Interim report on the results of testing the methodology across Europe and across themes, including proposals for improvement

Deliverable 5.2

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ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

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EU Horizon 2020 Coordination and support action

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1. Background

The ESMERALDA project ultimately aims at supporting European countries in fulfilling their duties in the frame of the EU Biodiversity Strategy Target 2 Action 5 "*Mapping and Assessment of Ecosystems and their Services*" (MAES). The ESMERALDA project will deliver a "flexible methodology" for mapping and assessment of ecosystem services (ES), based on a tiered approach and on the integration of different dimensions (e.g. biophysical, economic and social). This methodology will consist of various methods for developing high quality and consistent information on the condition of ecosystems and their services in EU Member States. Particularly, the methodology will help to select the most appropriate (combination of) methods to perform mapping and assessment of ES under specific conditions (e.g., data and time requirements, expertise and experience, scale of application), and for specific contexts (e.g., geographical area and biome) and purposes (e.g., policy questions, themes and sectors).

In the ESMERALDA project, WP 5 has the overall goal of "testing the proposed methods to map and assess ES to ensure that they meet users' requirements for all relevant themes, spatial scales and geographical contexts" (see DoA). Testing is here to be intended as a process of refinement of the flexible methodology that is being simultaneously developed in WP 3 and WP 4, as well as with input from WP 2 and other work packages (see Figure 1.1). Testing is conducted through a series of workshops with the ESMERALDA consortium partners and stakeholders, focusing on a set of case studies that are representative of specific conditions, contexts and purposes (for more information on selection of case studies see Deliverable 5.1). These testing workshops represent important moments in which the whole consortium could be updated about developments and discuss specific methodological issues as per the DoA. Finally, an additional objective of the ESMERALDA workshops is to contribute to build stakeholders' capacity in understanding the variety of existing methods for ES mapping and assessment, and the results that can be expected from their application. Thus, the workshops provide an important opportunity to involve stakeholders, and to collect their feedback on the proposed methodology.

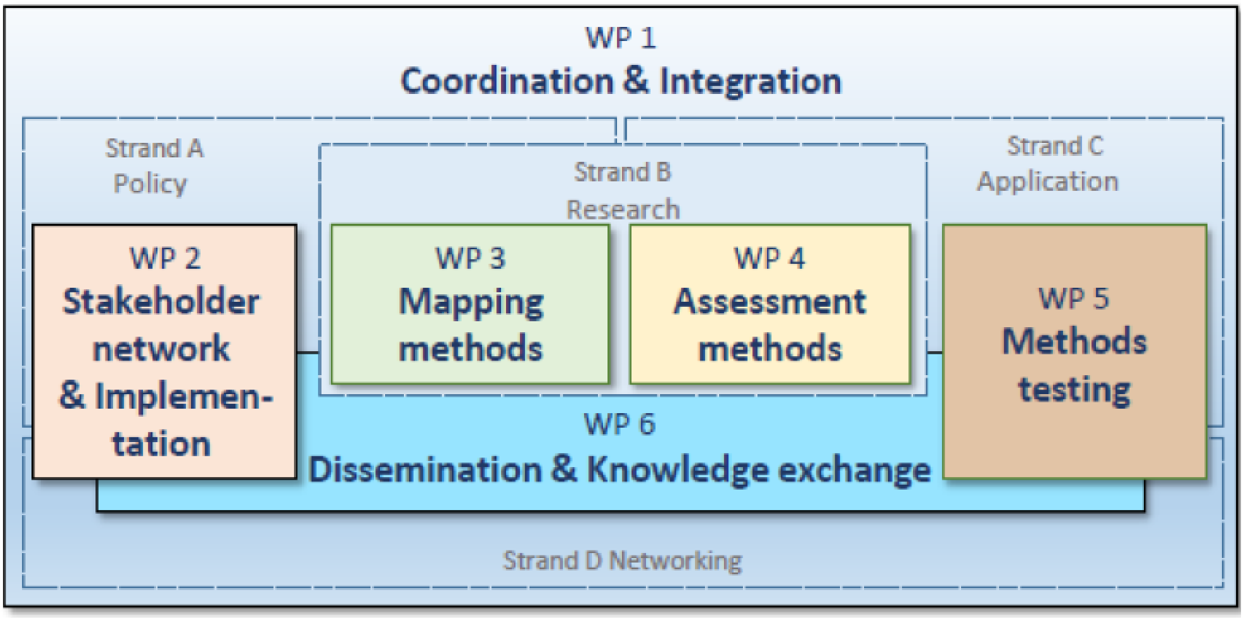

Figure 1.1: ESMERALDA project structure

2. Introduction to Deliverable 5.2

Deliverable 5.2 "*Interim report on the results of testing the methodology across Europe and across themes, including proposals for improvement*" relates to work carried out in "*Task 5.2: Testing the methods across Europe and across themes*" (DoA). It is a follow up of "*Task 5.1: Identification of case studies exemplifying different conditions, themes and geographical contexts*", reported in Deliverable 5.1, in which nine real-world case studies were selected to test and refine the methodology for mapping and assessment of ES under development mainly in WP 3 and WP 4 (see Figure 1.1).

Operationally, Task 5.2 was carried out by conducting three workshops with the ESMERALDA consortium partners and stakeholders to test and refine the proposed methodology in its different stages of development through case studies. Each workshop built on the efforts achieved in previous workshops and subsequent activities mainly in WP 3 and WP 4, where methods for biophysical, social and economic assessment of ES were being reviewed, discussed, and categorized to develop the first version of the **ESMERALDA flexible methodology** for mapping and assessment of ES. In each workshop, participants had the opportunity to first receive an update on the latest developments, and then discuss specific topics through a set of case studies. Additionally, Task 5.2 contributed to stakeholders' involvement and training, also starting from the results achieved in WP 2 concerning the analysis of gaps in ES mapping and assessment in EU Member States and recommendations to overcome them (see e.g. Deliverable 2.2).

In terms of content, each workshop generally consisted of three parts. A first part related to the case studies that provide evidence-base to discuss specific issues defined in the DoA. A second part dealing with the actual development of the ESMERALDA flexible methodology itself, which served to discuss burning questions and the applicability of the project outcomes. A third part aimed at contributing to building capacity of stakeholder in understanding the variety of existing methods for ES mapping and assessment, and the results that can be expected from their application.

More specifically, according to the DoA, three real-world case studies were selected for each workshop to investigate specific issues relating to the applicability of methods across Europe, across themes and across biomes and regions:

- **Workshop 3 "Testing the methods across Europe", 26-29th September 2016, Prague (MS24)**
  - **Latvia case study**: *Mapping marine ES in Latvia.*
  - **Czech Republic case study**: *Pilot National Assessment of ES.*
  - **Germany case study**: *Mapping ES dynamics in an agricultural landscape in Germany.*

- **Workshop 4 "Testing the methods across themes", 9-12th January 2017, Amsterdam (M25)**
  - **Netherlands case study**: *ES-based coastal defence.*
  - **Poland case study**: *ES in Polish urban areas.*
  - **Malta case study**: *Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.*

- **Workshop 5 "Testing the methods for specific biomes & regions", 4-7th April 2017, Madrid (M26)**
  - **Spain case study**: *Spanish National Ecosystem Assessment.*
  - **Azores, Portugal case study**: *BALA - Biodiversity of Arthropods from the Laurisilva of Azores.*
  - **Bulgaria case study**: *Mapping and assessment of ES in Central Balkan area at multiple scales.*

2.1. ESMERALDA case studies

As reported in the ESMERALDA Deliverable 5.1, the selected case studies all in all cover different geographical regions, types of biomes (at country level), spatial scales, themes, and ecosystem types (see Table 2.1). During the workshops, for each case study, two or three ES and related methods for mapping and assessment were selected for discussing specific issues (e.g. relating to scale, themes, geographic regions and so on) involving the case study stakeholders and other ESMERALDA consortium members. Table 2.2 provides an overview the ES and related methods.

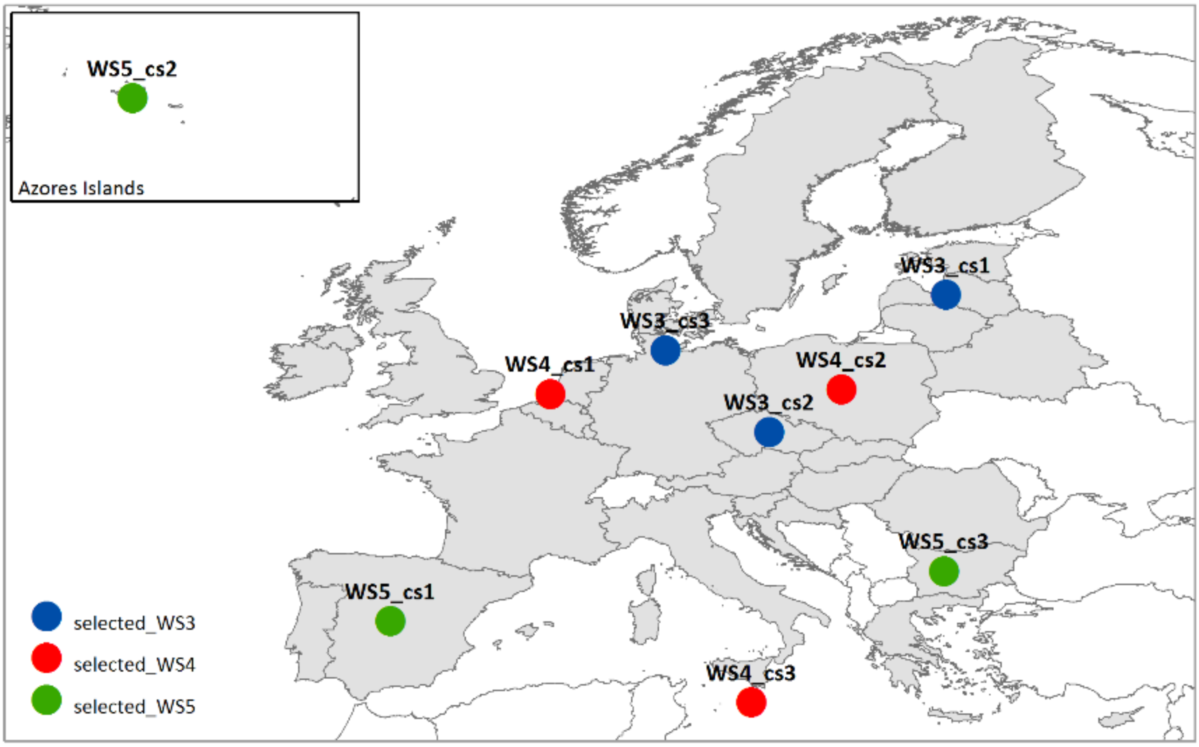

Figure 2.1: Map of the case studies selected for ESMERALDA Workshops 3, 4 and 5

Table 2.1: Overview of the nine case studies for the first three ESMERALDA testing workshops.

	BIONES	_4	_5	_6	_8	_11	_12	SCALE	_local	_sub-national	_national	THEMES	_nature conservation	_climate, water and energy	_marine policy	_natural risk	_urban/spatial planning	_green infrastructures	_agriculture and forestry	_business, industry and tourism	_health	_MAES	ECOSYSTEMS	_urban	_cropland	_grassland	_woodland and forests	_heatland and shrub	_sparsely vegetated land	_wetlands	_rivers and lakes	_marine inlets and transitional waters	_coastal	_shelf	_open ocean
FIRST SET																																			
WS3 cs1		√									√				√					√													√		
WS3 cs2		√	√								√											√		√	√	√	√			√	√				
WS3 cs3		√	√						√													√			√	√	√				√				
WS4 cs1		√							√							√									√					√	√		√		
WS4 cs2		√	√							√	√			√			√	√	√	√				√	√	√	√			√	√				
WS4 cs3							√			√	√											√			√			√	√			√	√		
WS5 cs1		√					√				√											√		√	√	√	√	√	√	√	√	√	√		
WS5 cs2							√			√			√					√									√								
WS5 cs3		√			√		√		√				√				√	√	√	√				√		√	√	√							

Table 2.2: Overview of the ES and related methods for mapping and assessment selected for discussing specific issues in breakout sessions [1]

	Latvia	Czechia	Germany	Netherlands	Poland	Malta	Spain	Azores	Bulgaria
	_WS3_cs1	_WS3_cs2	_WS3_cs3	_WS4_cs1	_WS4_cs2	_WS4_cs3	_WS5_cs1	_WS5_cs2	_WS5_cs3
Title	Mapping marine ecosystem services in Latvia	Pilot National Assessment of Ecosystem Services	Mapping ES dynamics in an agricultural landscape in Germany	ES-based coastal defence.	ES in Polish urban areas.	Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.	Spanish National Ecosystem Assessment	BALA - Biodiversity of Arthropods from the Laurisilva of Azores.	Mapping and assessment of ES in Central Balkan area at multiple scales
MAES status	Stage 1	Stage 2	Stage 3	Stage 3	Stage 2	Stage 2	Stage 1	Stage 1	Stage 2
Scale	National	National	Local/Regional	Local	Local-(regional)	Local-regional	National	Local	Regional
ES 1	Wild plants, algae and their outputs (1.1.1.3)	Surface water for drinking (1.1.2.1)	Plant-based [energy] resources (1.3.1.1)	Flood protection (2.2.2.2)	Filtration/sequestration/ storage/accumulation by ecosystems (2.1.2.1)	Reared animals and their outputs (1.1.1.2)	Food provisioning (1.1.1.1)	Pollination and seed dispersal (2.3.1.1)	Surface water for drinking (1.1.2.1)
Method 1	Spatial proxy models*	Value (benefit) transfer	Spatial proxy models	Benefit transfer*	Spatial proxy models	Spreadsheet methods	Production function	Macro-ecological models	SWAT model & water footprint
ES 2	Maintaining nursery populations and habitats (2.3.1.2)	Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	Buffering and attenuation of mass flows (2.2.1.2)	Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)	Physical use of land / seascapes in different environmental settings (3.1.1.2)	Pollination and seed dispersal (2.3.1.1)	Water provisioning (1.1.2.1)	Maintaining nursery populations and habitats (2.3.1.2)	Aesthetics (3.1.2.5)
Method 2	Spreadsheet method	Value (benefit) transfer	InVEST + GISCAME	Benefit transfer*	Spatial proxy models	B 7. Spatial Proxy Models + Field data	INVEST	Macro-ecological Models	Narrative assessment
ES 3	Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)	Entertainment (3.1.2.4)	Educational (3.1.2.2)						
Method 3	Process-based models*	Value (benefit) transfer	Narrative assessment						
Coordinator	A. Ruskule & K. Veidemane (BEF).	D. Vačkář (UVGZ)	B. Burkhard (CAU)	P. van Beukering (VU)	D. Łowicki (UPOZ)	M. Balzan (MCAST)	F. Santos Martín (UAM)	P. Borges (cE3c)	S. Nedkov (NIGGG BAS)
Stakeholders	Ministry of the Environmental Protection & Regional Development; Latvian Institute of Aquatic Ecology	Czech Nature Conservation Agency	State Agency for Agriculture, the Environment and Rural Areas Schleswig-Holstein	Droomfondsproject Haringvliet	City council of Poznan	MALTA Environment and Resources Authority	Ministry of Environment; Global Nature	Services of Biodiversity and Conservation, Azores; Director of Terceira Island Natural Park	Ministry of Environment and Water

[1] This table is based on the original information used at the time of each workshop, and might have been modified over the course of ESMERALDA project.

