - How to set priorities when selecting ecosystem services for assessment/management/ including priorities based on preferences of stakeholders?
  - Other technical support questions
    - Which methods are available to map, quantify and assess specific ecosystem services?
- **Questions on resources and responsibilities.** Questions about governance and resources
  - What are the costs and resources needed?
  - What can be an organizational or institutional setting to implement an ES based approach?
- **Application questions** (how to implement ES based approaches and how can mapping ES support applications)
  - How to set up payments for ES?
  - How to set up an ecosystem accounting system?
  - What are the cost and benefits of restoring ecosystems and enhancing services?
  - How to best communicate about ES?

Although the paper by Potschin-Young et al. (2018) explored these various roles through the application of the cascade model, these general headings are also relevant to better understanding the contribution that the IEA proposed within ESMERALDA might make.

The most obvious role of the ESMERALDA IEA is perhaps to provide a 'common reference point'. A key objective of ESMERALDA is to find ways of helping Member States to share experience. A mutually accepted representation of the field is, perhaps, one way of supporting this goal. A shared vision of what the assessment task entails was one of the key points identified in the review presented in Chapter 1. A review of the case study material presented in Chapter 3 suggests that all of them could locate their interests somewhere in the proposed framework, and so in this respect it might provide a way of people better comparing and sharing what they have done. A review of the material also suggests, however, that the fit was interpreted in a very general way, and it is often difficult to disentangle the particular, local perspectives on issues from those of more general interest. In fact, it seemed apparent from the responses of the case studies presented in Part 3, that it was not so much the common vision that interested them, but elements of the *analytical approach* that perhaps had more resonance for them.

It is interesting to note that the policy questions identified by the ESMERALDA consortium that are shown in Table 4.1 also seem to focus on analytical issues rather than on establishing common understandings across the different stakeholder groups that are often party to an ecosystem assessment. Communication and understanding issues linked to stakeholder engagement are more implicit in the issues identified in the set of policy questions than perhaps might have been anticipated; they are, for example, at the core of any attempt to prioritise or identify preferences in relation to selecting ecosystem services for analysis or evaluating potential policy outcomes.

The importance of stakeholders and where they fit in to the IEA was a key point to emerge from the consultation reported in Chapter 2; in the consultation process the most frequently cited issues concerned the identification of trade-offs among ecosystem services, stakeholders and ecosystem bundles; the identification of which ecosystem services are relevant to people; and, the identification of potential social conflicts arising from different stakeholder needs and perceptions.

By way of testing the adequacy of the framework it is interesting to reflect further on the material provided by the case studies in Chapter 3, which were asked to identify on the diagram those parts of the conceptual framework that their current work was dealing with. In reviewing this work, it is important to remember that the proposed IEA was not used to design the work they described, which in many cases was independent of the ESMERADA Project. Rather the assignment was to ‘retro-fit’ the IEA with a view to understanding if it captured their initial concerns. The need to understand and take account of different stakeholder perspectives was a common theme across the majority of the case studies. The emphasis given to this aspect of assessment in the revised IEA is therefore strongly supported by the case study responses.

Reflecting on the advantages of the IEA the Malta case study, for example, found that it was valuable in that it could stimulate a better dialogue between researchers, stakeholders and local communities, and at the same time provide opportunities for co-learning and knowledge sharing across disciplines and within communities. In the context of the urban flood regulation from Bulgaria, the researchers felt that the framework had the advantage of helping people to visualise the spatial aspects of this service and could contribute to the communication and dissemination of the results.

The revised IEA framework shown in Figure 2.2 therefore usefully complements the survey of relevant policy questions made in ESMERALDA by prompting the queries about where stakeholder issues fit in to each of them. In terms of providing guidance on how it might be used, a useful potential exercise is, therefore, to look at the policy questions through the lens of this framework to gain a better understanding of the social context of any assessment. In this sense the IEA can promote one of the other important roles of conceptual frameworks, namely to clarify and focus thinking about complex relationships, thereby supporting communication across disciplines, knowledge systems, and between science and policy.

The Polish case study on using the IEA to inform Environmental Impact Assessments illustrates how the ESMERALDA framework might support communication across disciplines, and between science and policy. In this work the researchers considered what the added value was of using the IEA to help assess impacts, and found that it could lead to better recognition of ecosystem services within EIA procedures. Basing their analysis on the impacts of a proposed road development they felt it could facilitate communication and discussion between the various interested stakeholders. It helped, they suggested, in taking a second analytical step, namely to move from the assessment of the impact of development on the ecosystems to the assessment of the impact on the structure and level of benefits from them for people.

Clarification of the complexities surrounding the analysis of ecosystem services is perhaps one of the most important roles of conceptual frameworks, and this has clearly been the intention of the development of the initial MAES framework that has evolved into the refined version shown in Figure 2.2. A key feature of the IEA throughout, for example, has been the juxtaposition of notions of ecosystem *condition* alongside those relating to ecosystem *services*. Although the analysis of ecosystem condition was not part of the brief for ESMERALDA, it has emerged both as an issue both in the set of policy questions (Table 4.1) and in the survey of user needs (Chapter 2), where users highlighted the requirement that ecosystem assessment should investigate the linkage between biophysical, social and economic parameters, and investigate the interactions between ecosystem condition and the value of ecosystem services.

Although the concept of ecosystem condition and how to measure it is still an active area of debate, thinking about it is sufficiently well aligned with ideas about the functional characteristics that underpin ecosystem services to suggest that the issue should be considered in any wide-ranging ecosystem assessment. Thus, the value of the ESMERALDA IEA is therefore, to highlight, perhaps for the first time, the central role that the analysis of condition might play in any assessment. It is in this context that the ESMERALDA IEA conforms to the final role of a conceptual framework, namely to serve as a device for 'structuring and prioritizing work'.

The IEA shown in Figure 2.3 potentially helps people structure their work, by attempting to set out the main methodological steps from identifying ecosystem services and underlying conditions through to their mapping. It also clearly sets priorities, by flagging the dual, central role of condition and services in any assessment. Several of the case presented in Part 3 strongly supported the need to incorporate the analysis of condition in their work; these included, for example, the work on Flooding in Bulgaria, scoping EIA in Poland, and the design of the Hungarian ecosystem assessment.

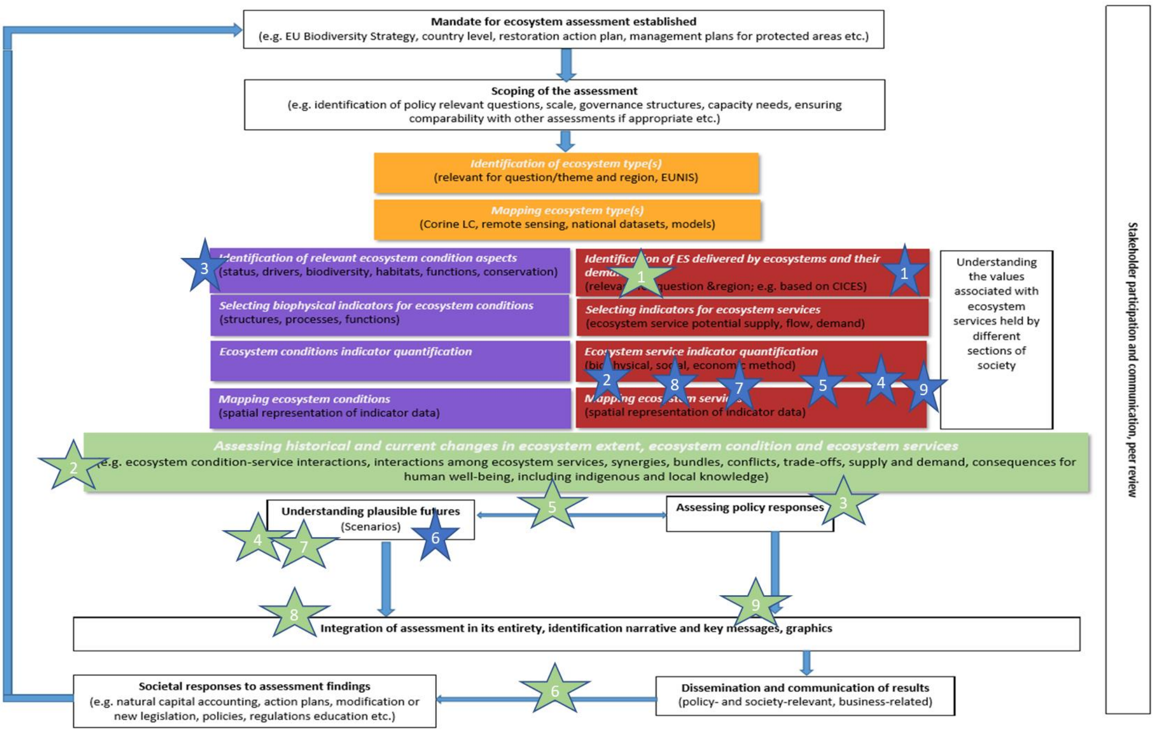
The clear focus on ecosystem condition and ecosystem services is a major positive feature of the ESMERALDA IEA. However, the material presented in this Deliverable suggests that as it currently stands the framework has two potential shortcomings that need to be resolved in future work. These concern the nature of the linkage between condition and services, and the linkage between condition and services on the one hand, and monetary and social values on the other. We will consider each of these issues in turn.

The first issue to consider in relation to the analysis of condition and services shown in the finalised ESMERALDA framework (Figure 2.3) is the extent to which measures of condition are independent from measures of ecosystem service. In the original MEAS diagram and the Burkhard et al 2018 version (Figures 1.3 and 1.4), there was step towards the bottom of the diagrams involving the integration of condition and service analysis to answer the question 'how does condition relate to service provision?' (e.g. Figure 1.3. This stage is lost in Figure 2.3, and it is unclear where this linkage is considered. The implication from the examples provided by the case studies in this Deliverable is that to some extent general indicators of condition can be identified, that determine the overall capacity of the ecosystem to deliver ecosystem services. This impression is strengthened by the recommendation in Burkhard et al. (2018) that in terms of the assessment steps they identify, condition is analysed before, and separately from services.

In their discussion Roche and Campagne (Case Study 3.2) suggest that since ecosystem condition focuses on the capacity to support ecosystem services many potential indicators should be related to aspects of ecosystem function such as NPP, energy efficiency or nutrient cycling. Such a view might suggest that to some extent condition and services can be treated somewhat independently. However, as has been argued in the review of ecosystem service classification and indicators methods (Deliverable 4.2, Haines-Young et al., 2018), if changes in ecosystem condition are to be mapped or documented in ecosystem accounts, and described fully in assessments more generally, then a clear link to the implications for specific ecosystem services is likely to be required if robust and credible analyses are to be made. It was concluded in relation to the application of service classifications in 'integrated assessments', that in practice it is likely that a good deal of iteration between the left and right-hand boxes in the IEA diagram, dealing with condition and services, would be necessary. There must be some resonance between measures of condition and either specific services or bundles of them, if the notion of integration between the two elements of the assessment is to be fully supported.

The second issue to consider is that however condition and service themselves are linked, there clearly also needs to be an explicit read-across to the analysis of benefits and values if a comprehensive assessment is to be made. These socio-economic elements were not highlighted in the original MAES framework (Figure 1.3) or the refined version published by Burkhard et al. (2018) (Figure 1.4), except to highlight where as a minimum stakeholder engagement might occur. In the finalised version presented here (Figure 2.3) these issues have a more prominent place indicated by a box to the right of the condition and service block. The need to reference 'the values of ecosystem service held by different sections of society' has been highlighted both through the consultation on the framework and in the case study material prepared for this deliverable. However, a limitation of Figure 2.3 is that the steps by which these values and stakeholder groups are identified and assessed is unclear. Moreover it is also unclear if and how these aspects can be, or should be, mapped.

Roche and Campagne (Case Study 3.2) argue that the inclusion of the assessment of condition is important because it not only leads to a focus on biophysical underpinnings of services, but also of the needs of people, since it "clearly refers to the capacity of ecosystems to provide humans with services and resources over the long term". A corollary of such a view is that there needs to be a clear articulation of indicators across the central part of the IEA to provide the read-across between the biophysical and socio-economic dimensions that is required. In order to do so one might consider the same four analytical steps shown for condition and services for all the elements of the ecosystem service cascade in the central part of this diagram. Such thinking would allow the conceptual framework to be better aligned with the proposals developed around the idea of a CICES-consistent indicator library that spans the different components of the cascade as discussed in Deliverable 4.2 and Czúcz, et al. (2018). Both these studies showed that the indicators used in published studies could be cross-referenced to the CICES classification and to different elements of the cascade. A library documenting such associations could go some way to supporting an understanding of how changes in ecosystem condition ultimately affects the well-being of people.