2.2. Case Study Booklets

The Case Study Booklets are presented in full as an appendix of this document. They represent important support material used during workshops, drafted during the preparatory phase by the case study coordinators. They illustrate the process of mapping and assessment of ES in the case studies, with information about the study area, main policy question and theme addressed, ecosystem types and conditions, mapping and assessment of ES, and finally, about the use and integration of the results (see Box 2.1).

1) **Case study factsheet and study area description**
2) **Main policy question and theme**
   a) Objectives of ES mapping and assessment
   b) Role of stakeholders
3) **Ecosystem Types and Conditions**
   a) Identification and mapping of ecosystem type(s)
   b) Assessment of ecosystem conditions
4) **Mapping and assessment of ES**
   a) Identification of ES
   b) Applied biophysical methods
   c) Applied socio cultural methods
   d) Applied economic methods
5) **Use & integration of ES mapping & assessment results**
   a) Addressing the policy question
   b) Results communication and dissemination
6) **References & Annexes**


ESMERALDA

Case study booklet for:
WORKSHOP 3: "Testing the methods across Europe" held in Prague, Czechia
26-29 September 2016

(Picture by Ilze Strēle)

Mapping marine ecosystem services in Latvia

(Version 1, 09 September 2016)

ESMERALDA partner: Baltic Environmental Forum (BEF)
Case Study Coordinators: Anda Ruskule

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Box 2.1. Content of the booklets illustrating ES mapping and assessment in the ESMERALDA case studies

Overall, the Case Study Booklets provide a set of good working examples of ES mapping and assessment in real-life, covering different conditions across Europe, across themes, and for specific biomes and regions, as per the DoA. Covering a wide range of ES and related method for mapping and assessment, the Case Study Booklets form the building blocks of the ESMERALDA flexible methodology. In particular, during the ESMERALDA workshops, a selected subset of ES (see Table 2.2) the Case Study Booklets provided an evidence-base to discuss more in detail different aspects relating scale of application, availability of data, resource requirement, among others.

For the sake of readability, the Case Study Booklets, describing all the ES considered in the study, are presented as separate annex of the Deliverable 5.2; while here presented are only the results that emerged during the ESMERALDA workshop discussions with respect to the selected ES shown in Table 2.2.

2.3. Method Cards

These Method Cards are another key support material used during workshops, drafted during the preparatory phase with the involvement the case study coordinators and other ESMERALDA partners acting as supporting experts. The Method Cards synthesize the main characteristic of the applied methods in terms of their data, and resources requirement, links and dependency on other methods, collaboration level needed, and spatial scale of application, among others. The Methods Cards, which also form a building block of the ESMERALDA flexible methodology, were made available to participants, discussed during the workshops and eventually updated afterwards.

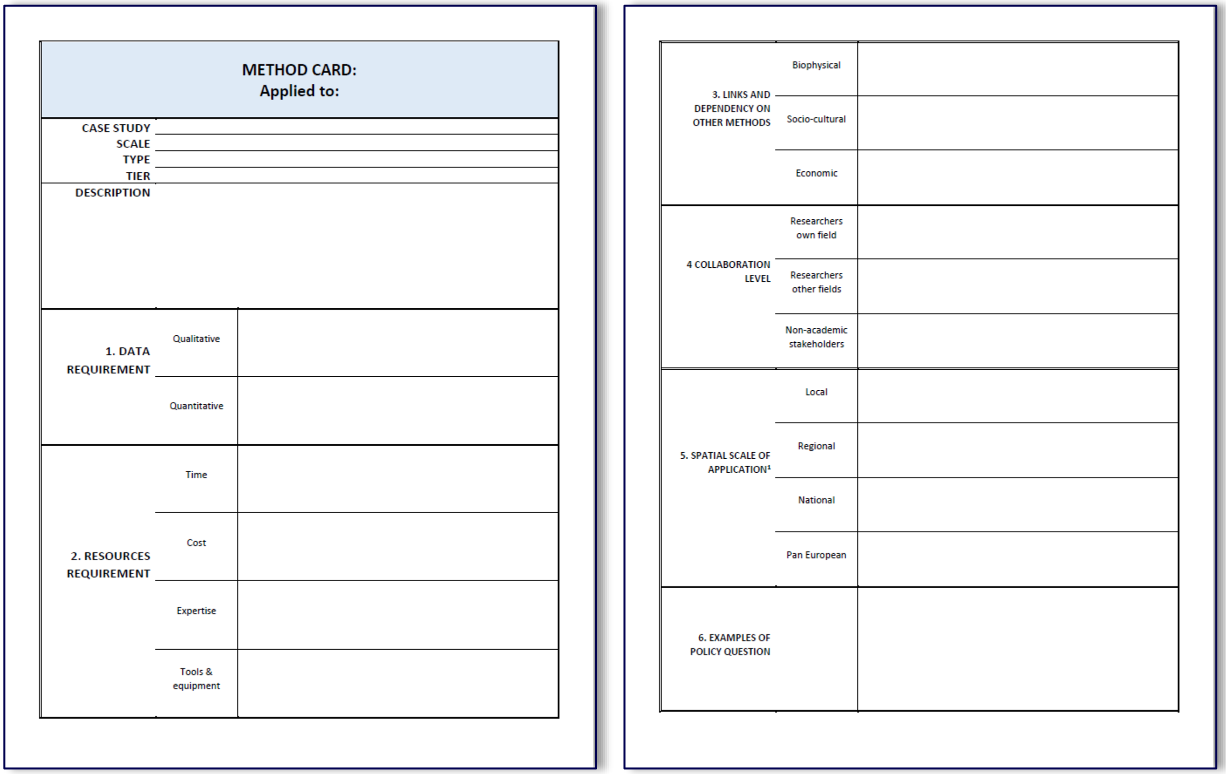


Figure 2.2: Example of Case Study Booklet (left) and Method Card (right).

In the following sections, we report the results of the three testing workshops of the ESMERALDA flexible methodology across Europe and across themes, including proposals for improvement. Each section is structured in four parts. A first part introduces the workshop and its aim; a second part presents the results related to the ESMERALDA case studies, including Method Cards and the key points that emerged during the breakout session discussions; a third part illustrates the main outcomes related to the development of the ESMERALDA flexible methodology itself; and finally, a forth part presents the results focusing on stakeholders' involvement, and training, including field trips. As final remark, the following sessions are designed to be read and consulted independently in combination of the Case Study Booklets reported in appendix. Moreover, the content (e.g. name of methods, tier level etc.) is the same as the original used during each workshop, so may be modified over the project.

3. WS 3 "Testing the methods across Europe", September 2016, Prague (MS 24)

3.1. Aim and structure of WS 3

This was the first of three ESMERALDA workshops aimed at testing the first version of the flexible methodology under development through real-world case studies (see Figure 3.1). Specifically, WS3 used case studies from Latvia, Czechia and Germany, which are currently representative of the variety of conditions across Member States in terms of the stage of achievement of the EU Biodiversity Strategy's Action 5 targets, as described in the ESMERALDA Deliverable 2.1. In WS 3, the discussion focused on the extendibility of the methods across different conditions, including data and resource availability, and expertise. WS 3 participants included both ESMERALDA project partners and stakeholders, who have been directly involved in the case studies. Stakeholders provided feedback on the suitability of the methods to be used in different decision-making processes.

Figure 3.1. ESMERALDA Workshop 3 in Prague, Participants Group Picture (By Pensoft)

Content wise, WS 3 included three types of sessions: case studies-, methods development-, and finally stakeholder involvement and training-related sessions. Given the early stage of the ESMERALDA methods development, the core of WS 3 was represented by breakout sessions in which the participants worked in three groups, each focusing on one case study. Breakout sessions addressed provisioning, regulating & maintenance, and cultural ES, respectively. Particularly, each case study discussed one ES per session, so that nine ES were covered in total during the workshop (see Table 3.1). The discussion started by considering the specific method that has been applied in the case study for the selected ES, and then moved into other possible methods that could be applied to the same ES. Here the purpose was: a) getting to know the specific method better, b) getting inspiration for other/own applications, and finally c) drafting the Method Cards to illustrate the breadth of application of the different methods.

Figure 3.2: Workshop III in Prague, Czechia – Picture from sessions (By Pensoft)

The breakout sessions were preceded by an update on the ESMERALDA methodology and presentation of the case studies, during which the case study coordinators provided an overview of the objectives, the process, and the methodology adopted for mapping and assessing ES, with special emphasis on the ES selected for this workshop. Further information on the case studies are contained in the case study booklets, which were provided to participants ahead of the workshop (See Appendix: Case Study Booklets). The workshop was rounded off with a final reporting and summary session.

In WS 3, a breakout session specifically addressed the role of stakeholders and the level of impacts of ES mapping and assessment. This was during an excursion day spent at the Třeboňsko UNESCO Biosphere Reserve and Protected Landscape Area, in which participants received information about, and visited the Reserve, including a CzechGlobe LTER Wet meadows research station.

In the remainder of this section, we report the main results of the workshop organized as follows:

- ESMERALDA case studies related results
- ESMERALDA methods development
- Stakeholder involvement and training

3.2. ESMERALDA case studies related results

3.2.1. Introducing WS 3 case studies and aim of the breakout discussions

In a plenary session, the salient elements of the three case studies were presented to pave the way for the discussion in the breakout sessions. The **objectives** and the general **process** of the ES mapping and assessment in the case studies were introduced, based on the Case Study Booklets (see Appendix: Case Study Booklets). Key questions addressed include "*What are the policy questions that motivated the mapping and assessment*?", "*how were ecosystems identified*?"; "*How were the ES and related selected and applied*?", "*What were the main outputs (maps, reports, table etc...) and how have they been used/can potentially be used to support policy and decision-making*?". Furthermore, the session detailed the methods for mapping and assessment adopted in the case studies, by addressing the questions "*What methods to map ecosystem types and conditions were applied?"* and *"What methods for mapping and assessing ES were applied, focusing particularly on the three selected ES?*".

As a result, the participants were exposed to the policy questions, and range of methods applied in the three case studies. Stakeholders were exposed to different methods. At the end of the session, it was clear where the selected methods fit in the overall *method matrix*[2] and which aspects were to be discussed during the breakouts. Moreover, inputs from stakeholders paved the way to the discussion on stakeholders and policy support. More information on the case studies in Appendix: Case Study Booklets.

Table 3.1: Overview of the case studies used in Workshop 3, Prague.

	LATVIA	CZECHIA	GERMANY
Title	Mapping marine ecosystem services in Latvia	Pilot National Assessment of Ecosystem Services	Mapping ES dynamics in an agricultural landscape in Germany
MAES status	Stage 1	Stage 2	Stage 3
Scale	National	National	Local/Regional
ES 1	Wild plants, algae and their outputs (1.1.1.3)	Surface water for drinking (1.1.2.1)	Plant-based [energy] resources (1.3.1.1)
Method 1	Spatial proxy Models*	Value (benefit) transfer	Spatial proxy models
ES 2	Maintaining nursery populations and habitats (2.3.1.2)	Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	Buffering and attenuation of mass flows (2.2.1.2)
Method 2	Spreadsheet method	Value (benefit) transfer	InVEST + GISCAME
ES 3	Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)	Entertainment (3.1.2.4)	Educational (3.1.2.2)
Method 3	Process-based models*	Value (benefit) transfer	Narrative assessment
Coordinator	A. Ruskule & K. Veidemane (BEF).	D. Vačkář (UVGZ)	B. Burkhard (CAU)
Stakeholders	Mrs. Ingūna Urtāne (Ministry of the Environmental Protection and Regional Development) and Mrs. Solvita Strāķe (Latvian Institute of Aquatic Ecology)	Ms. Iva Honigová (Czech Nature Conservation Agency)	Dr. Uwe Rammert (State Agency for Agriculture, the Environment and Rural Areas (LLUR) Schleswig-Holstein)
Supporting experts	S. Nedkov (NIGGG BAS)	Luke Brander (VU) Steven Broekx (VITO) Damian Lowicki (UPOZ)	Bálint Czúcz (REC) Mario Balzan (MCAST) Mihai Adamescu (UB)

[2] Method matrix refers to the database structure used to store different mapping and assessment methods, in which the columns represent ES (CICES v4.) and rows represent four spatial scale (i.e. local, regional, national, pan-European), each divided into three tiers (Tier 1, 2 and 3 from simple to more complex approaches).

Following the introduction, the discussion continued in breakout sessions in which the participants discussed the applicability of methods under specific conditions (e.g. data and time requirements, expertise and experience). As a result, a draft of the Method Card for the method applied in the case study with comments and remarks was prepared, and Method Cards were also partially compiled for the alternative methods discussed in the sessions. The Method Cards were further processed after the workshop, hence, shared online with all participants for comments and inputs. For the three case studies, the final version of the cards is presented in the next pages.

3.2.2. Latvia: Mapping marine ES

The mapping and assessment of marine ES was performed as one of the steps for implementation of the ecosystem based approach within development of the national Maritime Spatial Plan (MSP) for Latvian territorial waters and Exclusive Economic Zones (EEZ). The EU policy establishes ecosystem based approach (EBA) as interlink between implementation of the Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) aiming at Good Environmental Status of marine waters and the Directive 2014/89/EU establishing a framework for maritime spatial planning, which aims at encouraging «Blue growth». EBA is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, with the aim to ensure that human use of ecosystems is kept within the limits of ecosystems' capacity to regenerate with regard to their structure, dynamics and functions. EBA shall help to understand interaction between ecosystem and human activities, thus supporting sound decision making on sea use.