Key

Policy support questions (Blue stars) : How ES can be used to support policy making and implementation. (harmonization)

1. Which are the priority ES that need to be mapped & assessed? (13th MAES meeting);
2. How can MAES shape patterns of development through informing strategic spatial land use plans;
3. Supporting assessments of impacts of individual developments? (13th MAES meeting);
4. How might ecosystems & ES change under plausible future scenarios? (13th MAES meeting);
5. Farming already provides the ecosystem services that matter for our essential needs (food, energy)-why the fuss about the non-essential ones? (13th MAES meeting);
6. How can we better communicate the social benefits of nature based solutions into decision making? What kind of information will be recognized? (13th MAES meeting);
7. What is needed to come to innovative integration of social and natural science to really show, assess and value the importance of a healthy natural & physical environment to human health? (13th MAES meeting);
8. How should we incorporate the economic and non-economic values of ecosystem services into decision making and what are the benefits of doing so (question to be addressed 2020)? And what kind of information (e.g. what kind of values) is relevant to influence decision-making? (1st MAES report);
9. How to integrate and use lessons from work on the concept and valuation of eco- system services in practical management, and how to integrate this in an overall framework of ecosystem management.

Methods identified as relevant (Grey stars)

1. Deliberative assessment
2. Direct measurement
3. Ecosystem service assessment
4. Hedonic pricing
5. Market price
6. Participatory scenario planning
7. Photo-elicitation surveys
8. Public pricing
9. Value transfer (benefit transfer)

Figure 4.1: Locating the Lower Danube Case Study from Romania on the ESMERALDA IEA.

4.3 Flexibility and Integration

The discussion provided by Brown et al. (2018) in Chapter 2 made a distinction between conceptual frameworks themselves and the steps by which an assessment is actually undertaken. This is important because it must not be assumed that the elements shown in a diagram such as 2.3 are considered in a simple, sequential way from top to bottom (cf. Burkhard et al., 2018). As the case studies from Poland and Malta have emphasised, the development of an assessment is often iterative, and as illustrated by the example on EIA, there are multiple entry points leading to a consideration of the elements of the framework, depending on the policy question being asked. Such a situation is illustrated by the case study from Romania on the Danube Delta (Figure 4.1).

The Lower Danube study is a complex one, involving a shift in the dominant decision-making paradigm away from one which prioritises provisioning services in the form of agricultural production, to one which takes account of a wider range of ecosystem services. Thus, there is a need to explore both ecosystem service supply and demand issues, as well as the ecological conditions necessary to deliver them. Key questions include how to identify and handle monetary and non-monetary values, how to prioritise and how to evaluate the different management options. The case study authors have indicated in Figure 4.1 where in the finalised IEA they might be investigated.

It is not necessary to consider the specifics of the Romanian case study in detail, but rather to use the example to make the general point that as this and the other case studies illustrated, the refined framework presented here can be interpreted *flexibly.* It seems capable of representing the multiple perspectives on the assessment tasks required by EU Biodiversity Strategy 2020 in the same diagram. Moreover, it seems capable of representing the complexities of a single study which may involve multiple entry points into the assessment process. To be truly insightful, however, the framework must be capable of *integrating* all the different elements irrespective of the starting point.

As indicated in the discussion in Part 2 of this Deliverable, the theme of 'integration' has been a prominent one in discussions of the IEA during the ESMERALDA Project, and the question arose at an early stage concerning exactly *what* was being integrated. One feature, carried over from the original versions of the framework, was the integration of analysis of ecosystem condition and ecosystem services within a single schema. However, the case studies also variously argued that such integration had to extend bringing together the biophysical, social and economic dimensions of assessments, accommodating the different perspectives of stakeholder groups in the same framework, and the harmonising policy approaches across different sectors. The analysis of synergies and trade-offs, for example, also requires a particular type of integration if the balance between the output of different services is to be examined. Moreover, it is also clear that while the focus of ESMERALDA and MAES is on mapping, not all indicators have a 'spatial anchor' (Deliverable 4.2) and not all policy questions may, in fact, require such techniques. Such issues were flagged in the Portuguese case study as an overall reflection on how to conduct an ES assessment. The authors pointed out that in some circumstances it is more expedient to use non-spatial methods, especially at an early stage of the assessment.

Brown et al. (2018, and Chapter 2) noted that in general assessment processes are not well documented or evaluated. While this study has attempted to underpin the ESMERALDA IEA with a better thought through rationale, it is clear that many issues remain. In particular, the idea of integration itself remains problematic, in so far as it both seems to cover multiple characteristics of an assessment, and imply that there is such a thing as a 'non-integrated' type of assessment to which it is superior. It is interesting to note that in their definitions section while Burkhard et al. (2018) make a distinction between assessment and integrated assessments both involve the assimilation and bringing together of different type of analysis, data and interest groups. Assessments are in most key respects exercises in integration, and so the label integrated alongside the term assessment is probably tautological. It would perhaps be more helpful when providing guidance on the use of the framework developed in ESMERALDA to focus on what is being integrated and where, and how such integration is being achieved – for without efforts to integrate concepts, data, sectoral interests and goals, etc. and any assessment would be flawed.

4.4 Conclusions and Recommendations

The aim of this report has been to present a broad assessment framework and to test it. The framework presented aims to illustrate the integrated assessment cycle for practitioners working within the context of the EU Biodiversity Strategy 2020, and in particular the work being undertaken in the relation to the ‘Mapping and Assessment of Ecosystems and their Services’ (MAES) initiative.

As the thinking in MAES has developed various conceptual frameworks describing what mapping and assessment activities entail and how they relate to each other have been proposed. This work took as the starting point the refined version presented by Burkhard et al. (2018) which focussed especially on the relationships between ecosystem type, condition and service output. Our work has shown that while this schema is helpful it probably needs to be seen in a broader context. We found that the picture of integration that it gave needed to highlight more clearly the role of stakeholders at all stages in the assessment, and the links between condition and services on the one hand, and benefits and values on the other. The iterative rather than stepwise approach to assessment was also a feature that was emphasised in the revision proposed here.

On the basis if the findings presented in this Deliverable, when using the revised framework shown in Figure 2.3 of this deliverable we recommend that:

- Given the different ways in which notions of integration are applied by in different assessment, **it is essential when discussing or presenting the framework in relation to a particular study to be clear about what form this integration takes and how and where it occurs.** Assessments, we suggest are essentially integrative, and those concerned with the design and management of them need to demonstrate how integration is achieved if the assessment is to be considered robust and credible.

- The investigation of ecosystem condition and ecosystem services is not approached by two independent analytical pathways, and that while general condition measures might be identified, ultimately the functional underpinning of each service (or bundles of services) has to be related to *particular* condition measures if a robust and credible assessment is to be made. However, given that ideas about how to characterise ecosystem condition are evolving it would seem that the way the relationships are framed in the current ‘finalised’ version will probably need to be updated. One route to establishing the linkage between functional, condition measures and services might be through the development and documentation of the CICES-consistent indicator library proposed in Deliverable 4.2 (Haines-Young et al., 2018).

- Given that assessments, even those undertaken within the context of the EU Biodiversity Strategy, have to be relevant to social needs and concerns, the investigation of ecosystem condition and ecosystem service needs to be linked to the analysis of benefits and values.

Once again, we suggest that a such a read-across might be supported by the development of a CICES-consistent indicator library that explicitly spans all the elements of the cascade mode. Moreover, sufficient base line or temporal change data generated by the analysis of historical information or scenarios is probably needed to communicate how change may impact biodiversity and on human well-being.

- That despite the limitations that are evident in the revised framework shown Figure 2.3 it is sufficiently flexible and rich in its content to be able to represent the concerns of range of studies developed within the MAES community. In order to share this experience partners should be encouraged to describe key features of their work using this framework, indicating where their focus lies in terms of policy questions and methods applied. Such work could inform the further development of the conceptual framework and the guidance that surrounds it.

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Appendix A – Selected case studies of integrated assessments in Europe - Content

Appendix A: Case studies of integrated assessments in Europe

At set of assessments carried out in Europe, where analysed prior to the development of the framework to understand how assessment practitioners where addressing the concepts of integration. The case studies were developed in 2016 from publically available material for that particular assessment. Case studies for Finland, Flanders, France, Germany, Netherlands, Portugal, Spain and the UK are set out below.

Finland

A. Name of Assessment

Towards Sustainable and Genuinely Green economy - The value and social significance of ecosystem services in Finland (TEEB for Finland).

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (e.g. Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

In 2013, Finland conducted a two-year TEEB for Finland study which was based upon the framework of the EU's MAES project and international TEEB studies, in particular TEEB Nordic (Jäppinen and Heliölä, 2015). TEEB Finland was reported to have been implemented with close co-operation with other current national projects such as FESSI (the identification of national ecosystem service indicators) and Green Infra and EkoUuma (a method for assessment of green infrastructure based upon ecosystem services) (IPBES, 2016).

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The assessment was undertaken in order to address the need to improve knowledge and understanding of ecosystem services in Finland as a concept in addition to the measurement and valuing or ecosystem benefits (SYKE, 2013). Support for ongoing policy processes, at both national and regional level, was a high priority in the project objectives. Particular emphasis was placed upon three main areas:

- Firstly, the development of national framework for the assessment and monitoring of ecosystem services, including identifying and establishing appropriate indicators.
- Secondly, the development of national policy and policy instruments to support a "truly green 'green' economy".
- Finally, the support for sustainable regional development via the implementation of green infrastructure. Consequently, the project contributes to Finnish commitments towards the global and EU Biodiversity Strategy by 2020 (SYKE, 2013).

In 2015, the scoping study 'Towards Sustainable and Genuinely Green economy - The value and social significance of ecosystem services in Finland' was published (https://helda.helsinki.fi/handle/10138/152815) as a roadmap for policy-makers.

D. Integration

In what sense was the assessment integrated? What was being integrated?

The assessment described main drivers and trends which affect provision of ecosystem services and proposes ecosystem service indicators (Jäppinen and Heliölä, 2015). The Helsinki-Uusimaa region was provided as an example of spatial assessment and mapping of ecosystem services and green infrastructure (Jäppinen and Heliölä, 2015).

The study provides recommendations for improved integration of ecosystem services into Finnish policy processes. These include insights into steering mechanisms for improved safeguarding of natural capital – including ecosystem services (Jäppinen and Heliölä, 2015). Scoping assessment on natural capital accounting and reviews the relationship between green economy and ecosystem services were included (Jäppinen and Heliölä, 2015).

The integration of a wide range of ecosystem services into a green economy was linked to ensuring an environmentally and socially sustainable green economy.

The TEEB for Finland assessed six systems and multiple ecosystem services including; four provisioning systems, five regulating systems, three supporting services/functions and one culture service (IPBES, 2016). The scope of the assessment included: drivers of change in systems and services; impacts of change in services on human well-being; options for responding/interventions to the trends observed; and explicit consideration of the role of biodiversity in the systems and services covered by the assessments (IPBES, 2016).

The TEEB for Finland consists of five main components (SYKE, 2013).

- *“Identifying Finland's most important ecosystem services and their indicators*
- *Assessing the current state and future trends of Finland's most important ecosystem services*
- *Providing insights to the economic value of the most important ecosystem services*
- *Providing insights on how to better integrate ecosystem services into decision-making*
- *Identifying the importance of ecosystem services and their role in promoting green economy*
- *Synthesis and recommendations.”*

How was integration achieved? How did the assessment approach reflect the need for integration?

The establishment of thematic expert working group for different Finnish ecosystems was noted in the TEEB Finland report, identifying indicators and current evidence. Complementary workshops were used to engage a broader range of stakeholders within the process (SYKE, 2013).

Stakeholder knowledge played a key role in the TEEB Finland. Stakeholders were heavily involved in the creation of TEEB Finland and the associated ecosystem service indicator (FESSI) project, including; administration, ministries, business, researchers, managers and NGOs. Local level case studies were provided by regional and local-level practitioners such as spatial and environmental planners, experts from various fields, NGO's, managers and even citizens (ESMERALDA, 2015).

Finland has an active role in the Soil MAES Pilot, contributes to EU Marine MAES with Deltares and Forest MAES. Finland is reported to be planning participation in Urban MAES (ESMERALDA, 2015).
Virtual Lab applications have also been developed for integrated assessments and scenarios, using boreal watershed in southern Finland as a case study (Holmberg *et al.,* 2015).

The report also contains an assessment by IEEP and SYKE which investigates the ability to integrate ecosystem services and other natural capital within the national accounting system, entitled: 'Scoping assessment on policy options and recommendations for Natural Capital Accounting in Finland' (Jäppinen and Heliölä, 2015). TEEB Finland analysed opportunities for improvement of ecosystem service governance, including the relationship between ecosystem services and the development of a green economy in Finland. The project aimed to identify ways of integrating the value of ecosystem services into the national accounting system, known as Natural Capital Accounting (NCA), adding to the values of provisioning services already integrated (Jäppinen and Heliölä, 2015).

From the national assessment, the ‘Framework of National Ecosystem Service Indicators’ website has been produced (www.biodiversity.fi/), including 112 indicators to date. Based upon the International Common International Classification of Ecosystem Services (CICES), 10 provisioning services, 12 regulating services and six cultural services have been selected.

Were any barriers to integration discussed?