The objective of the ES mapping in Latvian MSP was to provide spatial information on distribution of areas important for provision services related to direct sea uses (e.g. fisheries, coastal tourism) and regulation and maintenance services essential for existence of resilient marine ecosystem and related benefits to human well-being (e.g. water purification, maintenance of nursery areas, and climate regulation). The mapping results were used to assess the possible impacts of different sea use scenarios, and to identify the optimum sea use solution from ecological and socio-economic perspectives, including suitable areas for locations of new uses - offshore wind farms and marine aquaculture farms. Moreover, the results are included in the strategic environmental assessment (SEA) of the proposed MSP solutions.

Methods for provisioning ES

- ❖ Selected ES 1: Wild plants, algae and their outputs (1.1.1.3)
- ❖ Applied method 1: Spatial proxy models

METHOD CARD: SPATIAL PROXY MODELS **Applied to: Wild plants, algae and their outputs (1.1.1.3)**	
CASE STUDY	Latvia
SCALE	National
TYPE	Biophysical
TIER	2
DESCRIPTION	

Spatial proxy models are defined as models that relate ES indicators to land cover, abiotic and possibly biotic variables by way of calibrated empirical relationships. In the case study, it is based on empirical data from field survey in combination of expert knowledge. The potential resource of red algae is mapped, using the expert knowledge to identify the benthic habitats that are related to the distribution of the key species (e.g. *Furcellaria lumbricalis*) and combining this information with data from field surveys. The field surveys have partly covered the possible species distribution area and provided information on coverage of algae beds within defined spatial units. The assessment results can be presented in scale, for example, from 1 to 3, where 1 refers to habitats suitable for distribution of the species, but no occurrence so far has been detected; 2 – low occurrence detected; 3 – high occurrence detected.
The discussion reviled doubts, if the applied method can be classified as spatial proxy model. Probably the first step of this approach (identification of benthic habitats suitable for growth of the *Furcellaria lumbricalis*) can be considered as spatial proxy model since it was based on scientific evidence - calibrated empirical relationships between habitat type and species distribution. While adding to this information another layers (score 2 and 3) with information from field surveys on mapping of the actual distribution of the species probably goes beyond the method of spatial proxy models. This shall be taken into account with regard to requirements of time and costs – the described efforts and tools for data collection refers to field surveys on actual distribution of the species, which is beyond the spatial proxy model.

1. DATA REQUIREMENT	
Contextual (note: the group suggested to distinguish between contextual and site-specific data)	• Expert knowledge about species requirements, i.e. habitat type and abiotic conditions (substrate, depth, light conditions - Secchi depth suitable for growth (R) • Helcom standard for habitat classification (or other classifications, e.g. EUNIS) (R)
Site specific	• Habitat map (R); Geological map (for extrapolation) (R) • Benthic habitat map, bathymetry map (EMODnetseabed mapping provide similar data for Europe) • Field survey data (on area covered by red algae *Furcellaria lumbricalis* beds, calculated as % of area unit) (R); • Biomass estimate (conversion from area to tons), including info on threshold that make exploitation interesting (demand) (not applied in the case study)
2. RESOURCES REQUIREMENT	
Time	• If you have the field data, processing is fast. If not it is very time demanding. It involves a marine survey including scuba diving with special equipment and then data treatment. • Remote sensing data cannot be applied in these waters, because of low water transparency in the eastern part of the Baltic Sea. • In this case the time to apply the method itself was relatively quick as the monitoring data on species coverage was available, • But: usually coverage of red algae is co-measured in the frame of other expeditions (e.g. marine monitoring)
Cost	• Dropped-down video is the most cost-effective approach (but only for assessing coverage of algae, not habitat conditions) • Costs are generally high in marine ES mapping (in terms of cost per unit) comparing to mapping ES in land area.
Expertise	• Marine hydro biologist (or other expertise related to sea); some GIS knowledge; technical expertise with equipment
Tools & equipment	• Boats, scuba diving equipment, drop-down video camera, side-scan sonar (See above);
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Biophysical mapping method
Socio-cultural	• Potentially could be linked with preference assessment: Demand for the ES from the coastal communities and business sector (not applied in the case study)
Economic	• Info about demand (market price) could be combined, but we need the ton per hectare info

4 COLLABORATION LEVEL	
Researchers own field	• Input was needed from Marine Biologist
Researchers other fields	• Not in the case study • Potentially high – economists for assessment of the potential monetary value of the resource
Non-academic stakeholders	• Not in the case study • Potentially medium – business sector representatives for assessment of the potential demand of the resource
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Applicable also at this scale.
Regional	• Applicable also at this scale.
National	• Appropriate, it is the scale of the case study
Pan European	• Applicable also at this scale.

Methods for regulating and maintenance ES

- ❖ Selected ES 2: Maintaining nursery populations and habitats (2.3.1.2)
- ❖ Applied method 2: Spreadsheet method
- ❖ Alternative method 2: State and transition model

METHOD CARD: SPREADSHEET METHOD Applied to: Maintaining nursery populations and habitats (2.3.1.2)	
CASE STUDY	Latvia
SCALE	National
TYPE	Biophysical
TIER	1
DESCRIPTION	
Simple methodology that provides a quick output in a spatial explicit manner and can involve different stakeholder/expert perceptions. Can be used in data-scarce areas. In the Latvian case study, the distribution of benthic habitats providing service of nursery sites for fish species was selected as an indicator.	
1. DATA REQUIREMENT	
Contextual information	• Expert knowledge on habitat type and abiotic conditions (substrate, depth) suitable for fish spawning and nursery
Site-specific information	• Habitat map; bathymetry map, Field survey/modelling data on distribution of fish spawning and nursery habitats NB. Research data are available only on spatial distribution of the daily spawn production of sprat, however this information was not used in ecosystem service assessment, because it is related to pelagic habitats, while assessment of regulating services in the case study was applied to benthic habitat related ES only.
2. RESOURCES REQUIREMENT	
Time	• The development of a benthic habitat map took few weeks (this task does include field works) • The assessment (running the analysis) took 1 day (but few meetings to decide about how to perform the assessment, which services can be assessed and based on which indicators)) • Expert scoring workshop 1 day + Producing final maps 1 day
Cost	• Low (if spatial data on benthic habitat and/or spawning and nursery areas are available) • Main cost: setting up the focus group.

Expertise	• Marine biologist, ichthyology, (basic GIS), group discussion facilitator of the scoring workshop
Tools & equipment	• No any specific tools or equipment were used • Look-up table
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• No dependency from other biophysical, economic, socio-cultural methods (optional). • Can provide input for indirect assessment on distribution of other marine species.
Socio-cultural	• Input to other socioeconomic
Economic	• Input to economic methods, such as cost/benefit, replacement cost/damage cost (optional) • Potentially, "Restoration costs" or "Value transfer" methods could be applied to assess the economic value of spawning areas.
4 COLLABORATION LEVEL	
Researchers own field	• Researchers of own field were needed (marine biologists, ihtiologists)
Researchers other fields	• Not needed
Non-academic stakeholders	• Not needed
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate (if the quality/scale of the habitat map allows)
Regional	• Appropriate (if the quality/scale of the habitat map allows)
National	• Appropriate
Pan European	• Appropriate

METHOD CARD: STATE AND TRANSITION MODEL Applied to: Maintaining nursery populations and habitats (2.3.1.2)	
CASE STUDY	Latvia
SCALE	National
TYPE	Biophysical
TIER	2
DESCRIPTION	
State and transition model	
1. DATA REQUIREMENT	
Contextual	• Required data depends on the service, in this case they are similar to the previous method (habitat/landuse, time series)
Site specific	• Expert knowledge on how the system may evolve
2. RESOURCES REQUIREMENT	
Time	• Time needed for calibration testing
Cost	•
Expertise	• Ecological modelling, besides marine ecology
Tools & equipment	• Freely available software tools, unless you want to use specific methods, such as Bayesian Belief Network. • Note: the methods are not spatial; you will need to apply it to each spatial unit, which may be complex. Still, some developments have been made e.g. to R or Quickscan
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Links with other biophysical methods

	• It is similar to BBN
Socio-cultural	•
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• Needed
Researchers other fields	• Link with BBN
Non-academic stakeholders	•
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate
Regional	• Appropriate
National	• Appropriate (BBN has been applied at national scale)
Pan European	• Appropriate

Methods for cultural ES

- ❖ Selected ES 3: Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)[3]
- ❖ Applied method 3: Process-based model*
- ❖ Alternative method 3: InVEST

METHOD CARD: PROCESS-BASED MODEL Applied to: Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)	
CASE STUDY	Latvia
SCALE	National
TYPE	Biophysical
TIER	2
DESCRIPTION	
Rely on the explicit representation of ecological and physical processes that determine the functioning of ecosystems. *In the case study, the method is based on empirical data in combination with expert knowledge. First, relevant factors are identified and selected, such as for example, marine tourism and leisure possibilities at the coast. The assessment value of each grid cell is then obtained by combination of several criteria, including number of visitors; suitability of the area (or best place) for particular tourism or leisure activity/life style (e.g. angling, bird watching, kiteboard, etc.); and accessibility – presence of parking lots and public access roads near the coast. The assessment results can be presented, for example, in a scale 1 to 5, where 1 means very low suitability for tourism and leisure activities and 5 – very high suitability*	
1. DATA REQUIREMENT	
Site specific	• 25 plots for counting tourists; infrastructure data – assessment of it quality), • **Suitability,** based on observations and expert judgment, of the area (or best place) for particular tourism or leisure activity/life style (e.g. angling, bird watching, kiteboard, etc.) • **Statistics on a number of visitors** - data collected in 2015. • **Accessibility –** available infrastructure including roads and parking lots (covering the whole coastal area)

[3] The assessment was not carried out to the CICES class level.

	• **Population distribution –** data on settlement pattern and population size
Contextual	•
2. RESOURCES REQUIREMENT	
Time	• Low – if field data is available. Medium – if data is collected. • The major data sets on visitors' statistics and accessibility was collected during summer season 2015. The data collection very much depends on seasonality of tourism and recreation. In Latvia, ~90% of tourism activity takes place from June-August. • Data collected in 25 selected monitoring sites (1 km long) for one full day (9:00-19:00), 3 times per season 2015. • Data processing (medium level of time consuming) 2 weeks in total, including time to develop the rule and run the analysis
Cost	• Low – if field data is available. Medium – if data has to be collected. • The data was collected for another purpose – to develop a long-term public infrastructure plan for the Latvian coastal zone along the Baltic Sea.
Expertise	• Expertise on tourism • GIS skills
Tools & equipment	• Basic GIS software.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Link to biophysical mapping methods (e.g. ESTIMAP; INVEST)
Socio-cultural	• Preference assessment
Economic	• Few methods could benefit from the results: Travel cost; Contingent valuation; Choice modelling; ES accounting
4 COLLABORATION LEVEL	
Researchers own field	• Low in the case study • The study could have been expanded to include differences in coastal habitats in relation to the assessed ES. The study considered the coastal area as one ecosystem.
Researchers other fields	• High – experts from tourism sector • Could benefit from collaboration with economists, anthropologists, sociologists, etc.
Non-academic stakeholders	• Municipalities providing information on accessibility (infrastructure); entrepreneurs providing tourism service • Depends if the aim of the assessment is more complex and involves socio-economic assessment → experts from tourism sector.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Do not make sense at local scale (at least in this case study the habitat areas were too coarse)
Regional	• Might be regional
National	• Appropriate
Pan European	•

METHOD CARD: InVEST Applied to: Physical use of landscapes /seascapes in different environmental settings (3.1.1.2)	
CASE STUDY	Latvia
SCALE	National
TYPE	Biophysical
TIER	2
DESCRIPTION	

InVEST is a suite of spatially explicit ecosystem service modelling tools that quantify service provision. They can be used for mapping and valuing the ecological or economic value of multiple ES at a local to regional scale. InVEST allows doing ES trade-off assessment of certain land use or management scenarios. It usually uses land cover maps as input and look-up tables for parameterization of ES indicators. The output is in form of ES maps. The service in the model is "Visitation: Recreation and Tourism". To quantify the value of natural environments, the InVEST recreation model predicts the spread of person-days of recreation, based on the locations of natural habitats and other features that factor into people's decisions about where to recreate. The tool estimates the contribution of each attribute to visitation rate in a simple linear regression. If there are no empirical data on visitation, it parametrizes the model using a proxy for visitation: geotagged photographs posted to the website Flickr. Using photo-user-day estimates, the model predicts how future changes to natural features will alter visitation rates. The tool outputs maps showing current patterns of recreational use and maps of future patterns of use under alternate scenarios.	
1. DATA REQUIREMENT	
Qualitative	• Recreation module requires basic data for the area of interest - shape (polygon), grid (size, type) • Other data are optional depending on the site specifics
Quantitative	• The tool provides several global spatial datasets which users can optionally include as predictor variables (population, OSM, protected areas, LULC, mangroves, coral reefs, seagrass)
2. RESOURCES REQUIREMENT	
Time	• The software is easy to use and does not require much time.
Cost	• Software is for free (ArGIS licence is necessary for older versions)
Expertise	• Basic GIS skills are necessary
Tools & equipment	• InVEST standalone or plugin to ArcGIS • Additional GIS software to produce maps;
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	•
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	• Tourism expertise
Non-academic stakeholders	• Tourism expertise
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate • However, the data limits the possibility to apply it, (as with all models…) • With typically available data it cannot be used at a local scale
Regional	• Appropriate
National	• Appropriate
Pan European	• Appropriate

3.2.3. Czech Republic: Pilot National Assessment of Ecosystem Services

This Czech pilot ES assessment and mapping followed the worldwide mainstreaming and establishment of global and sub-global assessments within the framework of the Millennium Ecosystem Assessment (MA) in order to substantially contribute to the knowledge on the state of the environment and the sustainable management of natural capital in the Czech Republic. Actual policy demand was driven mainly by the Aichi Targets (Strategic Goal D) and the EU Biodiversity Strategy to 2020 (Action 5), which focus on mapping and assessing the state of ecosystems and their services in the national territory, as well as streamlining ES into decision-making and national accounts. Therefore, meeting this goal required us to start with the completion of a national-scale mapping and assessment effort.

The objective of the pilot study was to map ecosystems within the territory of the country and assess the value of ES provided by nature in the Czech Republic. The economic valuation of ES was motivated by the objective to make the value of ES more visible and provide an initial estimate illustrating the importance of ES for society. This captured total value is also aimed to be included in national wealth and accounting, to further emphasize the benefits provided by ecosystems in the Czech Republic.

A preceding pilot study conducted for the government-based Nature Conservation Agency and the European Topic Centre on Biodiversity, focused on the benefits provided by grasslands in the Czech Republic. This is considered a complementary study where some of the methodological approaches were tested. The pilot assessment presented in this case study however, was the first inclusive assessment of ES provided by the diverse ecosystem types across the country.

Individual ES were identified and assessed. This was done with respect to local conditions, and applicable methodologies were prepared for both national and regional scales to further enable application into effective policy responses aimed at halting future ES degradation.

Methods for provisioning ES

- Selected ES 1: Surface water for drinking (1.1.2.1)
- Applied method 1: Value (benefit) transfer
- Alternative method 1: Net factor income

METHOD CARD: VALUE (BENEFIT) TRANSFER Applied to: Surface water for drinking (1.1.2.1)	
CASE STUDY	Czechia
SCALE	National
TYPE	Economic
TIER	2? Suggestion: Tier 1
DESCRIPTION	
It is the use of research results from existing primary studies at one or more sites or policy contexts (“study sites”) to predict welfare estimates or related information for other sites or policy contexts (“policy sites”). Value transfer is also known as benefit transfer but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable. In the Czech case study, the method was selected because of its time and cost effectiveness, and the potential to substitute the primary data when specific data is not available. The methodological framework for the case study application of the method consisted of 4 steps: (1) systematic review of the literature, (2) database construction, (3) value transfer, (4) analysis and subsequent data interpretation. **It does not really reflect the differences in market price at the location that it is transferred to**	

1. DATA REQUIREMENT	
Qualitative	• Peer-reviewed articles; • Criteria for suitability of the study (e.g. geographic);
Quantitative	• Volume of water/amount of water extracted and distributed; • Recharge volumes; Complete hydrological data of a watershed; • In the case study, the input data consists of research results from one study by Willemen et al. 2010, Ecological Economics 69 (2010) 2244–2254
2. RESOURCES REQUIREMENT	
Time	• Medium (Low in comparison to methods based on field survey data collection) 2 person/ week work – probably low
Cost	• Low (only personal costs)
Expertise	• Medium (or Low-Medium if it is not your field of study) • Adjustment of price levels across time and different countries
Tools & equipment	• Low (computer)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Not linked to different biophysical methods, but it could be linked to alterative biophysical methods • Just cubic meters (basic physical method)
Socio-cultural	•
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• You can do benefit transfer on your own
Researchers other fields	• Inputs from other expert needed, consultation only (no need of long term collaboration
Non-academic stakeholders	• None (publicly available data extracted from administrative bodies)
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate
Regional	• Appropriate
National	• Appropriate
Pan European	• Appropriate

METHOD CARD: NET FACTOR INCOME Applied to: Surface water for drinking (1.1.2.1)	
CASE STUDY	Czechia
SCALE	National
TYPE	Economic
TIER	1
DESCRIPTION	
The net factor income method estimates the value of an ecosystem service as an input in the production of a marketed good. It estimates the value of the ecosystem input as the total surplus between revenues and the cost of other inputs in production. For example, the value of wetlands as an input into the production of fresh drinking water can be calculated as the revenue received from selling drinking water, minus the infrastructure, labour, delivery and other costs of providing the water. $Net\ factor\ income = (Quantity * Price\ of\ Water) - Production\ Cost$	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Secondary data on quantity of water supplied to consumers; • Quantity of water extracted;

	• Costs of production (prices per unit of water); • Costs of all other inputs in the supply of water (infrastructure, labour, delivery, etc.) • Recharge volumes; • Complete hydrological data of a watershed;
2. RESOURCES REQUIREMENT	
Time	•
Cost	• Low (only personal costs)
Expertise	• Medium (or Low-Medium if it is not your field of study) • Survey of water companies to obtain data on quantities, prices and costs. • Simple data analysis
Tools & equipment	• Low (computer)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Not linked to different biophysical methods, but it could be linked to alterative biophysical methods • Just cubic meters (basic physical method) could be enough • Hydrological understanding of ecosystem's role in the supply of water useful
Socio-cultural	•
Economic	• Knowledge of economics of water pricing
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	• Inputs from other expert needed, consultation only (no need of long term collaboration)
Non-academic stakeholders	• High – a lot of collaboration (e.g. water company)
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Very appropriate, less than for larger scales
Regional	• Appropriate
National	• Feasible but costly
Pan European	• Not appropriate

Methods for regulating and maintenance ES

- ❖ Selected ES 2: Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)
- ❖ Applied method 2: InVEST
- ❖ Alternative method 2: Value (benefit) transfer

METHOD CARD: InVEST Applied to: Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	
CASE STUDY	Czechia
SCALE	National
TYPE	Biophysical
TIER	1
DESCRIPTION	
InVEST is used to do ES trade-off assessment of certain land use or management scenarios. Set of models for mapping and valuing the ecological or economic value of multiple ES at a local to regional scale.	
1. DATA REQUIREMENT	
Qualitative	• None

Quantitative	• Data on carbon pools assigned to different land use may be used; alternatively, default values provided by IPCC reports could be adopted (e.g. remote sensing works well for large patches) • Crown data + cadastre data + crop data • Be prepared for difference in detailed data for different land use classes. • There may be no data on land management of land on national scale, such as type of manure, fertilizers used…)
2. RESOURCES REQUIREMENT	
Time	• Low-Medium (demanding to get land use data) • Low-Medium (demanding to get look up tables)
Cost	• Labour costs mainly. - But if biophysical measurements are included, the costs increase to high
Expertise	• Not that demanding for InVEST if you know GIS • The terminology may be difficult • High uncertainties should be taken into consideration. Thus, the need to know what the assumptions behind each step are.
Tools & equipment	• GIS software, computer • If field measurements are included, you need very expensive equipment, and research stations. • May need quite complex statistical analysis.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Main Problem: What are the steps from stocks to flows? • You may use the look up tables for specific type of tress and biomass types. You may separately consider Soil Organic Carbon and Carbon storage in above and below ground biomass. There are different ways to approach carbon storage change of land use change
Socio-cultural	• Net flux and storage depend on management. Sometimes agri flows may be around zero or small minus. • We suggest the assumption that less carbon means less fertile soil.
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• GIS knowledge. You need to be prepared that this is interdisciplinary research
Researchers other fields	• Expert consultation to check internal consistency of data may be needed to decrease uncertainty. • You may need to collaborate with other researchers to get the soil data, but also with ecologists and biochemists.
Non-academic stakeholders	• Some state agencies may be interested to know what is the impact on carbon sequestration of nature management (e.g. wetland management) • Collaboration with stakeholders makes the results more publicly spread (they should be included at the beginning to fully accept the uncertainties) • usually the role of the stake holders is in helping you to develop scenarios
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Generally it is appropriate for all scales if you have data • Data sources match your spatial scales. • Local scale and Corine Land Cover may not be the best option.
Regional	• It depends
National	• It depends
Pan European	• It depends

METHOD CARD: VALUE (BENEFIT) TRANSFER Applied to: Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	
CASE STUDY	Czechia
SCALE	National
TYPE	Economic
TIER	1
DESCRIPTION	
It is the use of research results from existing primary studies at one or more sites or policy contexts ("study sites") to predict welfare estimates or related information for other sites or policy contexts ("policy sites"). Value transfer is also known as benefit transfer but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable. In the case study, the method was selected because of its time and cost effectiveness, and the potential to substitute the primary data when specific data is not available. The methodological framework for the case study application of the method consisted of 4 steps: systematic review of the literature, database construction, value transfer, analysis and subsequent data interpretation.	
1. DATA REQUIREMENT	
Qualitative	• The results form peer-reviewed articles published in recognized journals.
Quantitative	•
2. RESOURCES REQUIREMENT	
Time	• Medium
Cost	• Low
Expertise	• Medium
Tools & equipment	• Low
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Input relationship from biophysical methods
Socio-cultural	•
Economic	• Input from other methods required
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• High
Non-academic stakeholders	• None
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate
Regional	• Appropriate
National	• Appropriate
Pan European	• Appropriate

Methods for cultural ES

- Selected ES 3: Entertainment (3.1.2.4)
- Applied method 3: ESTIMAP
- Alternative method 3: Hedonic Pricing Method

METHOD CARD: ESTIMAP Applied to: Entertainment (3.1.2.4)	
CASE STUDY	Czechia
SCALE	National
TYPE	Biophysical ESTIMAP
TIER	2
DESCRIPTION	
Assess the supply, demand and flow of different ES at different scales. Simple, easy to understand, spatially-explicit approach that can be tailored to particular case studies.	
1. DATA REQUIREMENT	
Qualitative	• Scoring of nature protection
Quantitative	• different sources • the use of social media source of data • mobile phones operators data • topological data set (e.g. habitat area, water courses) • notion of naturalness Recreation can be estimated using three types of parameters: 1. Parameters for supply of the potential of recreation, such as: (a) Water proximity; (b) Naturalness, (c) Habitat, (d) Protection 2. Parameters for demand of recreation, such as: (a) Demographics, (b) Population density, (c) Visitation rates; 3. Accessibility parameters, such as: (a) Distance from/to roads.
2. RESOURCES REQUIREMENT	
Time	• Medium comparing to other methods (about one month work)
Cost	• Low – including only labour costs
Expertise	• Low-Medium (everyone is expert in recreation ☺ • Some GIS software expertise
Tools & equipment	• Computer, GIS software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	e.g. Mean Species Abundance Index • many biophysical methods may be included (usually results from the use of these methods are used later for economic analysis)
Socio-cultural	• stakeholder consultation • preference measures • methods for validation of the results
Economic	• e.g. travel costs • to estimate visit function explaining visitation rates • choice experiment • transfer visitor function from somewhere else (e.g. UK)
4 COLLABORATION LEVEL	
Researchers own field	• None
Researchers other fields	• Collaboration improves the quality of the results, but it is not necessary • It is good to collaborate with ecologists and people involved in the tourism research

Non-academic stakeholders	• Tourists • Managers of the protected areas (they may serve as data providers) • Tourism sector • Statisticians • Masterplan may be influenced by the results of such study
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Different level of details in the maps for different scales. • Different data available for different scales. • Supposedly better results for local scale. • Good to take into consideration how popular the place is and where the place is marketed. • Good to use local knowledge • If you do not have access to detail data, it may good to use a different method than ESTIMAP.
Regional	• Yes! However, local data needed.
National	• Some adjustments of the method to national characteristics and conditions is recommended
Pan European	• Yes. ESTIMAP was developed for this scale

METHOD CARD: Hedonic Pricing Method (HPM) Applied to: Entertainment (3.1.2.4)	
CASE STUDY	Czechia
SCALE	National
TYPE	Economic
TIER	2
DESCRIPTION	
HPM is one from the Revealed Preferences methods, which is used to estimate economic values for ecosystem services that affect market prices directly. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. It is based on households' real WTP for the dwelling's characteristics as revealed on the market, rather than households' assessment of hypothetical alternatives from which their supposed WTP is deduced. It integrates and values environmental quality and the features of the urban neighbourhood of the dwellings in a coherent framework, which also incorporates physical apartment and building quality characteristics (Baranzini et al, 2008).	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Example of data: (1) Quality of real estate (plot, flat, house): area, floor, age, materials used, media (electricity, water supply, sewage system), etc. (2) Environmental quality: air pollution, water pollution, noise, etc. (3) Environmental amenities: view, beaches, bike paths, protected areas, etc. (4) Urban surrounding: age and quality of buildings, disturbing elements (e.g. high voltage lines), prestige of the district, availability of schools, hospitals, train stations, etc.
2. RESOURCES REQUIREMENT	
Time	• Depends on the availability, usually few weeks for people with experience in this type of analyses, some data has to be gathered in the field. • However, if you have to start from scratch with no data, it would require more time.
Cost	• Usually for free, however, reliable and high quality real estate data are not always easily available.
Expertise	• No
Tools & equipment	• GIS and statistical software.

3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• No
Socio-cultural	• No
Economic	• No
4 COLLABORATION LEVEL	
Researchers own field	• Yes
Researchers other fields	• Medium to low. Some collaboration with experts on real estate valuation is desirable
Non-academic stakeholders	• Medium to low. Some collaboration with local authorities or real estate associations is needed
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Yes
Regional	• Yes
National	• No. Because on the national level it is too data demanding.
Pan European	• No. Primarily because we lack common database for whole Europe or people who can collect the data

3.2.4. Germany: Mapping ES dynamics in an agricultural landscape in Germany

ES mapping and assessment in the Germany case study has been so far mainly scientifically driven. This means that the ES assessment framework (including indicators, quantification methods, etc.) was applied and tested in the area. The case study is partially part of the LTER (Long Term Ecological Research) program. Several ecological data sets are available from previous projects (e.g. Long-Term Research in the Bornhöved Lake District; see Fränzle et al. 2008[4]). This information is used to detect changes in ecosystem conditions, biodiversity, ecosystem functions, land use and other human activities in the area.

In the case study area, the land cover pattern has been rather constant in the last decades. However, significant changes in agricultural land use regarding crop rotation are obvious. This is mostly due to policy changes in Germany that have been heavily promoting and supporting the use of renewable energy since the past years[5]. Resulting impacts were analysed by land use change detection and statistical analyses of resulting changes in ES supply and demand. The increasing cultivation of energy plants (such as maize or rapeseed) for biomass generation has caused changes especially within provisioning ES. Their supply shows a shift from fodder (and partly food) production towards biomass for energy. The increasing cultivation of maize has further effects on biodiversity, regulating and cultural ES. Thus, the real-life policy question to be addressed would be: "*How does the national German renewable energy strategy impact on the regional land use / land cover and related ES supply in a northern German agricultural landscape*?"

Methods for provisioning ES

- ❖ Selected ES 1: Plant-based [energy] resources (1.3.1.1)
- ❖ Applied method 1: Spatial proxy models*
- ❖ Alternative method 1: Replacement costs

METHOD CARD: SPATIAL PROXY MODELS* Applied to: Plant-based [energy] resources (1.3.1.1)	
CASE STUDY	Germany
SCALE	Regional
TYPE	Biophysical
TIER	2
DESCRIPTION	
Spatial proxy models are defined as models that relate ES indicators to land cover, abiotic and possibly biotic (although not often used beyond vegetation type) variables by way of calibrated empirical relationships. *In the case study, LULCC was classified based on a Landsat TM 5 remote sensing data series covering the time period from 1987 to 2014. In combination with statistical data on crop supply and demand, ES budgets for selected plants (cereals, maize, and grass) for electricity generation in biogas plants were calculated and mapped for selected years.*	
1. DATA REQUIREMENT	
Qualitative	• Proxies or estimates of the local area, yields for example.