Jäppinen and Heliölä (2015) noted that the legal system as a limiting factor which, in some cases, directly prohibits application of scientific knowledge and new concepts, including ecosystem services, and therefore suggesting the change of existing legislation within Finland. Currently, no official processes exist in order to achieve the incorporation of ecosystem services, biodiversity and other natural values into national accounting and reporting by 2020 (Jäppinen and Heliölä, 2015).
It has also been noted that the knowledge of ecosystem processes and other regulating services in Finland is relatively poor. However, following this report, many processes are now being investigated (Jäppinen and Heliölä, 2015).

What evidence is there if any ‘added value’ in the integrated approach?

Informational and knowledge drawn from the study has been utilised in the implementation of the Finnish National Biodiversity Strategy and Action Plan (NBSAP) 2013–2020 ’Saving Nature for People’. Furthermore, national actions related to the Convention of Biological Diversity’s (CBD) Strategic Plan for Biodiversity 2011–2020 and the EU’s Biodiversity Strategy 202, in particular ecosystem services and natural capital, have utilised such information and knowledge (Jäppinen and Heliölä, 2015). Jäppinen and Heliölä (2015) also note the revision of existing policies by the Finnish Government in a report entitled ' Intelligent and Responsible Natural Resources Economy'. The revision aims to enhance cross-sectoral policies in order to highlight Finland as a role model for sustainable natural resources economy in 2050 and states the assessment of ecosystem services is integral for this.

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Flanders

A. Name of Assessment

Flanders Regional Ecosystem Assessment (Flanders-REA). The first phase of this was NARA-T which describes the state and trends of ecosystems and their services in Flanders (Liekens *et al.*, 2015)

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (e.g. Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The Ecosystem service cycle was used as a conceptual framework (Stevens *et al.*, 2015). Figure 1 below from (Stevens *et al.*, 2015) presents the framework.

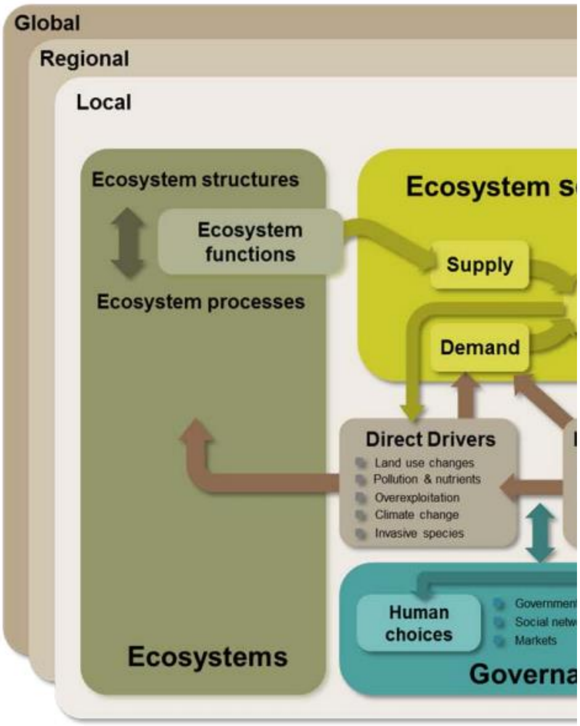

Figure 1. Ecosystem Service cycle (Stevens *et al.*, 2015)

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The assessment set out to answer eight questions (Stevens *et al.*, 2015):

1. "How do humans influence ecosystem services?
2. What are the state and trends in ecosystems and biodiversity?
3. What are the state and trends in ecosystem services?
4. What is the role of biodiversity for ecosystem services?
5. How do ecosystem services contribute to well-being?
6. How can we value ecosystem services?
7. What interactions exist between ecosystem services?
8. What are the characteristics of an ecosystem service-oriented policy?"

D. Integration

In what sense was the assessment integrated? What was being integrated?

The assessment integrated several elements, as it considered direct drivers of ecosystem change such as land use change as climate change (i.e. ecological elements) as well as indirect drivers including social, economic, cultural and technological factors (Stevens *et al.*, 2015). The assessment also considered the interaction between ecosystem services and how these are affected by supply and demand (Stevens *et al.*, 2015). The method to assign value to ecosystem services involved collaboration of ecologists, philosophers, economist and social scientists to take a broad value approach (Stevens *et al.*, 2015).

A broad-meta review method was used to cover the full extent of available knowledge on ecosystem service state and trends (Jacobs *et al.*, 2016).

How was integration achieved? How did the assessment approach reflect the need for integration?

The assessment considered the impact of ecosystem services, including provision services, regulating services and cultural services on human wellbeing (Stevens *et al.*, 2015). A broad value typology to assign value to ecosystem services was developed by a multi-disciplinary team of philosophers, ecologists, economists and social scientists and placed emphasis on the impact between biodiversity and people (Stevens *et al.*, 2015).

To assess the state and trends of ecosystem services, a broad meta-review was used to consider all available knowledge on the topic (Jacobs *et al.*, 2016). All of the information on 16 ecosystem services were considered 'data units' which were organized and compared, regardless of their nature, and a confidence score was assigned to each reference so that data units of different types could be compared (Jacobs *et al.*, 2016). Data on biophysical and socio-economic proxies was mapped to provide maps on the supply, demand, use and value of ecosystem services (Liekens *et al.*, 2015).

Stevens *et al.* (2015) discussed the fact that government policy focuses on the supply of ecosystem services but noted that policy affecting other areas such as education, spatial planning and health and well-being should consider ecosystem services.

A tool to value of ecosystem services in Flanders has been developed and has been made available to the public so that it can be used by a variety of stakeholders such as land managers, local and national authorities, NGOS and members of the public to assess the socio-economic importance of ecosystems (Liekens *et al.*, 2015)

Were any barriers to integration discussed?

Stevens *et al.* (2015) noted the complexity of assigning value to ecosystem services and how no method can combine all value types that is used consistently in all scientific disciplines.

Jacobs *et al.* (2016) considered that the separate maps produced for the Flanders regional assessment 'contain useful information' but noted that aggregation and comparison of multiple services was difficult as combined maps were difficult to interpret. It was also noted that although the team responsible for the assessment was interdisciplinary, further expertise was required from elsewhere, and as this had not been foreseen, experts were required to work on a *pro-bono* basis. (Jacobs *et al.*, 2016).

What evidence is there if any 'added value' in the integrated approach?

Jacobs *et al.* (2016) noted that 'science-policy cooperation, networking and building trust was a critical success factor for the Flanders REA'.

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France

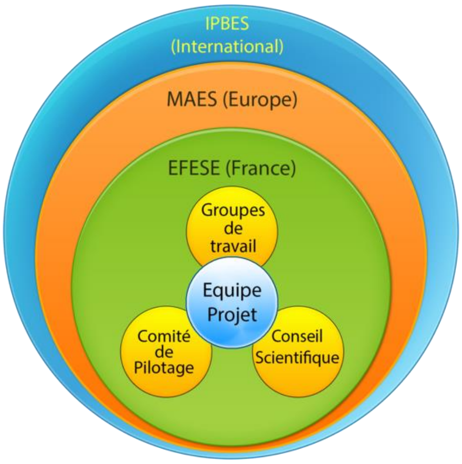
A. Name of Assessment

EFESE (Evaluation française des écosystèmes et des services écosystémiques)

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (eg Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The conceptual framework used for the assessment is based on the MAES framework



EFESE conceptual framework

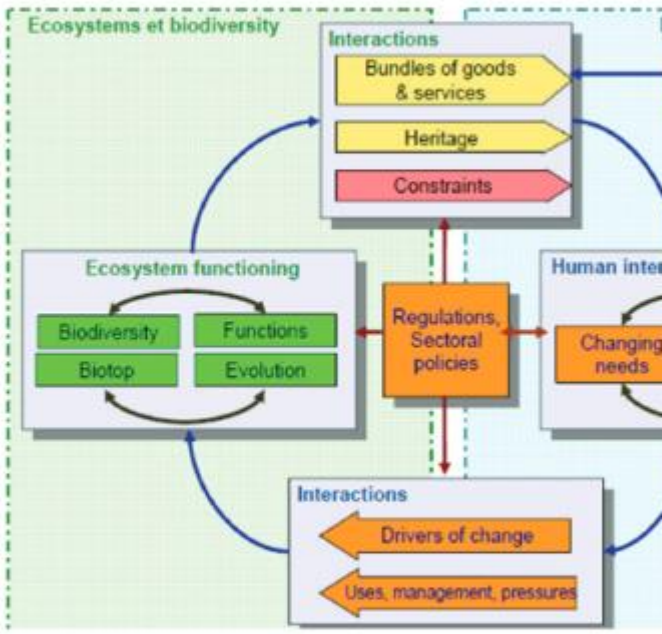


Table 2: Concordance table between MEA and EFESE typol

MEA (2005)	EFESE	
Supporting services	Ecological functions	Bioph
Provisioning services	Goods	Bioph marke
Regulation services	Regulation services	Bioph based
Cultural and spiritual services	Cultural services (measurable benefits)	Non-r marke
	Natural heritage (non-measurable benefits, intrinsic value)	Identi

(Roche et al. 2015)

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The objective of EFESE is to assess and map the main types of ecosystems and their services. The work is carried out in order to contribute to achieving the targets of the National Biodiversity Strategy and EU biodiversity strategy, and also to the National

Strategy for Ecological Transition Towards Sustainable Development. It is also aims at supporting the elaboration of different sectoral biodiversity strategies and plans, and specific action plans for species conservation such as wild pollinators. (Roche et al. 2015)

D. Integration

In what sense was the assessment integrated? What was being integrated?

There are five Working Groups (WG) that focus on different ecosystems:

- Forest,
- Wetlands & freshwater,
- Marine coastal ecosystem,
- Agro-ecosystem and
- Urban ecosystems

Scientific and technical committee and steering committee involving stakeholders have been set up.

Also, a process has been launched to look at values that are not well taken into account in current work which tends to focus on economic assessment. Issues that will be explored concern less tangible benefits such as spiritual and mental wellbeing. (Roche et al. 2015)

How was integration achieved? How did the assessment approach reflect the need for integration?

Working groups focusing on different ecosystems were formed with the aim to produce outputs (e.g. map of wetlands, report on what can be done in urban and case-studies, map and assessment of some ecosystem services such as pollination). A steering committee, that gathers all stakeholders, has been set up in 2013. Each stakeholder is also represented among the ecosystems WG. All reports have to be validated by the scientific committee, the steering committee, and the ministry before publication. As the project involves different stakeholders, the involvement of the private sector is planned. The aim is to promote the project but also to know which actions the business is taking on ecosystems services, and how to integrate the natural capital in corporate accounting in the longer run. (Roche et al. 2015)

Were any barriers to integration discussed?

The assessment aims at also exploring less tangible benefits such as spiritual and mental wellbeing. Experience has shown that it is difficult to communicate these issues and therefore one priority is on easy to use indicators for decision making process. (Roche et al. 2015)

E. References

Roche, P., Puydarrieux, P., Darses, O., Kervinio, Y., Kochert, T. and Mauchamp, L. 2015. ESMERALDA country fact sheet: France (FR) (2015). Available at: http://catalogue.biodiversity.europa.eu/uploads/document/file/1307/Esmeralda_country_fact_sheet_France.pdf

Germany

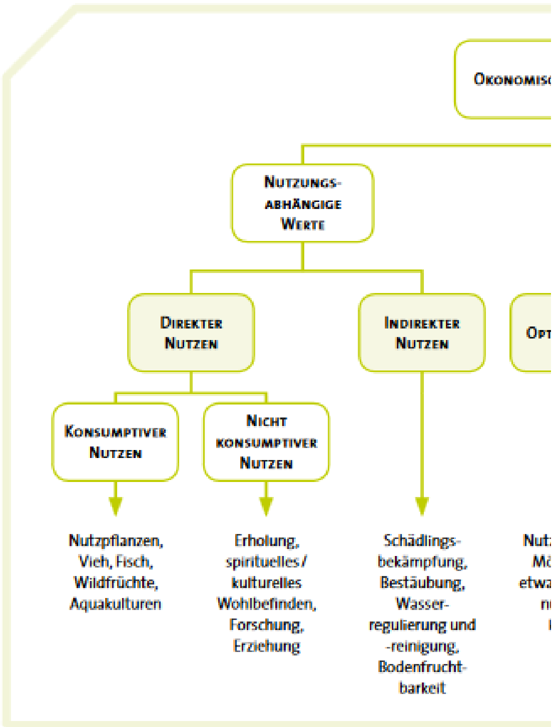
A. Name of Assessment

Natural Capital Germany- TEEB DE

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (eg Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The assessment utilises the conceptual framework of "The Economics of Ecosystems and Biodiversity" (TEEB) (IPBES, 2012).



(Naturkapital Deutschland – TEEB DE, 2012)

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

Natural Capital Germany – TEEB DE: Naturkapital Deutschland is the national follow-up study to the international TEEB study "The Economics of Ecosystems and Biodiversity", which analysed the interactions between nature's services, value added by economic activity, and human wellbeing. »Natural Capital Germany – TEEB DE« aims to make nature's potential and services more transparent and visible by adopting an economic perspective. (Dietrich et al. 2015)

The main aim of the project "Natural Capital Germany" is to gather existing knowledge about nature and its benefits. Additionally, a network will be established and processes initiated that will make a contribution towards valuing nature and incorporating its services better in future decisions. (Naturkapital Deutschland – TEEB DE, 2012).