[4] Blume, H.-P. et al., 2008. Ecosystem Organization of a Complex Landscape O. Fränzle et al., eds., Berlin, Heidelberg: Springer Berlin Heidelberg. http://www.springer.com/de/book/9783540758105
[5] http://www.bmwi.de/EN/Topics/Energy/renewable-energy.html

Quantitative	• Satellite images were classified and combined with statistical data, spectral resolution important (cloud-free, same year, same season etc.), resolution 30m x 30m. • Already classified ecosystem type / land use map are also needed • Possible use of EU's Sentinel satellite data (may be problems with licenses and thus accessibility to data) or other more detailed data. In regional scale, resolution of 30m x 30 m is enough. • Satellite images can be classified based on field data. • To provide flexibility in the method, some kind of modularity could be applied in how the ecosystem / land use is developed. • Many agricultural data exist (what farmers grow, what they put on their fields, etc.) but it is not publicly available, access is very restricted (e.g. in Germany and Finland very restricted but in Denmark freely available).
2. RESOURCES REQUIREMENT	
Time	• Medium (approximately classification 1 month, combining with statistics 1 week). • Collecting the data, pre-preparing it for the analysis, data combination can take a long time.
Cost	• Can be free if you have the people doing the classification (not taking into account the salary cost of own personnel).
Expertise	• Remote sensing expertise for classification of images. Agricultural knowledge.
Tools & equipment	• Classification software (some available free) and a computer
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Developed LULC could be used for regulating service modelling, e.g. erosion modelling. Other provisioning services can be combined, too, e.g. fodder. Mapping / assessing of pollination was done based on the developed LULC by combining data with field experiments and InVEST modelling about pollination / pollinators (very time-consuming work). In addition, ecosystem conditions can be assessed, e.g. by relating to intensive agriculture where pesticides are used and pollinators suffer.
Socio-cultural	• Preference studies based on the developed LULC. Demand for food was calculated based on population and amount of consumed food. Budget of supply and demand can then be produced for the different agricultural products (quite straightforward for energy, possible also for food).
Economic	• Market value could be done based on the results.
4 COLLABORATION LEVEL	
Researchers own field	• Lots of collaboration.
Researchers other fields	• Collaboration is needed for proper classification. Some knowledge in agriculture and agricultural practice is required. Expert assessments of yields etc. could be used, too, if statistical data is not available OR experts can check the statistical data after the map has been produced (proofing).
Non-academic stakeholders	• Farmers need to be engaged. In the German case study, no problem with motivating or justifying the research. In a prior study, farmers got compensation for the loss of yields in experimental sites or for keeping an eye on the equipment.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• A finer resolution would be needed for local scale, but at the local scale (single plot), each farmer already has data.
Regional	• The resolution of 30m x 30m is absolutely sufficient for regional level. The applicability of the method might be limited in very complex landscapes where it is more difficult to detect all the different land use classes from satellite images.
National	• Statistics for the national level are rougher and can be a bit challenging; would take many years to carry out the analysis for the whole country in Germany.
Pan European	• LULC classification with the required resolution (crop in each field) is not really applicable because the field types (what is grown where) cannot be detected in

	European scale. Maybe it is better to choose another method for Pan-European scale. However, the use of spatial proxy methods (combining LULC maps with statistical data) does not have per se a limitation in terms of scale.

METHOD CARD: REPLACEMENT COSTS Applied to: Plant-based [energy] resources (1.3.1.1)	
CASE STUDY	Germany
SCALE	Regional
TYPE	Economic
TIER	2
DESCRIPTION	
The replacement cost methods, as well as damage cost avoided and substitute cost methods, are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing environmental assets, or the cost of providing substitute services. The cost of replacing an ecosystem service with a man-made substitute is used in the replacement cost method as a measure of the economic value of the ecosystem service. The cost of investment and the maintenance cost should both be included in the replacement cost. The method could for example be applied for a) Value the flood protection capacity of wetlands by estimating the cost of replacing this capacity with the use of a human made protection, i.e. artificial coastal defence such as breakwaters or sea walls. b) Soil estimate value of soil fertility by looking at the cost of fertilizers needed to maintain a certain level of productivity. **c) Energy alternative: Use market prices, replacement costs (opportunity costs) for alternatives to oil and coal.** d) Fibre: use the market prices to replace the use of reed or other resources e) Biochemical, natural medicines, and pharmaceuticals – use for replacements costs by chemical processes; f) Ornamental resources Water regulation, including Flood regulation – used locally to estimate losses due to preventing flooding, **ensuring water supply to farming, industry etc. during dry periods etc.** Market values can also be calculated using replacement costs with hard engineering	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Cost related with fuel (like oil and coal dynamics over several years) • cost related to engineering works for energy production (as an alternative to cost for energy production using different other non-renewable sources for e.g.) • costs related to maintenance works (comparative costs for e.g. biogas plant to coal plant); • Estimation of the running costs (if this is the case)
2. RESOURCES REQUIREMENT	
Time	• Medium to high (depending on the available datasets) • 2-3 people (depending on the area)
Cost	• Relatively low but it is dependent on the available data
Expertise	• Medium to high (depending on the available datasets)
Tools & equipment	• Access to long term datasets; computer and statistical software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• The method could be used for many services, from regulating to provisioning; the method could also be highly dependent on other inputs; the method could be used in conjunction with other methods
Socio-cultural	• Preference costs
Economic	• The method could be used for integrated assessment alongside other methods
4 COLLABORATION LEVEL	

Researchers own field	•
Researchers other fields	• Medium (from architects to engineering)
Non-academic stakeholders	•
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Not appropriate
Regional	• Yes could be applied
National	• Yes could be applied
Pan European	• Yes could be applied

Methods for regulating and maintenance ES

- Selected ES 2: Buffering and attenuation of mass flows (2.2.1.2)
- Applied method 2: GISCAME
- Alternative method 2: Bayesian belief network

METHOD CARD: GISCAME Applied to: Buffering and attenuation of mass flows (2.2.1.2)	
CASE STUDY	Germany
SCALE	Regional
TYPE	Biophysical
TIER	2/3
DESCRIPTION	
The software tool GISCAME (GIS= geographic information system, CA = cellular automaton, ME = multi criteria evaluation) supports the simulation, visualization, and evaluation of land use changes. Due to its modular structure, problems can be elaborated individually from different perspectives. Here, effects of changes in grassland distribution on water erosion potential were modelled with the add-on tool in GISCAME based on the Universal Soil Loss Equation (USLE) with modifications to German characteristics (annual soil loss in t/ha).	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• LULC with distinguished classes for different crops. The more crops the more specific factors need to be included. • Detailed soil map with soil characteristics needed. All the factors to feed the USLE equation must be known. This may not be the case in certain contexts. • Digital elevation model (additional information).
2. RESOURCES REQUIREMENT	
Time	• Quite time-intensive. GISCAME tool well working so that does not need much time.
Cost	• Software company is now developing the tool as an online platform, which costs now 50 € / year.
Expertise	• GISCAME combines layers with an algorithm and provides the maps. The user interface is quite friendly. • Good GIS skills needed.
Tools & equipment	• GIS software to prepare the data and analyse the results.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Trade-offs with other biophysical factors (changes in provisioning services can be linked with different levels of soil erosion). • A strong conceptual relation with water retention (same factors).

Socio-cultural	• Driver: land use change –> to understand trade-offs between different ES
Economic	• Economic cost could be calculated based on the erosion analysis. Actually, economic impact has been assessed in Germany but access to this information is restricted. • Benefit transfer and replacement cost approach has been applied in some studies.
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	• Soil scientists, agencies that do their own modelling in the area (farm field mapping, very high-resolution set of maps: soil types, water levels, nutrient levels; production of these maps is extraordinarily expensive but the farmers are highly interested; assessment of the quality of management; both together would help farmers to better manage their fields). • (Quality of data management is very important as lots of data need to be integrated to assess erosion.)
Non-academic stakeholders	• Stakeholders could be engaged to refine the method, also discuss management issues, what could be done to avoid erosion, etc.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• At the local scale, other methods in collaboration with the farmers can provide results that are more meaningful.
Regional	• Appropriate. Case study done at this scale.
National	• Appropriate. A national scale erosion risk map already exists in Germany, but it could be possible to obtain the same results using GISCAME.
Pan European	• Can be difficult or even impossible due to difficulties in harmonizing data. Management systems of crops also differ from country to country. • Anyway, even if not "perfect", a more general erosion risk map in European level possible to see where the sensitive areas are. International agency for soil.

METHOD CARD: BAYESIAN BELIEF NETWORKS **Applied to: Urban Tree Valuation → Buffering and attenuation of mass flows (2.2.1.2)**	
CASE STUDY	Oslo, Norway, Openness case-study
SCALE	Regional/Local
TYPE	Biophysical
TIER	2
DESCRIPTION	
Bayesian Belief Networks (BBN) can be used for anything. A simple model or a very complex one are both possible. They can be applied to anything including probability. BBNs are for understanding uncertainty! Based on statistical modelling. BBNs are defined as graphical tools for building decision support systems to help make decisions under uncertain conditions (Cain, 2001). BBNs were originally developed to account for the impact of uncertainty about management systems so that decision-makers could balance the desirability of an outcome against the chance that the management option selected might fail. The representation of a system in terms of a set of relationships that have probabilities associated with them is at the heart of the Bayesian approach (Haines-Young et al., 2013). In the case study, the compensation value for city trees is calculated using the VAT03 assessment model developed by Randrup (2005) and adapted to a BBN by Barton et al, (2015). The model is based on the replacement cost of a city tree, including purchase and planting costs. This base value is then adjusted for the tree's structural health and for its qualities in a neighbourhood context, including adaptation and contribution to its local environmental. Environmental qualities include aesthetics, noise and pollution reduction, in other words several regulating ecosystem services. Further details about the BBN model can be obtained from here: http://openness.hugin.com/caseStudies/Oslo_trees	
1. DATA REQUIREMENT	
Qualitative	• Probabilities assessed by experts or stakeholders if evidence-based knowledge of the probability is not available.

	• Qualitative information/data, e.g. expert opinions, can be used.
Quantitative	• *E.g. in the Oslo model the following characteristics of trees was collected: tree species and age phase; damaged and new circumference (cm); price of a new tree (€); establishment cost (€); tree health: roots, trunk, branches, foliage and buds; Location: environmental factors, natural adaptation; aesthetics; visibility; architecture; Spill over: wood volume; neighbouring trees; wood price; tree height; distance to public spaces; forestry value;*
2. RESOURCES REQUIREMENT	
Time	• Medium-High if data validated by field observations
Cost	• Relatively low but it is dependent on the available data
Expertise	Medium-High • BBN software and method expertise. • Communicative skills are important. • Expertise related to the topic (in the Oslo case tree ecology and physiology, and valuation method).
Tools & equipment	• Access to local maps and datasets (in the Oslo case about tree distribution, ecology and physiology). • BBN software, both open source and commercial software are available. E.g. Hugin, Netica, Ilwis, Genie. Winbugs (includes spatial add-on related to statistical mapping). • Combining the BBN results with GIS data in a GIS software may be necessary if the tool does not include a GIS part. • QuickScan includes BBN
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• The method accounts for several environmental factors (e.g. in the Oslo case includes noise and pollution reduction by the tree species).
Socio-cultural	• The model may incorporate results obtained from socio-cultural methods. Examples from the Oslo case include distance to public spaces, public concern, aesthetics and visibility. • Narrative information as well as social science based data can be included.
Economic	• The method may be used for economic valuation (e.g. in the Oslo of urban trees).
4 COLLABORATION LEVEL	
Researchers own field	• Low-High depending on the case and simplicity / complexity of the model, research question, and capacity to do the assessment.
Researchers other fields	• Low-High depending on the case and simplicity / complexity of the model, research question and capacity to do the assessment. • The method makes use of biophysical, socio-cultural and economic methods. • Different kinds of expertise can be combined in a BBN model.
Non-academic stakeholders	• High. The BBN method aims to provide a management tool for land use managers and policy-makers.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• High
Regional	• High
National	• Somehow
Pan European	• Somehow

Methods for cultural ES

- Selected ES 3: Educational (3.1.2.2)
- Applied method 3: Narrative methods
- Alternative method 3:

METHOD CARD: NARRATIVE METHODS Applied to: Educational (3.1.2.2)	
CASE STUDY	Germany
SCALE	Local
TYPE	Socio-cultural
TIER	
DESCRIPTION	
Narrative methods mainly use qualitative data. By using narrative methods (e.g. in-depth and semi structured interviews, observations, voice and video recording of events, artistic expressions), it allows research participants to articulate the plural and heterogeneous values of ecosystem services through their own stories and direct actions (both verbally and visually). In the case study, to figure out in what multiple ways landscapes and ecosystems are used for educational purposes, individual questionnaires for forest and field ecosystems were prepared. Specifically, 15 photographs of typical landscapes used for evaluation (e.g. beach forest, maize field after harvest). No mapping based on the results. 40 respondents. When using this method it is useful to differentiate between institutional and non-institutional educational ES. Institutional = schools etc. using nature for education, non-institutional = learning from nature by the general public.	
1. DATA REQUIREMENT	
Qualitative	• Photographs and a number of respondents. Average of society should be chosen for respondents in the optimal case to have a representative study. Decide the right target group to survey based on the purpose of the study, suitable number of respondents. • Important to state clearly for what purpose the photos should be assessed (e.g. what is your favourite landscape – for what? this must be stated – but this is a preference study, not searching the educational value of presented landscape). Cross the number of items / processes that can be identified in the landscape presented in the photo. • Background statistics of the respondents and the answers. • Important to state which type of educational value is looked for (e.g. good places to learn from environmental damage, to learn from natural processes, etc.?)
Quantitative	•
2. RESOURCES REQUIREMENT	
Time	• Low
Cost	• Low
Expertise	• Medium; questions need to be designed and communicated to the respondents.
Tools & equipment	• Camera, projector, landscape theatre if possible
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Could use results from biophysical mappings? Pictures from biophysical monitoring sites where also e.g. forest growth etc. are regularly being measured. • Educational score can be combined in a grid consisting of a variety of layers describing the landscape. • Educational ES relating to: Erosion, geomorphology, water quality and so on. • (Capacity valuation of different landscapes based on educational value.)
Socio-cultural	• Dependent on socio-cultural situation / knowledge / science. • PPGIS methods can be used to assess and map educational ES and these can be correlated with biophysical mapping.