The objective of TEEB-DE is to collect existing evidence on social and economic importance of ecosystem goods and services and to identify and analyse trade-offs between different land management strategies and policy goals. It is also of importance to promote good practices and successful cases of biodiversity conservation and ecosystem management and to synthesise lessons for policy makers, administrators and business.

(Dietrich et al. 2015)

D. Integration

In what sense was the assessment integrated? What was being integrated?

The Ecosystem Services indicators are discussed with stakeholders from different sectors (forestry, agriculture, statistical office, water management etc.) and the scientific community. The aim is to have complete data sets on the national scale, comparing at least two points in time.

Additionally, indicator sets for the conditions of ecosystems are being developed. An internal preparation of a study to integrate ecosystem services in national environmental accounting systems is one of the core activities of the BMUB and BfN. The main subject of the project is a scoping study and an in depth analysis of non-monetary and monetary approaches for selected items of ecosystem services and capital. (Dietrich et al. 2015)

How was integration achieved? How did the assessment approach reflect the need for integration?

The assessment involved consultation with several stakeholder groups including policy and administration groups, conservationists, business and science (IPBES, 2012). To assure a successful implementation of the TEEB-DE process, different workshops are carried out since 2011. The aim is to present cases, evaluate existing practices and to provide recommendations. Two workshops are planned in 2016 with the objectives to transfer of ESS knowledge as well as the economic perspective on ecosystem services in rural and urban areas. Climate aspects such as nature-based climate protection and climate adaptation are also being considered.

E. References

Dietrich, K., Ekinci, B., Schweppe-Kraft, Grunewald, K., Albert, C., Bernd Hansjürgens, B., Burkhard, B. (editors). 2015. ESMERALDA country fact sheet: Germany (DE). Available at: http://catalogue.biodiversity.europa.eu/uploads/document/file/1308/Esmeralda_country_fact_sheet_Germany.pdf

IPBES 2012. Natural Capital Germany- TEEB DE. Available at: http://catalog.ipbes.net/assessments/35.

Naturkapital Deutschland – TEEB DE. 2012. Der Wert der Natur für Wirtschaft und Gesellschaft – Eine Einführung. München, ifuplan; Leipzig, Helmholtz-Zentrum für Umweltforschung – UFZ; Bonn, Bundesamt für Naturschutz. Available at: http://catalog.ipbes.net/system/assessment/35/references/files/274/original/Naturkapital_TEEBDE_WertNaturWirtschaftGesellschaftEinfuehrung.pdf?1352384711

Netherlands

A. Name of Assessment

The Dutch Atlas of Natural Capital (ANK)

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (e.g. Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The conceptual framework used for the assessment is based on the ecosystem services cascade model, the TEEB framework and the UK National Ecosystem Assessment (IPBES, 2015)

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The Dutch Atlas of natural capital identifies the services that natural capital can provide and provides information for a variety of stakeholders including governments, business, community organisations and local governments as all the information and contains elements of the DPSIR framework (The Government of the Netherlands, 2015). The Government of the Netherlands (2015) reported that the atlas is structured to allow business and governments to use to for decision making for optimal social benefit.

The aims of ANK is to 'provide all the information needed for sustainable decision-making by 2020' (IPBES, 2015). With the information, it is possible for decision makers to take steps to optimize sustainable use of ecosystem services (Breure *et al.*, 2014)

D. Integration

In what sense was the assessment integrated? What was being integrated?

The ANK integrates several elements as it provides maps on ecological services as well as social and economic benefits of services (ANK, 2015). ANK also provides maps from a variety of different sources that are publically available (ANK, 2015).

How was integration achieved? How did the assessment approach reflect the need for integration?

The maps provide data on a variety of ecosystem services which include provisioning services, regulating services, abiotic resources as well as cultural resources including green recreation, natural heritage, science and education (ANK, 2015). The ANK is made up of maps from various sources and is intended to be used for decision making by groups with different viewpoints including businesses, farmers, policy-makers and planners (Scholten *et al.*, 2015).

Were any barriers to integration discussed?

No information on barriers to integration was found.

What evidence is there if any 'added value' in the integrated approach?

The ANK website provides several real life examples of when information on a host of ecosystem services can be applied; these are diverse (they include regional planning, regulation disease and improving urban rainwater drainage) and show that decision-makers require information from different elements including social, economic and ecological to make informed sustainable decisions (ANK, 2015).

E. References

ANK 2015. *Atlas Natuurlijk Kapitaal*. Available at: http://www.atlasnatuurlijkkapitaal.nl/en/home.

Breure, A., de Nijs, T. and Rutgers, M. 2014. *Digitale Atlas Natuurlijk Kapitaal: Nederland werkt in 2014 aan de National Ecosystem Assessment (NEA)*. Available at: http://repository.ubn.ru.nl/bitstream/handle/2066/133073/pubversion_2066_133073-20151109154927.pdf?sequence=1.

IPBES 2015. *Atlas Natural Capital*. Available at: http://catalog.ipbes.net/assessments/248.

Scholten, L., Mulder, S., Petz, K., van Egmond, P., de Nijs, T. and de Groot, D. 2015. *ESMERALDA Country Fact Sheet: Netherlanda (NL)*. Available at: http://catalogue.biodiversity.europa.eu/uploads/document/file/1316/Esmeralda_country_fact_sheet_Netherlands.pdf.

The Government of the Netherlands 2015. *Atlas of Natural Capital*. Available at: http://www.atlasnatuurlijkkapitaal.nl/documents/1001696/1489993/ANK+brochure+EN/fdc0ae1f-7251-4419-bdf7-afaf58a7a1d8?version=1.0.

Portugal

A. Name of Assessment

ptMAES - Mapping and Assessment Ecosystem Services (Portugal)

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (e.g. Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The ptMAES assessment was carried out at regional scale (covering the NUTS II Alentejo that represents about 1/3 of Portugal Mainland Area) adopted the MAES conceptual and operational frameworks (Maes et al., 2013; Maes et al., 2014) -

Figure *8*. As such, the assessment aimed to map, following the European Nature Information System (EUNIS) habitat classification the dominant ecosystems within the NUTS II Alentejo and to map and assess ecosystem's condition and the ecosystem services provided (Marta-Pedroso, et al., 2014a)[7].

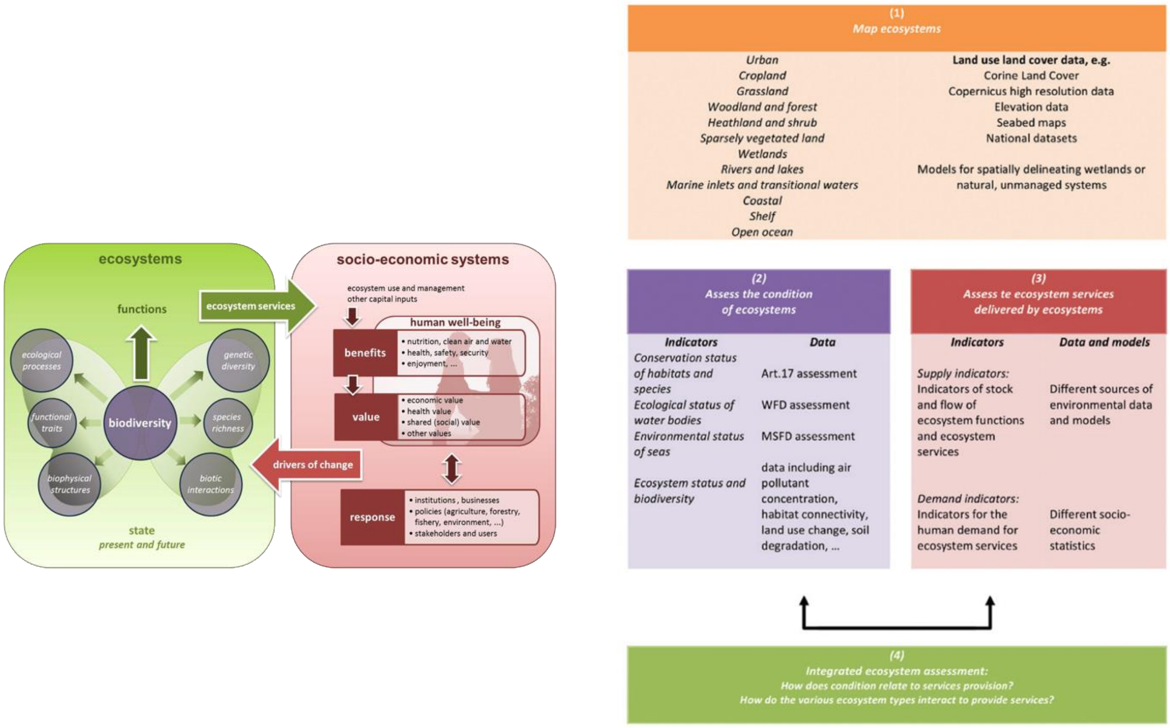


Figure 8 MAES Conceptual (MAES et al., 2013) - left side - and operational framework (Maes et al., 2014) – right side

[7] Available at http://www2.icnf.pt/portal/pn/biodiversidade/mase; it includes an executive summary in English.

As part of the ptMAES’s regional assessment, a local case study was selected, within the NUTS II Alentejo, in which estimation and mapping of the economic values of ecosystem services (ES) were brought into practice in the context nature conservation policy appraisal (Marta-Pedroso et al., 2014b; Marta-Pedroso et al., 2018). Since the focus of this local study was on economic valuation and mapping economic value of ES, rather than embrace all the MAES framework components of analysis, for the local case study, The Natural Park of Serra de S. Mamede, a TEEB based framework was adopted (Figure 9).

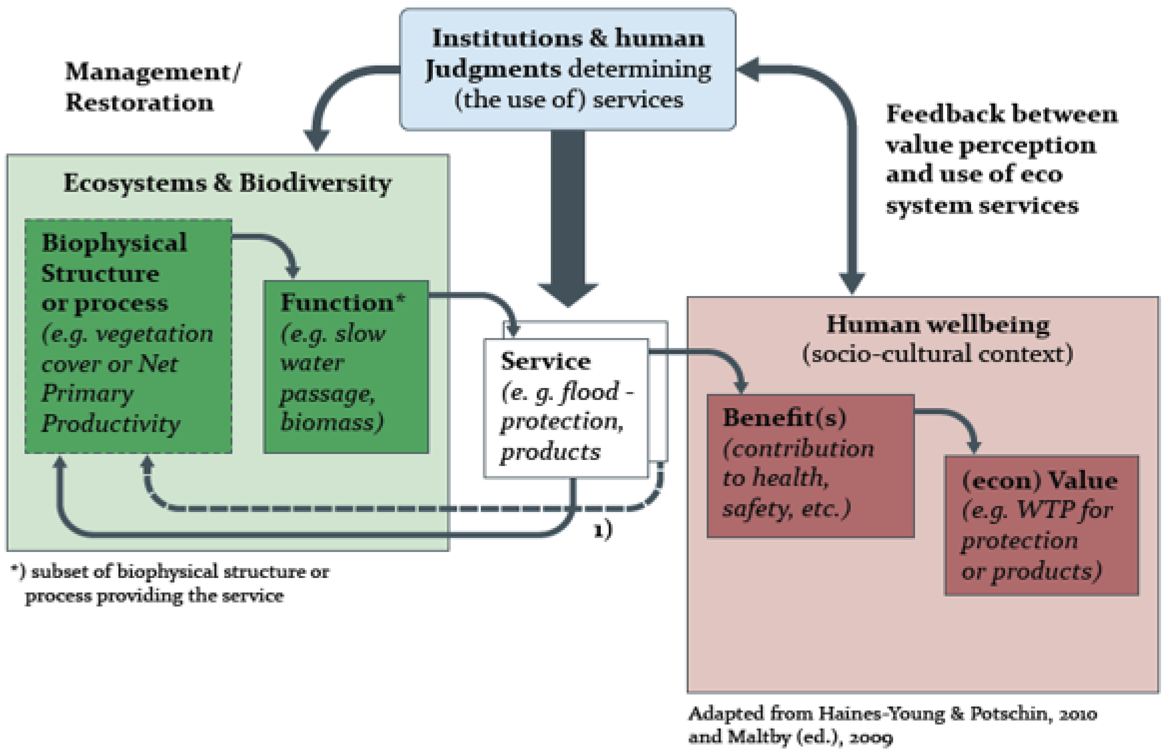


Figure 9 The Economics of Ecosystems and Biodiversity (TEEB) conceptual framework (de Groot, et al., 2010)

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The assessment was undertaken to develop an institutional methodological reference for national policies furthering the implementation of the EU Biodiversity Strategy to 2020, and in particular those concerned with Target 2, Action 5. These national policies include the Portuguese Nature Conservation and Biodiversity Strategy 2015-2020, the National Strategy for Forests up to 2030[8], and the Commitment for Green Growth 2020/2030[9]. The assessment was also used as a basis for discussion around the promotion and launch of the national MAES.

[8] http://www.icnf.pt/portal/icnf/docref/enf
[9] http://www.crescimentoverde.gov.pt/

D. Integration

In what sense was the assessment integrated? What was being integrated?

The regional ptMAES (Alentejo NUTS II) assessment focused on mapping ecosystems, their condition and the quantified ES flow considering the biophysical dimension. For the local case study selected within the Alentejo NUTS II (Natural Park of Serra de Sao Mamede) the economic value dimension was also estimated and mapped and stakeholders engagement promoted through the means of participatory approaches. In doing so, integration was brought into analysis not only from the functional perspective (i.e., following the cascade model) but also by considering the supply and demand sides of ES, plurality of ES values and, last but not the least, by linking in a same framework different expertise and methods to pursue the goals defined in the assessment mandate.

How was integration achieved? How did the assessment approach reflect the need for integration?

Ecosystem mapping (Figure 10) was based on establishing relationships among the different typologies of land use (using the Portuguese Land use/cover cartography - COS'07) and the EUNIS (European Nature Information System) habitat classification. Whenever possible, a direct and unambiguous relationship between one COS'07 typology and one EUNIS habitat was established (1:1 relation). Auxiliary information, such as topography, cartography of vegetation series, geological cartography, and satellite imagery was used for establishing unique relationships in ambiguous cases, e.g., where a type 1:n relation was identified.

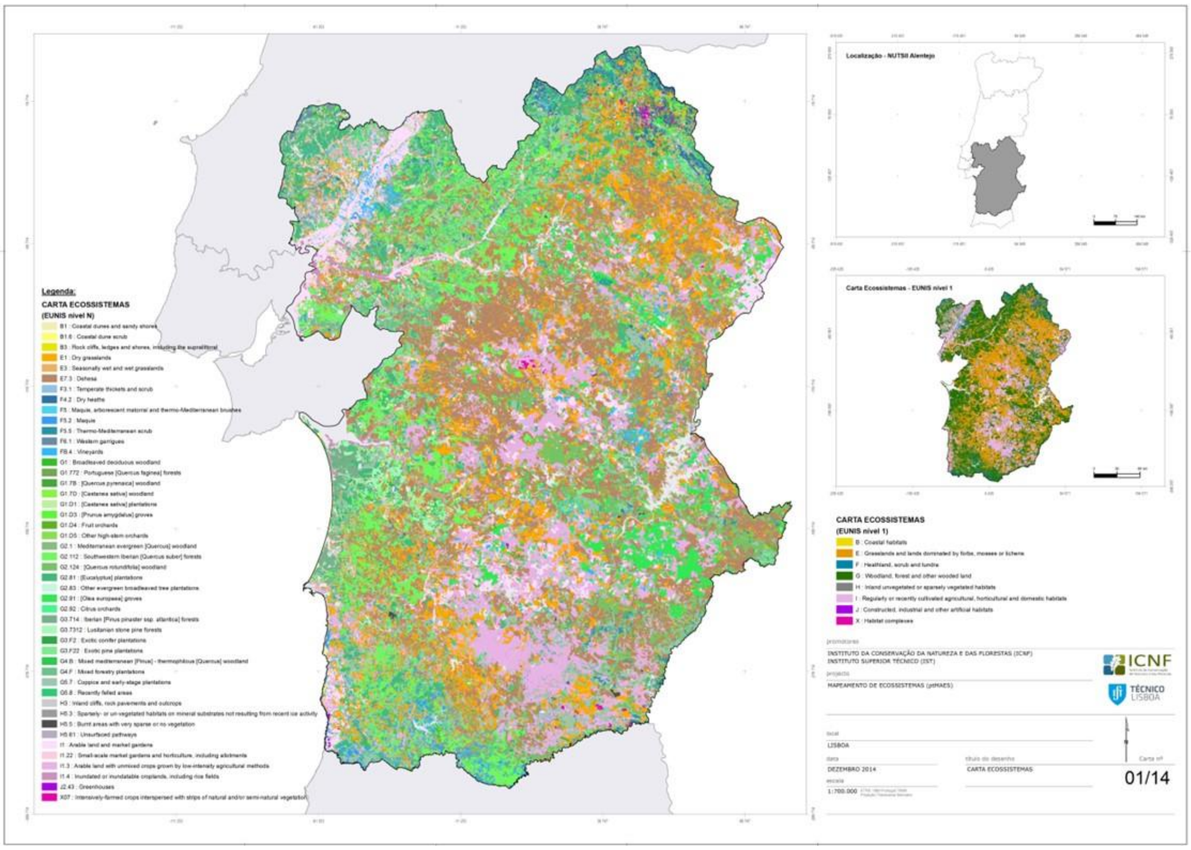


Figure 10 Ecosystems map - EUNIS level N - Alentejo NUTS II (Portugal)

The condition of ecosystems was established using four indicators; organic matter content, ecological value of plant communities, phytodiversity, and zoodiversity (Figure 11).

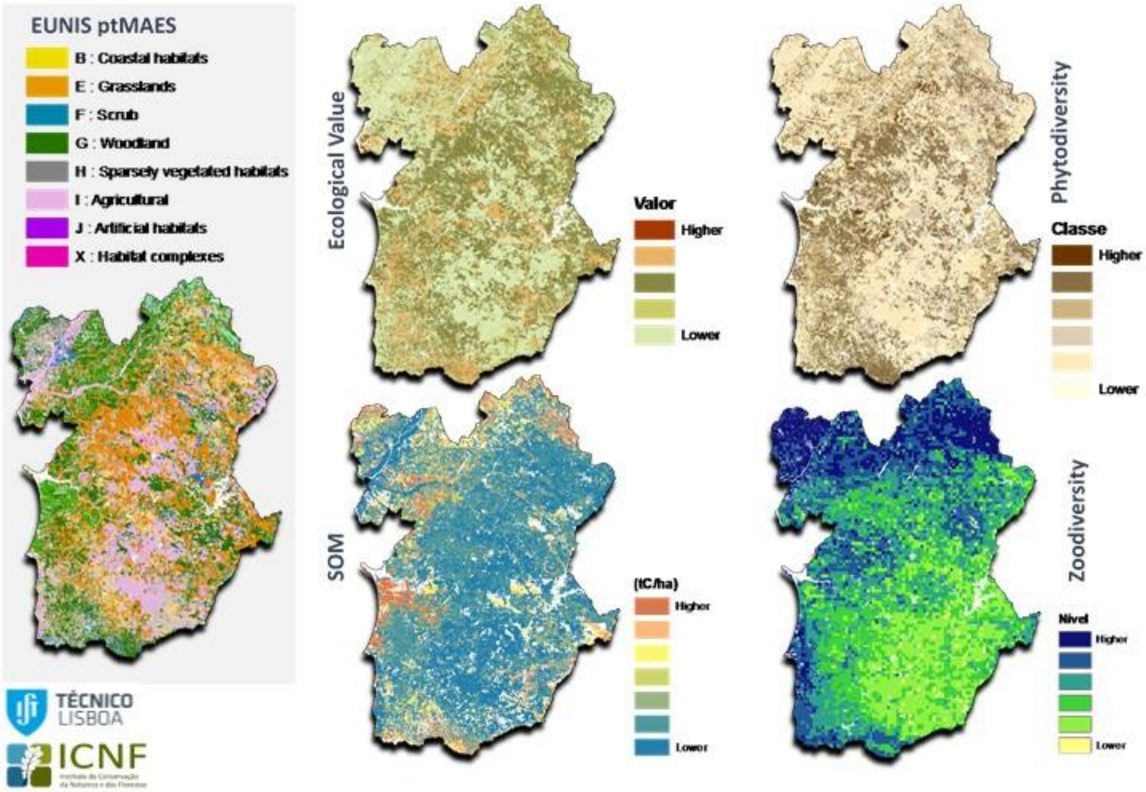


Figure 11 ptMAES Ecosystem condition indicators and maps

Biophysical dimension of five ecosystem services were mapped following a tiered approach: soil protection, climate regulation through carbon sequestration, fibre production, crops, and extensive animal production (Figure 12)

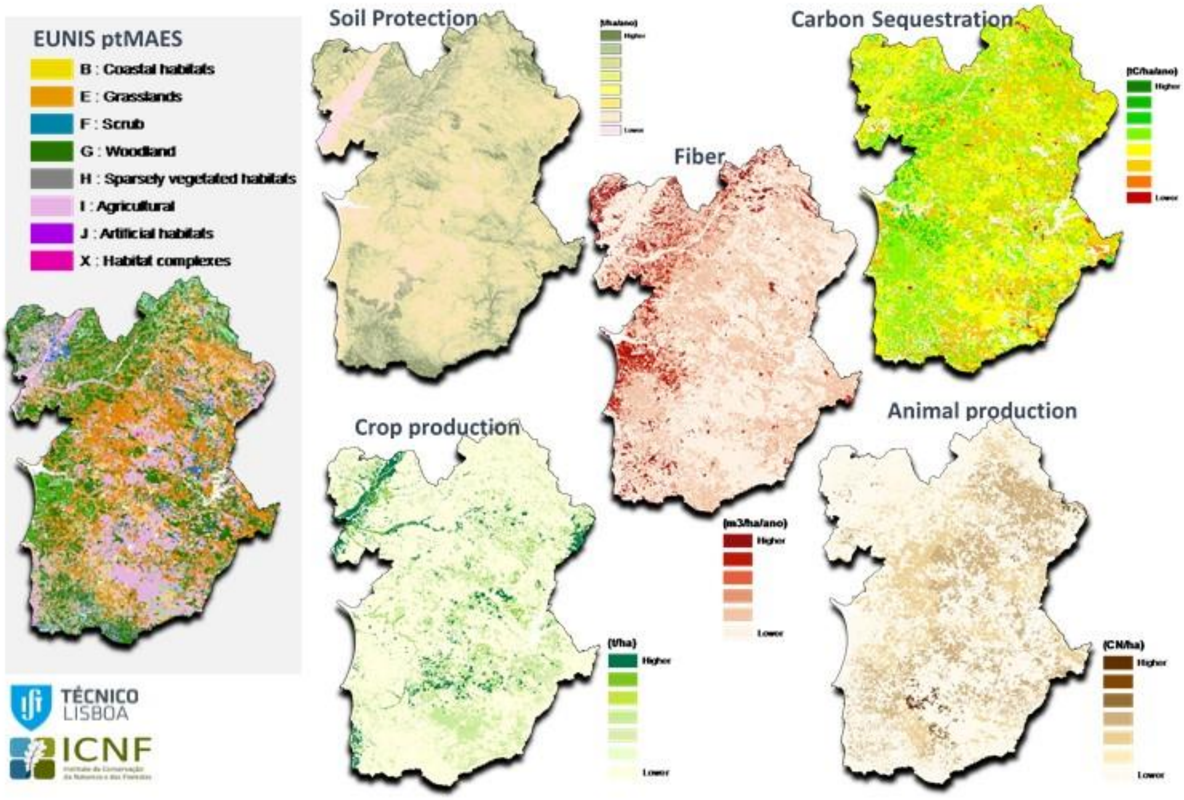


Figure 12 ptMAES Ecosystem Services maps

Economic dimension of ES was also quantified and mapped, though solely for the local case study selected within the NUTS Alentejo (as described in Marta-Pedroso et al., 2018).

Were any barriers to integration discussed?

Data limitations- scale, availability and coverage- affected the inclusion of certain datasets. Time constraints prevented a comprehensive assessment of all ecosystem services provided by the mapped ecosystems as well as the development of a wide array of indicators.

E. References

de Groot, R., Fisher, B., Christie, M., Aronson, J., Braat, L., Gowdy, J., … Rin, I. (2010). *Integrating the Ecological and Economic Dimensions in Biodiversity and Ecosystem Service Valuation. The Economics of Ecosystems and Biodiversity (TEEB).* Ecological and Economic Foundations (ed. by P. Kumar), pp.9-40. Earthscan, London, UK and Washington, USA.

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Marta-Pedroso, C., Laporta, L., Gama, I. and T. Domingos (2018): Economic valuation and mapping of Ecosystem Services in the context of protected area management (Natural Park of Serra de São Mamede, Portugal). One Ecosystem 3 (in press).

Spain

A. Name of Assessment

The Spanish National Ecosystem Assessment (SNEA) (Santos-Martín *et al.*, 2014).

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (e.g. Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The Spanish NEA adapted the Driver-Pressure-Sate-Impact-Response (DPSIR) framework (Wilson *et al.*, 2014;Santos-Martín *et al.*, 2013). Figure 1 below, taken from Santos-Martín *et al.*, (2014), shows the conceptual framework used for the Spanish National Ecosystem Assessment (SNEA). The authors noted that it was modified from the Millennium Assessment and that it represents a change in Spanish conservation policies as it combines the intrinsic value of nature with ecosystem services- linking ecosystems with human wellbeing (Santos-Martín *et al.*, 2014).