Economic	• Hypothetical market value of educational ES identified by stakeholders in different levels from local to national. • Use the value of e.g. wood in the place valued for educational ES.
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	• Social scientist is needed - if the method user is not a social scientist, a researcher from another field need to be engaged, at least social science knowledge is needed.
Non-academic stakeholders	• Teachers at kindergartens, schools, universities, nature schools, etc.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Yes
Regional	• Yes
National	• Depending on the purpose and setting of the study, on the question that you want to get an answer.
Pan European	• Depending on the question that you want to get an answer.

3.2.5. General comments from the breakout sessions

Since they were applied for the first time, Method Cards have also been discussed within the groups. Comments on the structure of the cards and the various fields have been collected and used to improve them. Below are the main comments that have emerged:

- In the Method Card, the distinction could be between "contextual" vs "site-specific" information, instead of qualitative vs quantitative.
- For "Time requirement", person/month per mapping unit could be used (e.g. specifying how long it took in a particular context, possibly break out the estimate for the different stages).
- For "Cost", we could give estimate of what can be done with different budget.
- For "Tools & Equipment", categories could be used, such as "highly specialized" to….
- The "Links and dependency on other methods" field could be split into dependency and synergy. Plus, it could be expanded to consider synergy for mapping other ES.
- For "Spatial scale", the card could include info on the actual size of the area, maybe considering threshold below/above which the method does not make sense. Moreover, perhaps include information about data production (e.g. is the method better suited for smaller area because you are not able to produce the data?). Include comments on "mandatory" data.
- Add a field to the method card for method limitations;
- Add a field for validation of the results;
- Add to the Method Cards what are the strengths of the method. For e.g., in BBNs strengths are that visual network enhances understanding of complex interactions. Parameters can be changed when understanding builds up. Visually helping discussion with stakeholders. However, clear distinction which factors are fixed and which have a probabilistic component in them is problematic. Similarly, in InVEST, there is an erosion model but it works on watershed basis.
- Add to the Method Cards a section for aims/policy questions that the method can answer (e.g. "even if the method can be applied, it might be not the best choice for this particular ES".)
- Consider the possibility of adding "warnings"/"cautions" to inform future users.

3.3. ESMERALDA methods development

3.3.1. ESMERALDA Methodology

A plenary session updated the participants about the development of the methodology and the activities that followed Workshop 2 (Nottingham, April 2016). Particularly, updates were presented about the methods matrix (collecting input and experience from the ESMERALDA consortium, also referred to as 'Google doc'[6]), the methods literature review, and the definitions and recommendations for methods "tiering". Thus, the session also exposed stakeholders to the overall ESMERALDA approach and to the breadth of the available methods for mapping and assessing ES. Following are abstract of the three plenary talks.

Flexible methodology in ESMERALDA: An introduction

ESMERALDA aims to deliver a 'flexible methodology' that can simultaneously provide 'innovative building blocks' for pan-European, national and regional ES mapping and assessment work (DoA, p.6). It will do this by developing ES mapping and assessment methods that are sufficiently versatile that they can be applied in all EU member states, as well as in the outermost regions, marine areas and specific biomes (DoA, p.8). To ensure a successful outcome for the Project, we need to be clear about what such a 'flexible methodology' actually is. This presentation introduces our current understandings of the idea, and what possible form it might take. The important point to emerge is that the design of such a flexible methodology can only be achieved if we see it as a process, involving the review of methods, and the discussion, testing and refinement of approaches. This presentation takes stock of what has been achieved so far in ESMERALDA, and where we are in this process of articulating what a flexible methodology is. The methodology clearly needs to take account of the different approaches to biophysical, social and economic mapping assessment, and especially the ways in which data and insights from them can be integrated and applied in different contexts. For the future, we need to identify how the ideas about this flexible methodology can be tested though our case studies and the various workshops, and how the lessons can be used to ensure that the outcomes of ESMERALDA support the needs of users working in the areas of concern touched upon by Action 5 of the EU Biodiversity Strategy for 2020, namely: planning, agriculture, climate, water and nature policy. This will perhaps involve providing guidance for ES mapping and assessment to the EU MS, with recommendations on how to map different ES at all scales across all the ecosystem types found in Europe, using various 'tiered' methods.

Understanding the use of mapping and assessment method in EU: looking for gaps and overlaps-preliminary results of the analysis

An overview of the variety of methods is gained in a systematic method review that included more than 300 scientific papers on ES in EU. Key characteristics such as dimension, methods, data used and ES assessed were stored in a database in order to review the common methods used at different scales, in different ecosystems and with different ES. The review is expected to help choosing suitable methods for

[6] 'Google doc' refers to the entries of case studies from the ESMERALDA consortium members, which started in WS 2 in Nottingham and continued overtime in the form of a "Google document"

different goals of mapping or assessment. The preliminary results presented in this meeting identify the different conditions, themes and geographical contexts in Europe, with the objective to be used as background information that can help at the development process of creating a flexible methodology to map and assess ES in EU. This presentation describes the potential uses of the database and highlights some challenges for future activities on mapping and assessment of ES.

Towards a tiered approach

A tiered approach applicable to all types of ES together with a decision tree providing guidance in the selection of tiers is presented (see Figure 3.3). We show how the methods listed in the method matrix can be related to the different tiers and discuss challenges and opportunities for the further development of the suggested tiered approach within the ESMERALDA project.

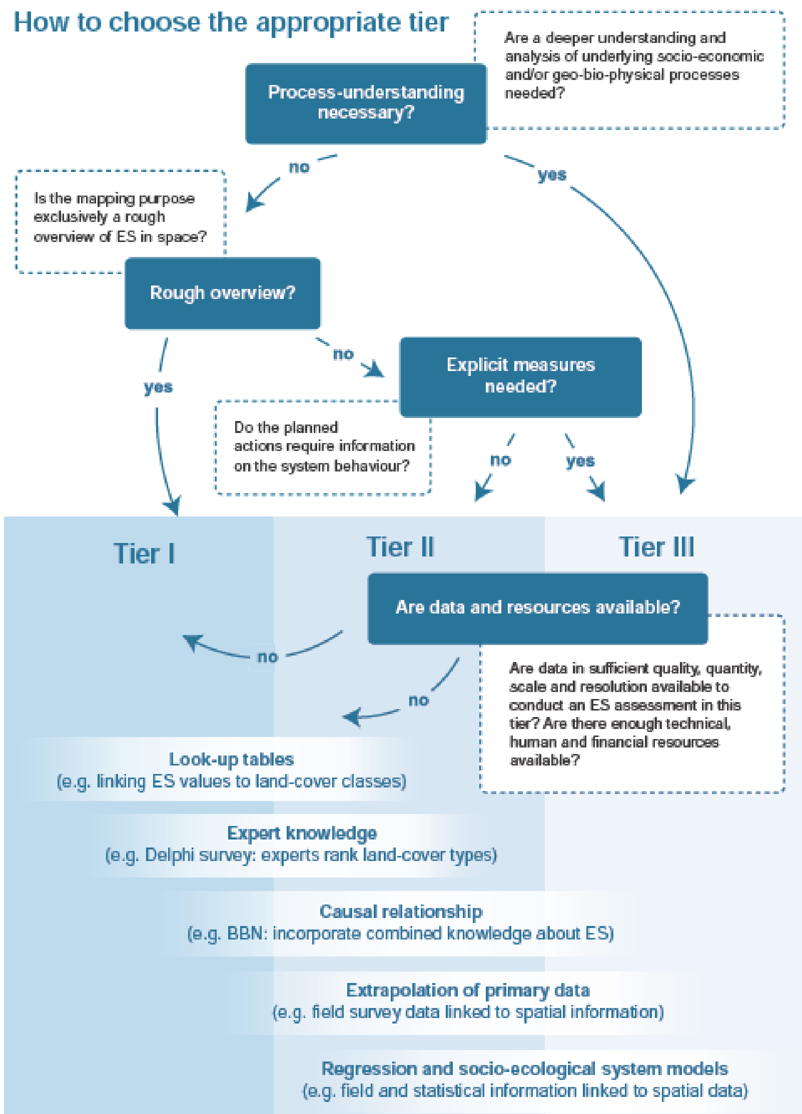


Figure 3.3. Decision tree guiding the selection of tiers for ES Mapping (Source: Grêt-Regamey et al. 2017[7])

[7] Grêt-Regamey, A., Weibel, B., Rabe S., Burkhard B. (2017). A tiered approach for ecosystem services mapping. In Mapping Ecosystem Services, Burkhard, B. & Maes, J., (Eds), Pensoft Publishers (Available online and fully Open Access at http://ab.pensoft.net/articles.php?id=12837).

3.4. Stakeholder involvement and training

3.4.1. Visualizing the ESMERALDA method databases

As part of the stakeholders' involvement and training, posters visualizing two method databases were displayed during the workshops (Figure 3. 4). A first set of posters showing the database based on the collection of input and experience from the ESMERALDA consortium, compiled following WS 2 in Nottingham (Figure 3.5). A second set of posters illustrating the database based on the on a comprehensive scientific literature review of methods carried out in WP 3 and WP 4 (Figure 3.6). The poster session allowed participants to visualize the structure of the method databases and discuss it with the experts involved in its development At this stage, a key aspect that emerged was for example the need to combine these two databases; another aspect dealt with the classification of the biophysical, socio-cultural, and economic methods. Both these aspects were addressed in the following workshops.

Figure 3. 4. Poster session in ESMERALDA WS3, Prague

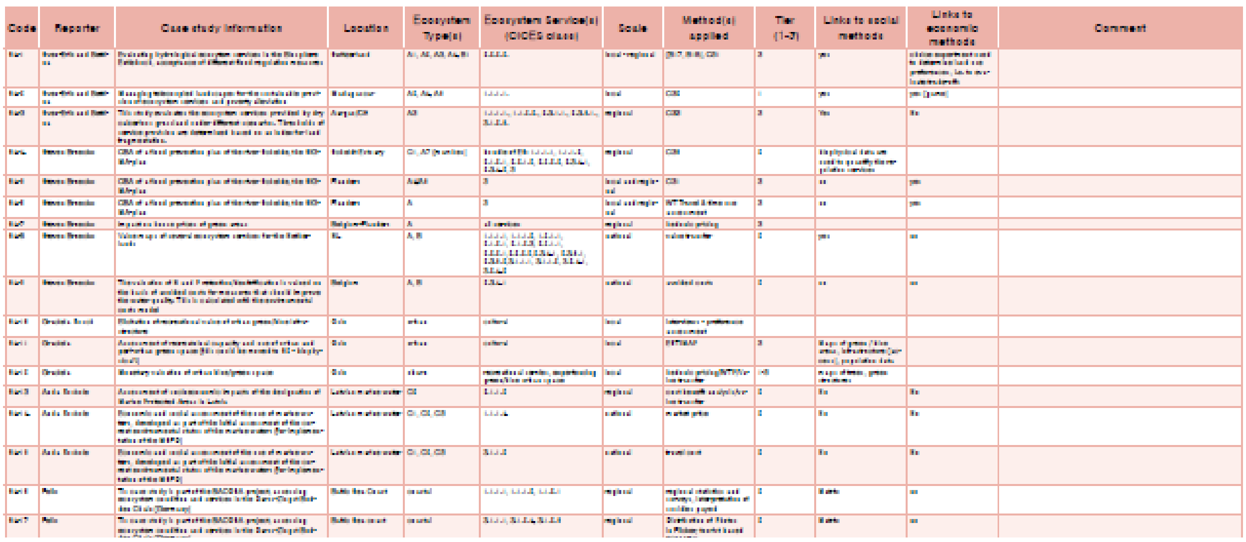


Figure 3.5. Example of poster of methods based on input and experience from the ESMERALDA consortium: each row represents a study and the columns are relevant entries such as ecosystem type, ES assessed, method applied etc. (Graphics: Maria Susana Orta Ortiz, M.S., UNITN)

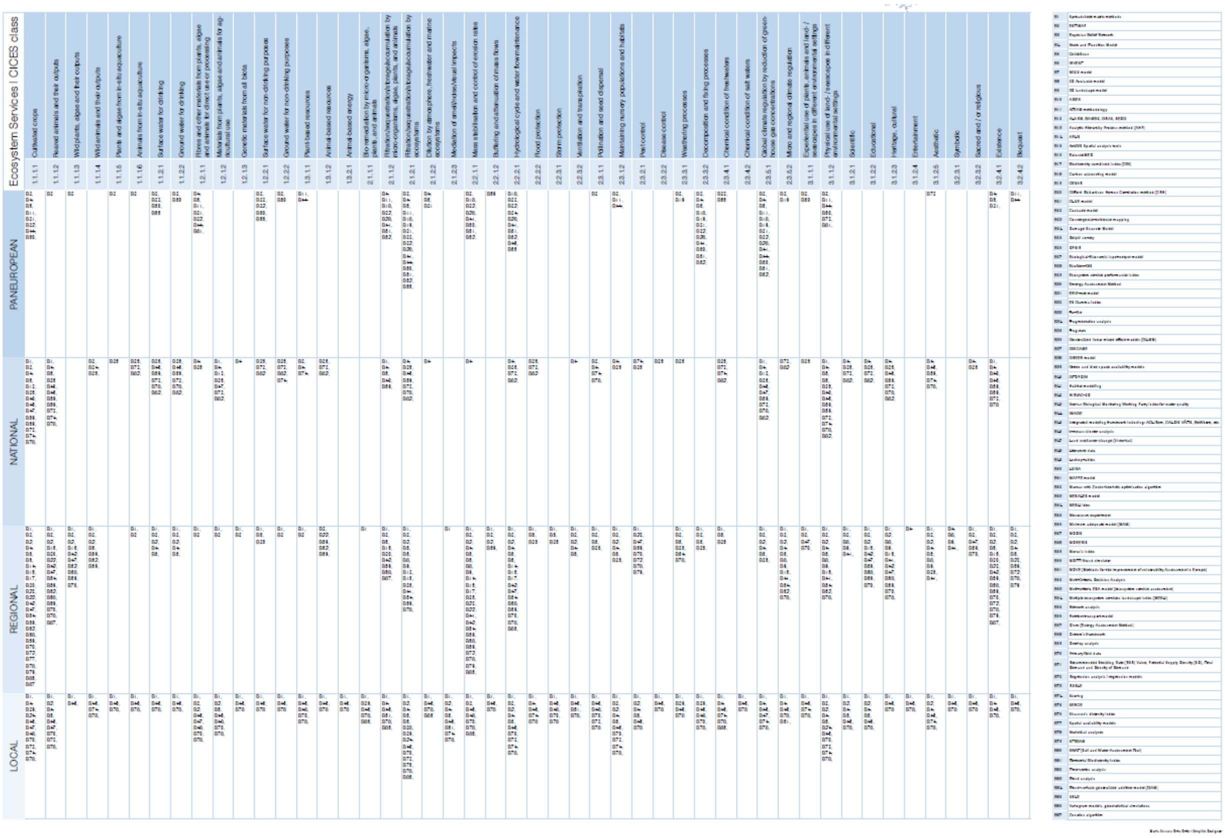


Figure 3.6. Example of poster of biophysical methods based on a comprehensive scientific literature review: columns represent ES according to CICES v4.3 and rows represent spatial scales (Graphics: Orta Ortiz, M.S., UNITN)

3.4.2. Discussion on the level of impacts of ES mapping and assessment

The session started with a panel discussion during which the stakeholders from the three case studies (see Table 3.2) shared their experience with ES mapping and assessment for policy and decision-making. To this end, during the preparatory phase, stakeholders were asked to answer some of the questions that helped build the panel discussion. Box 3.1 is an example of input provided by the stakeholder of the Germany case study: Dr. Uwe Rammert, from the State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein, Germany / Christian Albrecht University of Kiel.