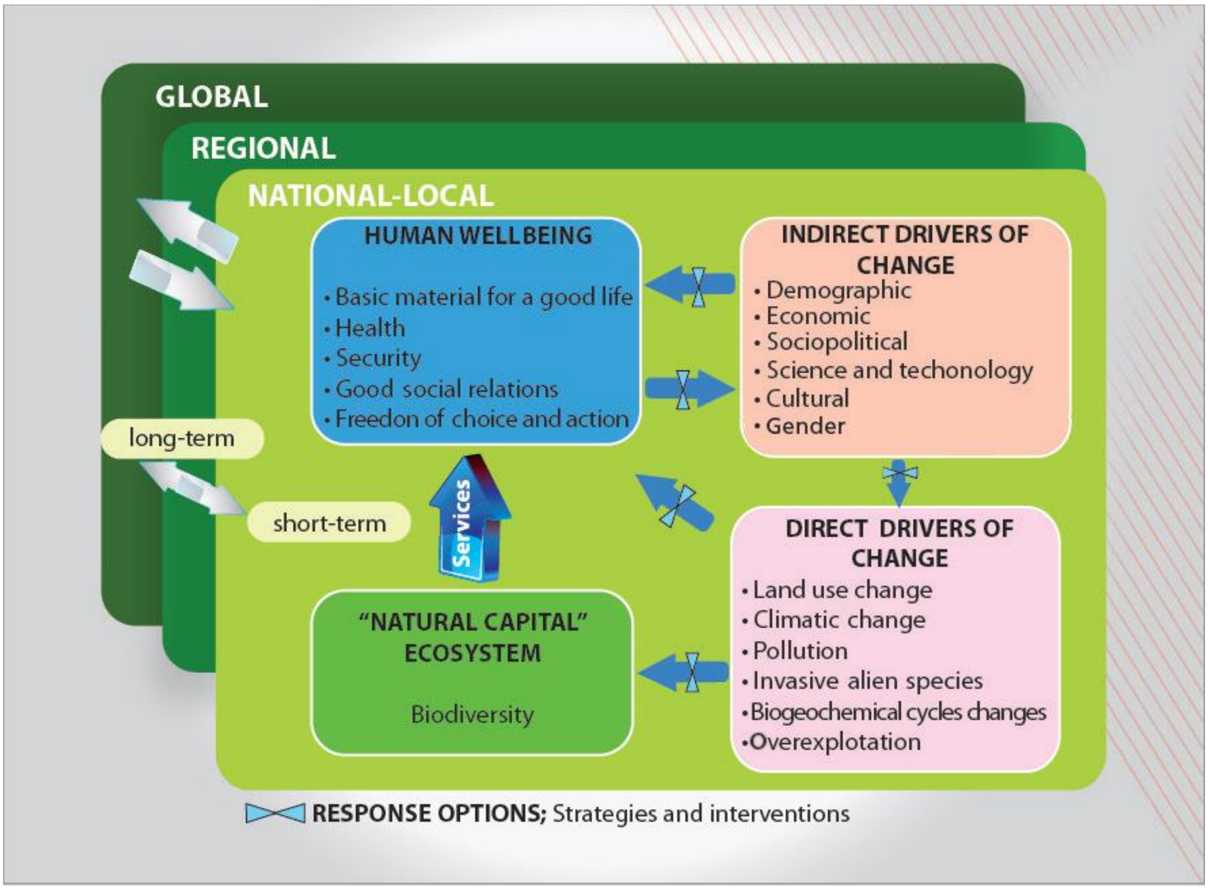
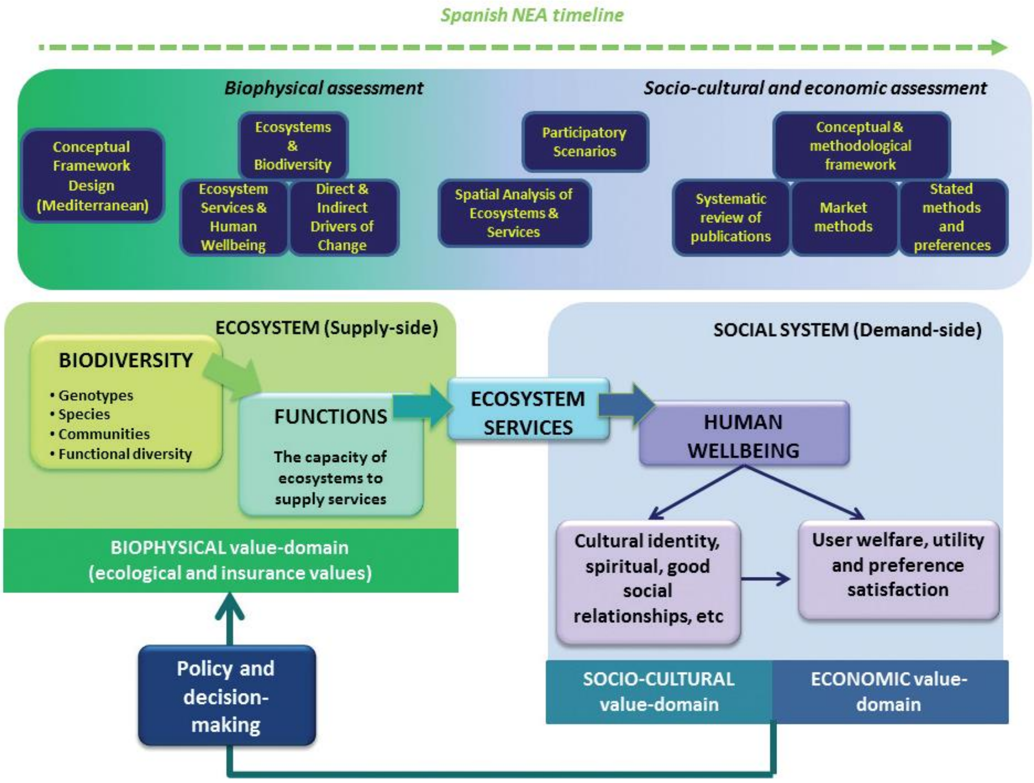


Figure 1. Conceptual Framework used in the Spanish National Ecosystem Assessment

Santos-Martín *et al.* (2014) noted that the conceptual framework was based on six components: Ecosystem, Biodiversity, human wellbeing, ecosystem services, direct drivers of change and indirect drivers of change.

The following figure, also from Santos-Martín *et al.* (2014) shows the framework used for assessing ecosystem services.



C. Purpose of the assessment

Why was the assessment being undertaken? Were policy relevant question established?

The goal of the assessment was to 'lay a foundation for a new generation of environmental policy in Spain by evaluating and providing to society, including stakeholders from a variety of sectors, 'the interdisciplinary information on the consequences of changes in aquatic and terrestrial ecosystems and the loss of biodiversity for human well-being over the last five decades in Spain' (Santos-Martín *et al.*, 2014). The assessment is also expected to increase awareness of Spanish society, including the business sector, of the importance of biodiversity and ecosystem services (Montes *et al.*, 2012). The assessment evaluated the direct and indirect effects that the ecosystem services have on human wellbeing (Santos-Martín *et al.*, 2013a)

The project also aimed to address several policy questions, all of which are listed in Table 1 below and to 'build a common language between scientists and policy makers' (Santos-Martín *et al.*, 2014).

Table 1. Policy questions addressed by The Spanish National Ecosystem Assessment (taken from (Santos-Martín *et al.*, 2014)

How is biodiversity changing in Spain?
What is the status of trends occurring in Spanish ecosystems and the services they provide to society?
What are the main direct drivers of change for Spanish ecosystems and their services?
What are the underlying causes of ecosystem degradation in Spain?
How do ecosystem services affect human wellbeing, and who are the beneficiaries?
How can we integrate a multiscalar approach into national ecosystem assessments?
What is the Spanish public´s current understanding of ecosystem services, and how can we communicate our main results?
How might ecosystems and their services change in Spain under plausible future scenarios?
How can we initiate a transition to socio-ecological sustainability in Spain?

The assessment aimed to show that ecosystems and biodiversity make up the Natural capital of Spain and to show the link between nature and society by focusing on the relationships between ecosystems biodiversity and human wellbeing (Santos-Martín *et al.*, 2014).

D. Integration

In what sense was the assessment integrated? What was being integrated?

The project involved integration of elements as well as the processes, by involving collaboration from stakeholders from different sectors.

A total of 818 indicators were used in the assessment were used in the assessment which included biophysical, socioeconomic, cultural and socio-political indicators (Santos-Martín, 2015; Santos-Martín *et al.*, 2014). The assessment collaboration of scientists from biophysical and social sciences from over 20 universities as well involvement from other groups including the government, NGOs and the private sector (Santos-Martín, 2015).

How was integration achieved? How did the assessment approach reflect the need for integration?

The project integrated economic, social and environmental information by combining biophysical assessment with a future scenario exercise and spatial explicit analysis that considered biodiversity, ecosystem services as well as socioeconomic variables analysing the economic and social value of ecosystem services (Santos-Martín, 2015).

Furthermore, the project involved integration of 60 researchers from different disciplines across over 20 universities and research centres as well as involvement from the government, NGOS and the private sector (Santos-Martín *et al.*, 2014; Santos-Martín, 2015). The project involved collaboration from a variety of interest groups, to contribute ideas, provide information and spread the results (Santos-Martín *et al.*, 2013b). Furthermore, a communication unit formed part of the team, responsible for disseminating results to stakeholders and users and to help incorporate the user's needs and requests into the assessment (Santos-Martín *et al.*, 2013b).

Were any barriers to integration discussed?

Santos-Martín *et al.*, (2014) noted that it was a challenge to integrate results obtained at different spatial scales using the same conceptual approach but different assessment methodologies.

What evidence is there if any 'added value' in the integrated approach?

The SNEA provided data that could address policy needs at global, EU and national levels (Wilson *et al.*, 2014). Wilson *et al.*, (2014) noted the potential for governmental and non-governmental entities to participate in the same goals and strategies proposed by the SNEA. (Santos-Martín *et al.*, 2013a) noted that there was insufficient institutional response to address the drivers of biodiversity loss and that integration of biodiversity conservation into economic and landscape policies was required. The integration of ecological and social scientists, the government, NGOs and the business sector in the assessment, may help to achieve this.

Santos-Martín *et al.*, 2014) represented the 'integrative results', showing the losses of biodiversity and the drivers responsible as a figure (see Figure 2 below). They reported that the SNEA promoted a paradigm shift to not only address the effects of loss of biodiversity, but also consider the causes including socio-political factors that can lead to the loss of biodiversity (Santos-Martín *et al.*, 2014). Santos-Martín *et al.*, (2014) argued that the indirect drivers of the loss of biodiversity and degradation of ecosystems are the result of decisions of many different stakeholders and that new environmental policies should address these factors in order to halt the rate of loss. This is exemplified by the fact that two factors that both combine social, political and environmental change (the change from rural to urban and the abandonment of traditional agricultural society in the 1960s and consolidation of the urban society in the 1970s and 1980s) explained 68% of the variability from the 40 indicators used (Santos-Martín *et al.*, 2014).

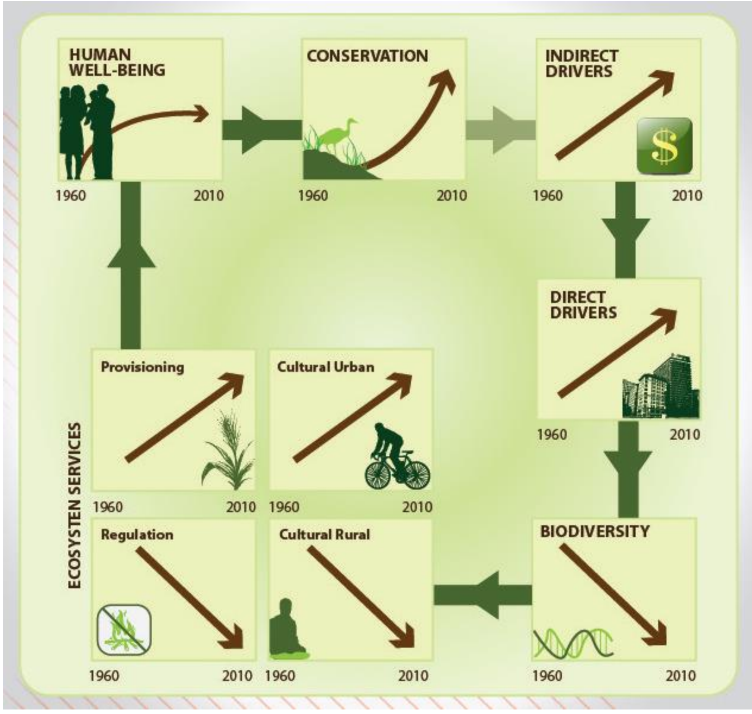


Figure 2. Taken from (Santos-Martín *et al.*, 2014).

E. References

Montes, C., Santos, F., Martín-López, B., González, J., Aguado, M., López-Santiago, C., Benayas, J. and Sal, A.G. 2012. La Evaluación de los Ecosistemas del Milenio en España. Del equilibrio entre la conservación y el desarrollo a la conservación para el bienestar humano. In: Secretaría General Técnica and Ministerio de Agricultura Alimentación y Medio Ambiente (Eds.). *Evaluación de los ecosistemas del milenio en España*. Madrid, Spain. 2–12.

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United Kingdom

A. Name of Assessment

UK National Ecosystem Assessment (NEA)

B. Conceptual Framework

Which Conceptual Framework did the assessment utilise (eg Millennium Ecosystem Assessment (MA), IPBES, TEEB, MAES or another)? Please include a graphic if the conceptual framework was developed specifically for the assessment.

The UK National Ecosystem Assessment (NEA) utilised the Millennium Ecosystem Assessment (MA), producing a conceptual framework (Figure 1) adapted from Bateman *et al.* (2011) and Mace *et al.* (2011) (IPBES, 2016).

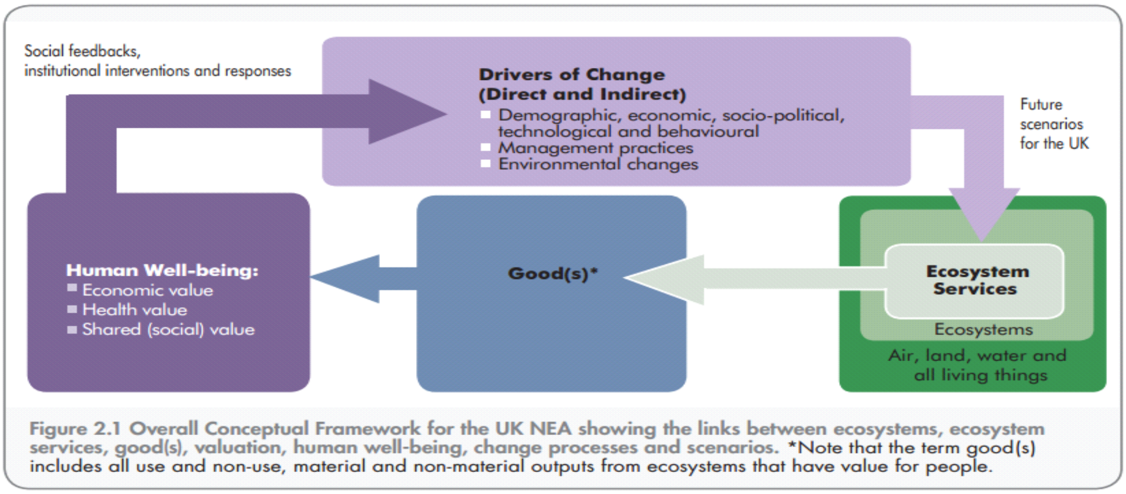

Figure 1. Overall Conceptual Framework for the UK NEA showing the links between ecosystems, ecosystem services, good(s), valuation, human well-being, change processes and scenarios. *Note that the term good(s) includes all use and non-use, material and non-material outputs from ecosystems that have value for people (Mace *et al.,* 2011).

C. Purpose of the assessment

Why was the assessment being undertaken? Where policy relevant question established?

The UK NEA was completed in 2012 with a follow-on project (UK NEAFO) reported in 2014. The objectives of the assessment were three-fold:

- *"To produce an independent and peer-reviewed UK National Ecosystem Assessment for the whole of the UK.*
- *To raise awareness of the importance of the natural environment to human well-being and economic prosperity.*
- *To ensure full stakeholder participation and encourage different stakeholders and communities to interact and, in particular, to foster better inter-disciplinary cooperation between natural and social scientists, as well as economists"* (IPBES, 2016).

Key policy-related questions addressed by the UK NEAFO (2014) include:

- *"What response options might be used to improve policy and practice for the sustainable delivery of ecosystem services?*
- *What constrains and enables the use of knowledge about our ecosystem services in decision-making?*
- *How can we embed the Ecosystem Approach and an Ecosystem Services Framework into effective advice and tools for improved policy and decision-making?"*

D. Integration

In what sense was the assessment integrated? What was being integrated?

The NEA assessed eight systems and 13 species groups in addition to ecosystems services and functions including; six provisioning services, nine regulating services, four supporting services and one cultural service (IPBES, 2016). A variety of different tools and processes were used including; modelling, geospatial analysis, indicators, scenarios, economic valuation and social (non-monetary) valuation (IPBES, 2016).

Conceptual framework, methodologies and tools were developed for use by different stakeholders (including government, private sector, NGO’s) in order to inform and improve decision-making (UK NEAFO, 2014). The basis of the conceptual framework is the processes which link human societies, and associated well-being, with the environment.

How was integration achieved? How did the assessment approach reflect the need for integration?

Short reports were tailored to specific audiences and end users (including: national government departments, government agencies, local authorities, the general public, businesses, environmental non-governmental organisations, and the research community) summarising the actions to be taken for implementation of the ecosystem services framework and enable sustainable benefits (IPBES, 2016).

The integrated approach outlined by the UK NEAFO (2014) between governance and evidence-based science includes three main areas (see also Figure 2):

- Production of an updated Ecosystem Services Conceptual Framework
- Production of Adaptive Management Principles, enabling responses to inform policy- and decision-making to be flexible as knowledge increases
- Implementation of a Decision Support System (DSS) Toolbox which aids decision-makers in the navigation and access of existing tools and materials
- Use of a Balance Sheet Approach in order to collate, analyse and present appraisal evidence

The report provided an enhanced understanding of the economic and social values of nature, supporting the inclusion of natural capital in the National Accounts of the UK and development of products and tools to enable the Ecosystem Approach (IPBES, 2016). Via integration, four areas were highlighted and investigated; economic analysis, cultural ecosystem services, future ecosystem changes and tools and supporting material required for the communication of findings of the report to a diverse range of audiences (IPBES, 2016).

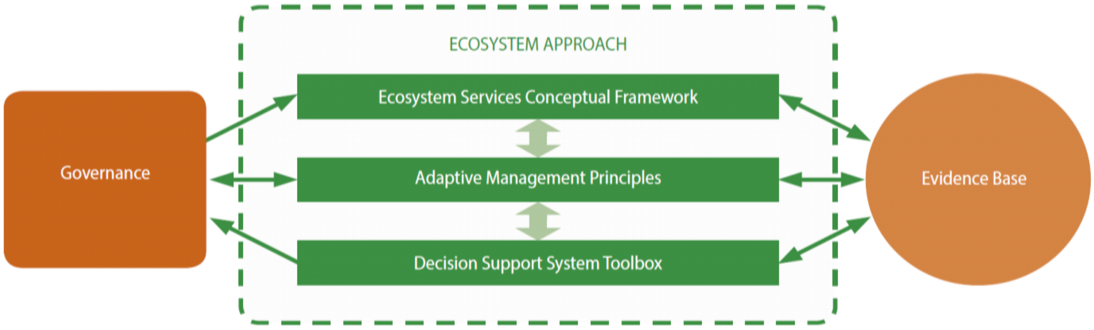

Figure 2. Illustration of the implementation of the Ecosystem Approach by using the UK NEAFO Ecosystem Services Conceptual Framework, Adaptive Management Principles and Decision Support System (DSS) toolbox (UK NEAFO, 2014).

Were any barriers to integration discussed?

THE UK NEAFO (2015) identifies barriers which prevent embedding the ecosystem services framework into decision-making. Measures to enable this include; improvements to integrated datasets, an increase in accessible projects for language and demonstration, stronger leaderships, enhanced communication across sectors and actors and use of mechanisms which connect interacting policies.

What evidence is there if any 'added value' in the integrated approach?

UK NEAFO (2014) states that, although gaps in knowledge regarding ecosystems exist, the utilisation of the UK NEA and UK NEAFO enable more informed decisions to be made, and with beneficial outcomes. Furthermore, although incomplete, evidence suggests that ecosystem services do support economic sectors, regional and national wealth creation and employment (UK NEAFO, 2014).

The report concludes, as one of its seven key findings, that the integration of ecosystem services knowledge into appraisals of projects, programmes and policy is critical for decision making (UK NEAFO, 2014). If taken into consideration at the early stages of policy development, the knowledge could provide wider benefits for society (UK NEAFO, 2014).

E. References

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Appendix B: ‘Understanding integration in ecosystem assessments’ survey questions

An overview of questions as presented in the online survey ‘Understanding integration in ecosystem assessments’ available at https://docs.google.com/forms/d/e/1FAIpQLSc5bojlbyI03q6ne-tyhfqqAWAKVEZu17JDlBj7T5OBKlsydw/viewform?usp=sf_link

1. Which overarching conceptual framework did you use to guide your assessment? (Tick all that apply
2. Did you use integrated methods in your ecosystem assessment?

    2.1 If you did not use integrated methods, what were your reasons for not doing so? (Tick all that apply)

3. Why did you choose to use an integrated approach to your ecosystem assessment? (Tick all that apply)
4. In the context of the assessment you carried out, how did you interpret 'integration'?

    4.1 Did you include social, economic and environmental information in your assessment?

    4.2 What types of social data did you collect? (Tick all that apply)

    4.3 What types of economic methods did you use? (Tick all that apply)

5. Did you use a consultative process, engaging external stakeholders?

    5.1 At what stage(s) of the assessment did you involve external stakeholders? Who did you involve? And in what capacity?

    i. At what stage(s) of the assessment did you involve external stakeholders? Who did you involve? And in what capacity?

    ii. Design stage (i.e. determine user needs; establish governance structure; choose temporal and spatial scale; consider different knowledge systems)

    iii. Implementing work programme (i.e. assess ecosystem services and human well-being; determine drivers of change; develop plausible futures; develop response options)

    iv. Developing output and communicating findings (i.e. assess ecosystem services and human well-being; determine drivers of change; develop plausible futures; develop response options)

    v. Decision-making/using assessment results

6. Which specific tools or methods, or combination thereof, did you use to involve external stakeholders? (Tick all that apply)

6.1 How did you decide on the tool(s) you used? (Tick all that apply)

7. In your opinion, did using an integrated assessment approach add value to the outcomes / lead to better results?

   7.1 Have you also undertaken non-integrated assessments?

   7.2 Based on your experience of doing non-integrated assessments, what would you say are the major differences to the integrated assessments?

   7.3 How would you evaluate your experience of integrated vs. non-integrated assessments?

8. What lessons did you learn from the integrated assessment process? What pointers would you pass on to the future assessments?

   8.1 Is there anything (e.g. resources, guidance, training, other) that would improve future integrated assessments or would make them easier to implement?

Appendix C: ‘ESMERALDA Policy Questions’

ESMERALDA Policy questions (developed by Joachim Maes and colleagues, draft 15.11.2017)

Ecosystem assessments usually start with a set of policy questions. Also the MAES initiative organised a workshop in December 2012 to formulate a number of broad policy questions which justified the development of a knowledge base. ESMERALDA tries to link these questions to the flexible mapping and assessment methodology. To this end, a second survey of policy questions was organized during the 13th working group MAES meeting on 16 March 2017. Besides, project partners have been able to submit policy questions when submitting case study information. So prior to the meeting 82 policy questions were collected

Methodology

The 82 questions served as basic material for the session. Participants of the session were asked to work in pairs of two people. Each pair was given a policy question. Next every pair had to mark (for yes and for no) on the card on which the question was printed whether or not scientific tools, methods or procedures are available which can give a direct answer to the question. Following an agreement between both participants, a next question was handed over until all questions were marked. In a next round, two pairs were grouped and the conclusions of each pair were reviewed another pair of participants. In case of contrasting conclusions a discussion resulted in a final conclusion or in no conclusion.

Classification of policy questions

An analysis of the submitted questions led to the following five groups: knowledge requests, policy support questions, technical and methodological questions, questions about resources and the governance of implementation of ES based approaches, and applications (Table 1). This classification can serve as a basis to link methods to policy questions.

Table 1. Classification of policy questions

- **Knowledge requests:** Questions for conceptual clarification and information needs. Examples are:
  - What are ecosystem services;
  - How are they linked to biodiversity and condition;
  - What are the trends of ecosystem services?
- **Policy support questions**: How ES can be used to support policy making and implementation.
  - Agricultural policy
  - Biodiversity policy
  - Spatial planning
  - Impact assessment
  - Disaster risk reduction
  - Economic policy
- **Technical and methodological questions**: Questions for specific technical details of mapping ecosystem services:
  - Spatial scale:
    - How to use data which collected at other spatial scales than the scale of assessment.
  - Uncertainty:
    - How to address conceptual and scientific uncertainty (e.g. role of biodiversity in providing ecosystem services)
    - How to address data uncertainty
  - Priority and preferences:
    - How to set priorities when selecting ecosystem services for assessment/management/ including priorities based on preferences of stakeholders
  - Other technical support questions
    - Which methods are available to map, quantify and assess specific ecosystem services
- **Questions on resources and responsibilities.** Questions about governance and resources
  - What are the costs and resources needed
  - What can be an organizational or institutional setting to implement an ES based approach.
- **Application questions** (how to implement ES based approaches and how can mapping ES support applications)
  - How to set up payments for ES
  - How to set up an ecosystem accounting system
  - What are the cost and benefits of restoring ecosystems and enhancing services
  - How to best communicate about ES

Linking the classification to specific methods and tools of ESMERALDA

Not all policy questions can be directly linked to a specific method, tool or procedure to map or assess ecosystem services.