Table 3.2. Stakeholders from the three case studies.

Latvia	Czechia	Germany
Mrs. Ingūna Urtāne (Ministry of the Environmental Protection and Regional Development) **Mrs. Solvita Strāķe** (Latvian Institute of Aquatic Ecology)	**Ms. Iva Honigová** (Czech Nature Conservation Agency) **Mr. Jiří Klápšte** (Ministry of the Environment of the Czech Republic)	**Dr. Uwe Rammert** (State Agency for Agriculture, the Environment and Rural Areas (LLUR) Schleswig-Holstein)

Role and examples of main activities:
Role 1: support information management and integrative approaches in the work of a State Agency responsible for monitoring, conceptual work and public information in all fields of environmental Protection and planning, in this role one of the main data sources for the German part of the project.
Role 2: lecturer at Kiel University, mainly dealing with environmental management, policy development and communication, implementation of environmental policies and legislation, implementing sustainability in decisions and concepts.

Policy context of operation
Formerly, responsible for the EIA part of granting procedures for large infrastructural projects as well as the development of technical and methodological guidelines for EIA implementation. Today senior advisor and information manager for plans, policies and programs, as well as for public information.

Examples of the type of decision-, and policy-making processes
- Providing appropriate information (and information technology) to answer relevant questions in the context of infrastructure planning and environmental protection
- support answers to parliamentary (=political) questions
- prepare and transfer information to different customers like ministries, agencies, NGOs and the public
- support bottom-up communication processes in project planning, e.g. in agro-environmental projects
- Development of a communication concept and practical tools and help to support project communication[8], so far developed for farmers and advisors, development for municipalities and universities is the target of a recently running INTERREG project with Denmark.

Some examples of policy-questions (both general and related to a specific ES) related to the case study
- How will different land management strategies influence the ecological situation in the region? (E.g. biodiversity, nutrient flows, etc.)
- What will be the impact of a planned road / incineration plant / housing area on different ESS locally, regionally and for the State?

Type of output that are the most useful for answering the different policy questions
- Maps showing the status of an area with regard to a certain influencing factor
- Maps showing the vulnerability
- Interactive maps that allow a decision maker to “ask questions” to a certain system status / influence / outcome of a management decision (→ Decision Support System)
- Easy to understand and to communicate information about ES, ES status, ES sensitivity for public information and for the support of new bottom-up project communication
- Further input for the recently running master´s thesis (supervised by Felix Müller and Uwe Rammert), dealing with the presentation of ES information in the framework of the recently developed Data Warehouse of the Ministry.
- Assessment of the environmental data provided by the State Agency regarding their usability and usefulness for the analysis and description of ES, possibly hints for useful improvements in the data.
- Most important output: secure a long-term effect of the communication about ES, avoiding short term enthusiasm vanishing in the haze after a short while, leaving no traces in the discussions of politicians, stakeholders and agency people / planners. Thus, the methodology should be easy to understand and easy to discuss / to be used in every day decisions. Moreover, it should help people to “map” their own plans and imperatives with ES in order to find out what they already know / want, and what the effects of their plans / actions may be. Ideally, it’s advisable to start a permanent process instead of a short-term straw fire.

Other users of the outputs within your organization: purpose and types of interaction
- People taking decisions about maintenance measures for nature areas, dealing with Biodiversity Strategy, Biotope Mapping
- People taking decisions about land use changes, infrastructure projects etc., dealing with instruments like EIA
- People answering questions coming from the parliament, the ministry, other agencies
- People fulfilling reporting obligations to the State Government, the Federal Government, the EU or the public
- People involved in education on various levels

Characteristics that make the outputs fit for supporting decision-making
- fast and interactive provision of actual information, tailored to the needs of the customers
- the source of data must be accepted to be reliable
- the information must fit to the problem addressed in their temporal and spatial resolution, must fit to different planning levels (local ←→ national) and time frames (reaction to an accident ←→ reaction to climate change)
- The information must accept the federal principle and give the same answers, even if we have 16 different State solutions or ever so many national approaches for a single problem. ES information and assessments should not be depending on individual viewpoints, but they should have a broadly accepted basis.

Box 3.1. Contribution by the stakeholder of the Germany case study

The stakeholder panel discussion was followed by breakout discussions focusing on the three case studies. The main here was to explore the extent to which ES mapping and assessment produced impact on policy

[8] http://www.agri-enviro-solutions.eu

and decision-making processes in the case studies, identifying some key factors that determine the level of impact. As an outcome, the "Pathway for and level of impact" framework by Ruckelshaus et al. (2015) shown in Figure 3.7 was filled in and discussed for the three case studies. Thus, some key factors to increase the impact of ES mapping and assessment on policy and decision-making, which can provide input towards the design of the ESMERALDA methodology, were identified.

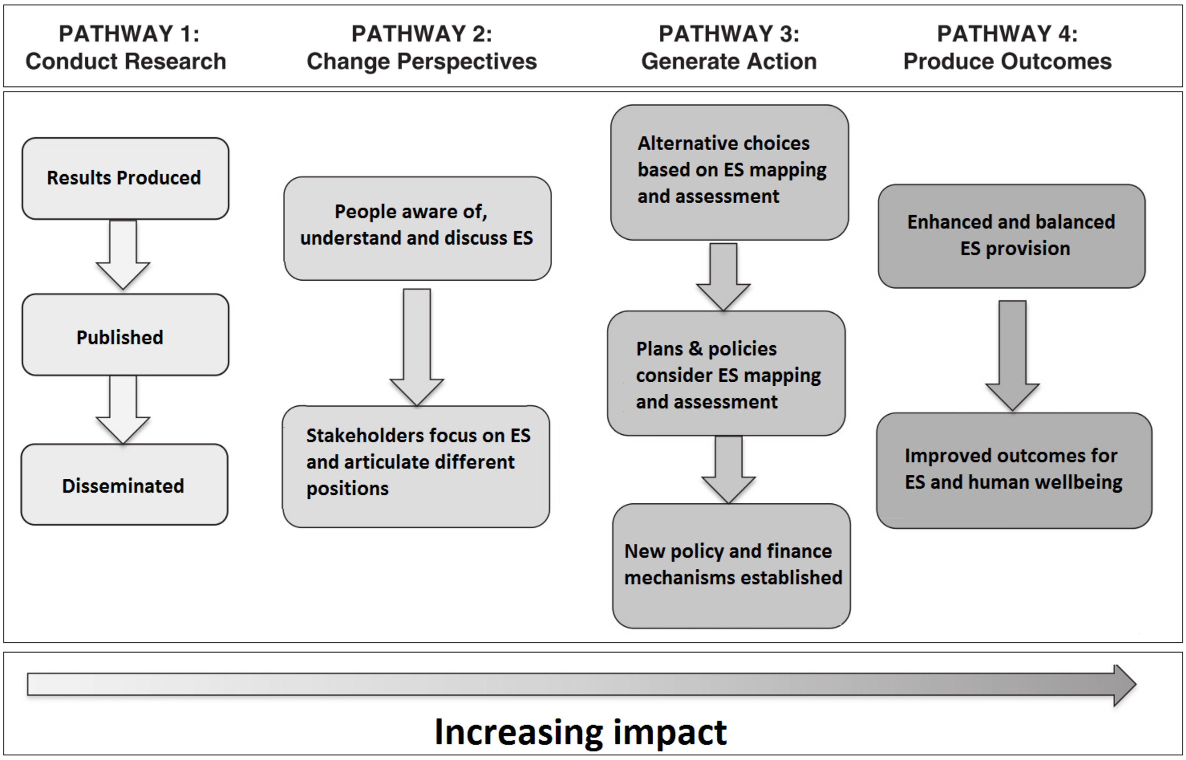


Figure 3.7. Pathways for and levels of impact of ES mapping and assessment information on decisions. (Modified after Ruckelshaus et al., 2015 [9])

[9] Ruckelshaus, M., McKenzie, E., Tallis, H., Guerry, A., Daily, G., Kareiva, P., Polasky, S., Ricketts, T., Bhagabati, N., Wood, S. a., Bernhardt, J., 2015. Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions. Ecol. Econ. 115, 11–21. doi:10.1016/j.ecolecon.2013.07.009

Session No. 4: Level of impact of ES mapping & assessment — Case Study LATVIA			
PATHWAY 1: CONDUCT RESEARCH	**PATHWAY 2: CHANGE PERSPECTIVE**	**PATHWAY 3: GENERATE ACTION**	**PATHWAY 5: PRODUCE OUTCOMES**
• Research was not the primary objective of the case study. Though, mapping &assessment marine ecosystems conducted as a part of the maritime spatial planning with the aim to support decision-making processes (pathway 3) • Expert driven process applied to assess ES	• new perspective on marine ecosystem introduced, since ES concept is still unfamiliar for the most of stakeholders • Very little feedback from stakeholder on ES as assessment did not include economic valuation • Lack of time to have discussion focused on ES during the MSP process • Lack of obvious conflict between different sectors and supply of ecosystem services	• MARITIME SPATIAL PLAN that includes a zoning proposal, which considered produced maps of ES supply • STRATEGIC ENVIRONMENTAL ASSESSMENT: impacts on marine ecosystem and its elements assessed; different solutions for sea-use were compared, using the information on ES	
• Several deliverables submitted to the Ministry of Environmental Protection and regional Development Disseminated trough websites and intensively communicated		• Most important information (maps, maps of ES hotspots) → they gave arguments for discussion among different sectors • MARINE STRATEGY PROGRAMME OF MEASURES (can use the same information)	

<table>
<tr><th colspan="4">Session No. 4: Level of impact of ES mapping & assessment — Case Study CZECHIA</th></tr>
<tr><th>PATHWAY 1:
CONDUCT RESEARCH</th><th>PATHWAY 2:
CHANGE PERSPECTIVE</th><th>PATHWAY 3:
GENERATE ACTION</th><th>PATHWAY 5:
PRODUCE OUTCOMES</th></tr>
<tr>
<td>• (Main question: How to involve stakeholders at this stage?)
• Results produced
• Aim: purely scientific
• Funding: Scientific project</td>
<td rowspan="2">• Let non-scientists to explain the concept
• Involve local people
• Identify champions (they support the concept and can spread the idea)
• Communicate and marketing your results</td>
<td>• The role for other stakeholders than researchers</td>
<td rowspan="2"></td>
</tr>
<tr>
<td rowspan="2">• Published in peer-reviewed journal
• Published in the nature conservation journal in the Czech Republic</td>
<td rowspan="2">• Links to specific policies
• Stakeholders like scenarios most
• Addressing need/policies of agencies
•</td>
</tr>
<tr>
<td rowspan="2">• E.g. the council of stakeholders
• How to deal with the distrust towards your results?
• It is important who is presenting the results</td>
<td rowspan="2"></td>
</tr>
<tr>
<td>• Available at GIS portal of the Czech Republic
• Published as an newspaper interview
• Presented to research community and governmental bodies
• This national ES assessment is mainly research driven!</td>
<td></td>
</tr>
</table>

Session No. 4: Level of impact of ES mapping & assessment — Case Study GERMANY[10]			
PATHWAY 1: CONDUCT RESEARCH	**PATHWAY 2: CHANGE PERSPECTIVE**	**PATHWAY 3: GENERATE ACTION**	**PATHWAY 5: PRODUCE OUTCOMES**
	• public presentations • pick people from the point (in terms of knowledge) where they are • make people aware that they have a stake • provide solutions where they are need • provide examples	• discuss with local stakeholders • ask questions • co-production of knowledge • make connections between the services • co-operate and work together (shared projects) • show best practices & real-world examples • need for economic & non-economic support • "fashionable" concepts can be useful to involve decision-makers •	
	• farmers happy to know that their products can be considered as "services" • Scientists are stakeholders too! and their participation promotes the acknowledgement of "invisible" services	• work on visions and desired futures of local people • go back with research results to the different agencies	
		• a longer-term perspective • more flexible policies and understanding of the effects (see biogas plants in DE)	

moving from "change perspective" to "generate action" is the biggest and most difficult step!!!

TOOLS: maps and interactive tools are particularly useful. **OTHER USERS OF MAES**: planners + NGO + education + public (= electors!")

10 See Box 3.1.

3.4.3. Insight into Czech Experience

The session provided the stakeholders and participants with an insight into Czech experience with ES research and applications, with examples from projects in the context of the Central and Eastern Europe.