- The broad **knowledge requests** would need to be translated into sets of more specific questions in order to find a matching method. Typically they can be addressed by conceptual models which clarify the links between different components of the social-ecological system. Such an approach can then help target specific methods for more specific questions.
- **Policy support questions** coming from sectoral policies could in principle be linked to specific ecosystem services and thus to specific methods.
- ESMERALDA could certainly couple **technical support questions** to specific methods and to ESMERALDA case studies.
- **Questions on governance and resources** related to implementation may fall out the scope of ESMERALDA. We are not really collecting data to address these questions.
- **Application questions** could possibly be matched with case studies but also with specific methods.

Table: Linking policy questions to tools and methods. This is still to be done and a future opportunity.

Questions	Biophysical methods	Economic methods	Social methods
Knowledge requests			
Policy support questions			
Agricultural policy			
Biodiversity policy			
Spatial planning			
Impact assessment			
Disaster risk reduction			
Economic policy			
Technical and methodological questions			
Spatial scale:			
Uncertainty (conceptual, model, data, scenario)			
Priority and preferences:			
Other technical support questions			
Questions on resources and responsibilities			
Costs			
Resource needs			
Governance			
Application questions (how to implement ES based approaches and how can mapping ES support applications)			
How to set up payments for ES			

How to set up an ecosystem accounting system

What are the cost and benefits of restoring ecosystems and enhancing services

How to best communicate about ES

Table 2. List of policy questions

Policy question (in brackets the source of the questions)	Comment for grouping	ESMERALDA can provide an answer	ESMERALDA cannot provide an answer	No conclusion	Biophysical method	Economic method	Social method
How can the ecosystem service concept be made relevant and find its entry into the development of the next CAP? (13th MAES meeting)	sectoral policy (CAP)	x					
What are ecosystem services farmers could be paid for?	Application of payments	x					
How can we link different result and data sets at different scales (i.e. EU, National, Local)? (13th MAES meeting)	Scale (upscaling and downscaling)	x					
Which are the priority ES that need to be mapped & assessed? (13th MAES meeting)	Priority setting	x					
How can MAES shape patterns of development through • Informing strategic spatial land use plans • Supporting assessments of impacts of individual developments? (13th MAES meeting)	Sectoral policy (land planning) (impact assessment)	x					

Where to get an independent measurement of ES flows to validate our calculations/ models predicting ES delivery? (13th MAES meeting)	Data (field observations)/uncertainty	x		
Why different methods for mapping & valuing ES will provide different results(13th MAES meeting)	Uncertainty			x
How can the data & knowledge gained through MAES/ Maes-type projects be used by local planners – eg where to put a new housing development or road? (13th MAES meeting)	Policy support (planning)	x		
How might ecosystems & ES change under plausible future scenarios? (13th MAES meeting)	Technical Uncertainty	x		
Farming already provides the ecosystem services that matter for our essential needs (food,energy)-why the fuss about the non-essential ones? (13th MAES meeting)	Clarification (concept)	x		
How mapping of degradated ecosystems could contribute for MAES process? (13th MAES meeting)	Policy support (biodiversity)		x	
How can Member States contribute to development of pilot studies? Is it possible	Technical (technical support)	x		

to provide technical support for them? (13th MAES meeting)			
How can we better communicate the social benefits of nature based solutions into decision making? What kind of information will be recognized? (13th MAES meeting)	Technical (communicating ES)	x	
Why should we invest in measuring carbon stocks if they do not have real-life economic value? (13th MAES meeting)	Costs/resources Clarification (concept)	x	
How can the lack of knowledge on ESS production functions be addressed within the MAES process? (13th MAES meeting)	Technical Uncertainty		x
What is needed to come to innovative integration of social and natural science to really show, assess and value the importance of a healthy natural & physical environment to human health? (13th MAES meeting)	Conceptual clarifications		x
How will ministries that use or influence natural capital (transport, energy, economy) uptake MAES information/scientific information in order to improve sectorial policies? (13th MAES meeting)	Policy support (sectoral)	x	

What is necessary to bridge all that is known on ESD in the scientific community to the policy domain? (13th MAES meeting)	Technical (communication)		x	
How can health benefits of ecosystem services be valued in such a way that decision making on spatial planning is influenced? (13th MAES meeting)	Policy support (planning)	x		
On the long term, is there a third assessment round on ES foreseen to determine trends with higher reliability and link these to political/economic conditions and decisions? (13th MAES meeting)	Uncertainty			x
What is the public’s current understanding of ES? (13th MAES meeting)	Uncertainty Communication	x		
ES delivery is influenced by number of biotic and abiotic factors. What is the role of biodiversity among those factors? Would the ES Assessment really contribute to the biodiversity restoration/conservation? What would we do if we came to the conclusion that biodiversity conservation impose (somewhere) a constraint to needed ES delivery? (13th MAES meeting)	Uncertainty and conceptual clarification		x	
What can we take back as a mission to our MS agency and administration concerning	Conceptual clarification		x	

ecosystem condition? Is there a clear target and date, some critical mass and incentive to convince the MS or region to spend efforts on it? (13th MAES meeting)				
The cost-benefit analysis is an appropriate tool to handling ESs and valuing such bundles. Is this work to be taken up within MAES? (13th MAES meeting)	More information	x		
What are the main risks of trade-offs between provisioning services e.g., in the context of agriculture and the “nature relevant” services like pollination, recreation, maintaining biodiversity? (13th MAES meeting)			x	
How can the national approach to ESS valuation be reconciled with the need to value cross-border ESS like migratory species support? (13th MAES meeting)	Scaling	x		
	Policy support (planning and biodiversity)			x
How can we use MAES/MAES-type work to determine optimisation of land use/ where restoration should occur? Some folk suggest modelling but the information required is very burdensome. - is here a suite of different questions (like a flow chart) that could be need to help policy-makers come to	Technical support questions			

the right (or an) answers? (13th MAES meeting)			
What institutional set-up is envisaged for MAES work formal reporting by MS, having in mind that monitoring needs also the allocation of resources? (13th MAES meeting)	Resources/Costs	x	
How is the "intrinsic value of nature" as addressed in 7th EAP and BD strategy to 2020, captured with "elsewise" utilitarian approach of ecosystem services? (13th MAES meeting)	Conceptual clarification		x
Ecosystems that are not commercially interesting tend to be subject to more pressures by, i.e. land grab and fragmentation. Will the MAES pilots develop priority measures to address this (i.e. by prioritising their ESS?) (13th MAES meeting)	Technical Priority setting	x	
Provisioning services are best developed in terms of indicators and the easiest to communicate to policymakers and business. Are there measures planned to overcome the potential bias as Ess perception is surely another business opportunity to "Harvest	Technical Priority setting		x

from nature” without sustainable management? (13th MAES meeting)				
What can we take back as MS representatives on ES accounting? What are the envisioned useful applications on MS level? What are the envisioned appl at EU level potentially impacting the MS? (13th MAES meeting)	Applications accounting			x
How can MAES inform the spatial targeting of expenditure to conserve and enhance ecosystems? (13th MAES meeting)	Resources and costs	x		
How, if at all, will ES approach be linked/aligned/matched with typology of Nature Based solutions that will be developed / with over arching conceptualisation of nature’s values within IPBES (13th MAES meeting)	Conceptual clarification	x		
How to harmonize across the EU the prioritization of ecosystem services which are selected by national stakeholders (13th MAES meeting)	Technical Priority setting		x	

What are the current state and trends of the EU’s ecosystems and the services they provide to society? (1st MAES report)	Knowledge requests	X	
What are emerging trends and projected future state of the EU’s ecosystems and the services they provide to society? How is this currently affecting human well-being and what are the projected, future effects to society? (1st MAES report)	Knowledge requests	X	
What are the key drivers causing changes in the EU’s ecosystems and their services? (1st MAES report)	Knowledge requests		X
How does the EU depend on ecosystem services that are provided outside the EU? (1st MAES report)	Knowledge requests	X	
How can we secure and improve the continued and sustainable delivery of ecosystem services? (1st MAES report)	Knowledge requests	X	
How do ecosystem services affect human well-being, who and where are the beneficiaries, and how does this affect how they are valued and managed? (1st MAES report)	Knowledge requests	x	
What is the current public understanding of ecosystem services and the benefits they	Knowledge requests	x	

provide (some key questions could usefully be included in the 2013 Eurobarometer on Biodiversity)? (1st MAES report)			
How should we incorporate the economic and non-economic values of ecosystem services into decision making and what are the benefits of doing so (question to be addressed 2020)? And what kind of information (e.g. what kind of values) is relevant to influence decision-making? (1st MAES report)	Technical support question (methods)	x	
How might ecosystems and their services change in the EU under plausible future scenarios - What would be needed in terms of review/revision of financing instruments? (1st MAES report)	Knowledge requests Costs and resources		x
What are the economic, social (e.g. employment) and environmental implications of different plausible futures? What policies are needed to achieve desirable future states? (1st MAES report) (1st MAES report)	Knowledge requests Conceptual clarification		x
How have we advanced our understanding of the links between ecosystems, ecosystem functions and ecosystem services? More broadly, what is the influence of ecosystem	Knowledge requests Conceptual clarification		x

services on long-term human well-being and what are the knowledge constraints on more informed decision making (1st MAES report)			
How can MAES assist MS in assessing and reviewing the priorities to be set for ecosystem restoration within a strategic framework at sub-national, national and EU level? (1st MAES report)	Priority setting	x	x
How can MAES help to assess and review the design of prioritisation criteria for restoration and at which scale to get significant benefits in a cost-effective way (e.g. relevance for biodiversity; extent of degradation of ecosystems and the provision of key ecosystem services)? (1st MAES report)	Resources	X	
How can MAES help to provide guidance and tools to support strategic deployment of green infrastructure in the EU in urban and rural areas to improve ecosystem resilience and habitat connectivity and to enhance the delivery of ecosystem services at Member State and sub-national level? (1st MAES report)	Technical support questions	x	x
How to foster synergies between existing and planned initiatives at local, regional or	Scale issues		x

national levels in Member States, as well as how to promote further investments, thereby providing added value to Member States action? (1st MAES report)		
Do the measures generate social benefits? (Esmeralda matrix)	Application How to measures lead to benefits	x
How high are costs of landscape degradation? How to protect landscape? (Esmeralda matrix)	Costs and resources	X
What is the economic value of nature (bird watching) and what is its contribution to tourism management.	Knowledge request	x
“What do nature and water have to do with economics?” (Esmeralda matrix)	Knowledge request	x
Are people have preferences for heathland restoration or river restoration. (Esmeralda matrix)	Setting priorities	x
Can habitats, important for providing different ecosystem services and biodiversity benefits, meet the growing needs of agricultural production or demands from society for recreation and open space amenities? (Esmeralda matrix)	Knowledge request	x

How can we use ecosystem services for future vision building of a region? (Esmeralda matrix)	Technical support Uncertainty			x
How much to invest in forest management (Esmeralda matrix)	resources	x		
How to achieve economically viable grassland management while maintaining biodiversity? (Esmeralda matrix)	Resources Application (cost benefit)			x
How can the ES approach be integrated into planning and EIA processes? (Esmeralda matrix)	Policy support Planning	x		
how to integrate and use lessons from work on the concept and valuation of eco- system services in practical management, and how to integrate this in an overall framework of ecosystem management,	Policy support Planning	x		
how to map water quality-related ESs necessary for the implementation of specific measures in different planning levels (Esmeralda matrix)	Policy support planning			x
How to protect against flood risks resulting from tidal waves. (Esmeralda matrix)	Policy support (disaster risk reduction)			x
In response to these figures, the I–O model developed below is used to answer the	Applications		x	

following question: what would be the ecological and economic impact of precautionary measures applied to fish habitats while still respecting the principles that environmental damage should be rectified at the source and that the polluter should pay? (Esmeralda matrix)	Costs and benefits Payments		
Is there a positive preference for habitat restoration in coniferous forests (Esmeralda matrix)	Priorities and preferences	x	
Should the most valuable areas for ESs provision be taken into account as conservation priorities? (Esmeralda matrix)	Costa and benefits		x
To assess the strengths and weaknesses of an ESS approach to support decisions in integrated pond to provide a generic monetary value function to assess the public benefits of amenity (Esmeralda matrix)			x
What are possible impacts of planned sea uses on ecosystem service supply? (Esmeralda matrix)	Spatial planning	x	
what are the most important actual and wanted ess (Esmeralda matrix)	Priorities and preferences		x

What are trade-offs between different landscape scenarios? (Esmeralda matrix)	Uncertainties Technical support: which methods are available	x	
What environmental factors are most important for people who want to move out from the city? How to protect landscape? (Esmeralda matrix)	Priorities		x
what social benefits will the plan bring about? (Esmeralda matrix)	Applications Costs and benefits	x	
Where further improvement in land use should be targeted to strengthen the supply of analysed ES? (Esmeralda matrix)	Spatial planning	x	
Where are optional areas for specific land use that have not been realized so far? (Esmeralda matrix)	Spatial planning Technical support questions	x	
whether or not aquatic vegetation removal in the study area gives full cost recovery (Esmeralda matrix)	Cost and benefits	x	
which are emphasised as particular priorities in current development policy and/or seen as major areas of opportunity for future economic growth (Esmeralda matrix)	Policy support Planning Growth		x

Which measures protect against flooding having the highest BC-ratio	Costs and benefits	x