ES research in the context of CzechGlobe projects and Central and Eastern Europe transitions
By **David Vačkář** (Global Change Research Institute, Czech Academy of Sciences)

The aim of the talk is to summarize recent activities in the area of ES research and applications in the Czech Republic. First efforts started within the project supported by the Technology Agency of the Czech Republic on "Integrated assessment of ecosystem services in the Czech Republic". This project brought first estimate of economic value of ecosystems in the CR, reaching 1.5 of annual GDP. Other applications followed, focusing on trade-off analysis and risk analysis for ES. Context of climate change and adaptation to climate change is also addressed, with applications in UNESCO Biosphere Reserves and cities. Urban ES and green infrastructure are currently important aspect of ES research in the context of changing cities.
The context of Central and Eastern Europe is illustrated on transitions in ecosystem management, presented recently in special issue of Ecosystem Health and Sustainability, new journal of Ecological Society of America and the Ecological Society of China. The context of streamlining of ES into decision-making and Sustainable Development goals is illustrated on examples of Experimental Ecosystem Accounting (SEEA-EEA) approaches and applications in Kyrgyz Republic.

A brief story on long efforts
By **Iva Hönigová** (Nature Conservation Agency of the Czech Republic, NCA)

The Czech Republic stepped into ES debate in its very early stage thanks to prof. Bedřich Moldan and Dr. Jan Plesník, who joined the Millennium Ecosystem Assessment in the period of 2001–2004. They used the opportunity and introduced the topic to colleagues and interested public. At the same time, Charles University Environment Centre (CUEC) had been working on several projects in related fields of study. Therefore, we were able to accept the challenge when the European Topic Centre for Biological Diversity proposed a pilot study on grassland ES to be elaborated in the Czech Republic in 2010–2011. NCA supplied a map of grasslands and the CUEC team provided both biophysical and socio-economic quantitative estimates of 7 ES. The Austrian Umweltbundesamt GmBH joined the study a year later and supplemented a part on trade-offs among ES provided by grasslands under various use.
ES assessment could continue thanks to efforts of the CUEC team whose substantial part resettled to CzechGlobe. Their project resulted in the quantitative estimates of majority of ES provided by all ecosystems in the CR on its entire area. The assessment was based on the Consolidated Layer of Ecosystems which captures land use/land cover in the country in much better detail than Corine Land Cover. Methodological framework for ES assessment in the CR produced by the CzechGlobe within the same project was accepted relatively fast and in June 2016 the Ministry of Environment finally agreed to initiate necessary steps towards the national assessment. Therefore, a brief overview of the ES assessment story in the Czech Republic could be concluded by promising vision of the ES assessment extending from the scientific labs to the decision making bodies.

3.5. Conclusions of WS 3

During the last workshop day, a general discussion took place to a) synthesize and discuss the results and outcomes of WS 3 and b) to communicate how the generated knowledge about methods will contribute to the development of the overall ESMERALDA flexible ES mapping and assessment methodology.

The synthesis and discussion showed that WS 3 was well-perceived by the participants and considered to be useful to increase knowledge about different methods and their applications in different policy and decision making contexts. The workshop has furthermore been useful to create a common understanding of methods and the overall aims of ESMERALDA and MAES. Suggestions for improvements included the wish to focus more on the technical aspects of ES mapping and assessment. This would be taken up in the following workshops in order to harness the consortium members' knowledge and to increase the common understanding of the various aspects that are part of ES mapping and assessment.

The gathered information and knowledge about ES mapping and assessment methods and the related methods database(s) will form the core of a diagnostic tool. That tool can eventually be used to, for example, query the ESMERALDA methods database in order to a) identify the appropriate method for ES mapping and assessment, b) analyse existing application of methods and c) identify gaps in ES mapping and assessment methods. Different entry points will be offered to access the data base, e.g. in form of decision-trees based on different query nodes (such as ES mapped, scale of study, quantification domain, tier, …), analytical question (such as identifying all methods mapping cultural ES with a Tier 3 approach), application queries (all methods used to address policy question xy on scale z) and methods availability (which ES were mapped most/least frequently on which scale, etc.).

It has been discussed to provide the ESMERALDA flexible methodology with i) a computer interface (potentially being programmed by partner ETH with contributions of all partners), and ii) a text documentation in a suitable format (guidance document to be developed by all partners based on various ESMERALDA Deliverables from all six WPs). The following workshops will be used to further develop these products, to test and to improve prototypes and to finally deliver the methodology and to provide it to relevant stakeholders from science, policy, society and practice in order to support MAES activities in their countries.

4. WS 4 "Testing the methods across themes", January 2017, Amsterdam (MS 25)

4.1. Aim and structure of WS 4

This Workshop was the second of three ESMERALDA workshops aimed at testing the first version of the flexible methodology under development in real-world case studies. It built on the work of the first testing workshop in Prague (September 2016) and on the results of WS 2 in Nottingham (April 2016) and subsequent activities, where methods for biophysical, social and economic studies of ES were being reviewed, discussed and classified. This led to outputs being developed including a methods compendium[11], a new structure for the ESMERALDADA database (based on the merging input and experience from the ESMERALDA consortium and a comprehensive methods literature review), as well as preliminary definitions and similar examples for the flexible methodology.

The overall aim of WS 4 was to explore whether the methods have the flexibility required to promote the integration of ES in a variety of policy themes and spatial scales relevant across the EU (DoA). WS 4 considered case studies from the Netherlands, Poland and Malta, mainly concentrating to the following themes: Natural risk (NL), Agriculture and Forestry (ML) and Urban and spatial planning (PL). Here, the discussion focused on the extendibility of the methods across different themes and spatial scales. At the same time, WS 4 also served to update the consortium about the latest developments towards the flexible ESMERALDA methodology for ES mapping and assessment. Hence, it provided the participants with an opportunity to contribute to the methods classification, database generation and methodology development during break-out sessions.

Figure 4.1. ESMERALDA Workshop 4 in Amsterdam, Netherlands - Participants Group Picture (By Pensoft)

[11] Method compendium refers to the (continually updated) list of biophysical, socio-cultural, and economic methods identified based on the comprehensive literature review and the input from consortium members.

In terms of content, also WS 4 consisted of three types of plenary/breakout sessions: case studies-, ESMERALDA methods development-, and finally stakeholder involvement and training-related sessions. With respect to the case studies, participants worked in three groups, each focusing on one case study (Netherlands, Poland and Malta). In these breakout sessions, each case study focused on one ES, resulting in a total of six ES covered during the whole workshop (see Table 4.1). First, the specific method that has been applied in the case study was presented, followed by another possible method suitable for mapping and assessing the same ES. The aim of these sessions was (1) to learn from the process of ES mapping through the concrete case studies using the illustration of input and output data, challenges and examples of concrete applications, and (2) to discuss the methods flexibility to promote the integration of ES in a variety of policy themes and spatial scales. In line with the previous workshop in Prague, Method Cards were prepared beforehand to support the discussion of different methods across spatial scales and policy themes and to provide detailed technical information.

Concerning the ESMERALDA methods development, the participants jointly worked for the further development of the method compendium, and ESMERALDA database. Here, the aim was to: (1) review a list of relevant biophysical, socio-cultural and economic methods and discuss a possibility of hierarchical classification system of nested methods (method compendium), (2) contribute to merging the two previous databases (ESMERALDA 'Google doc'[12] and literature review[13]) into a comprehensive ESMERALDA database and defining its final structure, and (3) discuss the structure of the ESMERALDA flexible methodology as a final key product.

Finally, concerning stakeholder involvement and training, WS 4 participants consist both ESMERALDA project partners, including new ones, and case study stakeholders, who provide feedback on the suitability of the methods to be used in different decision-making processes. In this respect, a day of the workshop was spent at the Biesbosch National Park, one of the last extensive freshwater tidal wetlands in Northwestern Europe. This gave the participants an opportunity to see and experience the practical context of the ES mapping and assessment of the Netherlands case study.

In the remainder of this section, we report the main results of the workshop organized as follows:

- ESMERALDA case studies related results
- ESMERALDA methods development
- Stakeholder involvement and training

[12] 'Google doc' refers to the entries of case studies from the ESMERALDA consortium members, which started in WS 2 in Nottingham and continued overtime in the form of a "Google document"
[13] Literature review refers to the comprehensive scientific literature review of methods coordinated by WP 3 & 4.

4.2. ESMERALDA case studies related results

4.2.1. Introducing WS 4 case studies and aim of the breakout discussions

In a plenary session, the salient elements of the three case studies were presented to pave the way for the discussion in the breakout sessions. The objectives and the general process of the ES mapping and assessment in the case studies were introduced, based on the Case Study Booklets (see Appendix: Case Study Booklets). Key questions addressed include "*What are the policy questions that motivated the mapping and assessment*?", "*how were ecosystems identified*?"; "*How were the ES and related selected and applied*?", "*What were the main outputs (maps, reports, table etc...) and how have they been used/can potentially be used to support policy and decision-making*?". The session also detailed the methods for mapping and assessment adopted in the case studies, by addressing the questions "*What methods to map ecosystem types and conditions were applied?"* and *"What methods for mapping and assessing ES were applied, focusing particularly on the three selected ES?*".

Figure 4.2: Pictures representing the Netherlands, Poland and Malta case studies (left to right)

Table 4.1: Overview of the case studies used in ESMERALDA Workshop 4, Amsterdam.

	NETHERLANDS	POLAND	MALTA
Title	ES-based coastal defence.	ES in Polish urban areas.	Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.
MAES status	Stage 3	Stage 2	Stage 2
Scale	Local	Local-(regional)	Local-regional
Theme	Natural Risk	Urban and Spatial Planning	Agriculture and Forestry
ES 1	Flood protection (2.2.2.2)	Filtration/sequestration/ storage/accumulation by ecosystems (2.1.2.1)	Reared animals and their outputs (1.1.1.2)
Method 1	Benefit transfer* Damage cost avoided Choice modelling	Spatial proxy models	Spreadsheet methods
Alt. methods	SWAT/Kineros-Model	-	Spatial proxy models Macro-ecological models
ES 2	Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)	Physical use of land / seascapes in different environmental settings (3.1.1.2)	Pollination and seed dispersal (2.3.1.1)
Method 2	Benefit transfer* Travel cost method / input-output modelling	Spatial proxy models	B 7. Spatial Proxy Models + Field data
Coordinator	P. van Beukering (VU)	D. Łowicki (UPOZ)	M. Balzan (MCAST)
Stakeholders	Droomfondsproject Haringvliet	Łukasz Mikuła (City council of Poznan)	Nikolas Cassar (MALTA Environment and Resources Authority)
Supporting expert	Bettina Weibel (ETHZ)	Inge Liekens (VITO)	Hannah Östergård (SEPA)

During the plenary the participants were exposed to the policy questions, and range of methods applied in the three case studies. Stakeholders were exposed to different methods. At the end of the session, it was clear which ES, related methods as well as which aspects were to be discussed during the breakouts (see Table 4.1, Figure 4.2 and further information in Appendix: Case Study Booklets).

In the breakout sessions that followed, for each case study, the selected ES and related methods for mapping and assessment were discussed bearing in mind two specific objectives. The first objectives was to discuss the applicability of mapping and assessment methods applied for the selected ES in the case study across different policy themes. Here, the idea was not to cover all the different policy themes rather to explore those that were more meaningful for the methods. The second objective was to analyse the main characteristics and applicability at different scales of the ES mapping method applied in the case studies and the alternative methods proposed by the supporting experts. Here, the discussion addressed issues related to data availability, resource requirement, usability of results, and in general, other strengths or limitations of applying the method at a specific spatial scale. Following are the results for the three case studies.

4.2.2. Malta: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.

This ES assessment and mapping has been mainly scientifically-driven, with the objective of this study being that of carrying out a first assessment of the capacity and flow of ES in the Maltese Islands. ES capacity is defined as the potential of ecosystems to provide services appreciated by humans, while ES flow refers to the actual use of the ES and occurs at the location where an ES enters within a utility or production function. Given the insular and urbanized environment, and the dependence on local ecosystems for the delivery of key ES, a policy objective could be that of analysing the spatial variation of ES in Malta. This would allow identifying spatially overlapping bundles of ES, and analysing the impact of policies and developments on the ecosystems' capacity to deliver key ES, and on their actual flow.

This work is particularly relevant to policy objectives of Malta's National Biodiversity Strategy and Action Plan, 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 ES.

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 316 km^2. The landscapes of the Maltese Islands have been shaped over several millennia by the geo-climatic conditions, and human exploitation, but nonetheless harbour considerable biodiversity; a consequence of the interesting biogeography of the Archipelago.

Discussion on Methods for different themes

- Selected ES 1: Reared animals and their outputs (1.1.1.2)
- Applied method 1: Preference Assessment

METHOD CARD: Preference Assessment Applied to: Reared animals and their outputs (1.1.1.2)	
CASE STUDY	Malta
SCALE	Local
TYPE	Socio-cultural
TIER	1
DESCRIPTION	
Preference assessment is a direct and consultative method used to demonstrate the social importance of ecosystem services by analysing social motivations, perceptions, knowledge and associated values of ecosystem services demand or use. In this case-study, a preference assessment exercise was carried out with beekeepers to determine the characteristics of ecosystems preferred for honey production and beekeeping. Questionnaires were used in the initial stages of the research to determine the preferred plants and habitats, and their contribution to the delivery of the ES. This was followed by a focus group with another group of beekeepers, during which they were asked to provide information about the role of different ecosystems across time and space. In this case, an emphasis is placed on collective preferences of service users	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Satellite images were used to create a land use land cover baseline map. This was validated using ground truth areas. • The respondents' contributions were analysed quantitatively and an emphasis was placed on collective preferences.
2. RESOURCES REQUIREMENT	
Time	• Medium
Cost	• Low/Medium – the cost is dependent of the availability of baseline data and/or the human resources required to obtain any necessary data.
Expertise	• Remote sensing expertise • Stakeholder participatory techniques • Agricultural and ecological knowledge of the area
Tools & equipment	• GIS and classification software, and the necessary hardware.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• The assessment and mapping of other provisioning, regulating and cultural ES was based on the developed LULC maps. This allows for the assessment of the ability of different ecosystems to deliver multiple ecosystem services (ES bundles).
Socio-cultural	• Preference assessments were carried out with beekeepers to determine the importance of different ecosystems for beekeeping and honey production.
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Medium
Non-academic stakeholders	• High. During this case-study beekeepers participated in a preference assessment documenting habitats and places important for the maintenance of these ES across spatio-temporal scales.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly. This assessment/mapping exercise is considered as being a local study, even though it has been implemented at a national scale in Malta, given the small terrestrial surface area covered. The study area is characterized by a high land use heterogeneity and the small size of the landscape units.

Regional	• Highly. This method can be applied at the local and regional scales, when local land use land cover data is available and through the participation on local experts and non-academic stakeholders.
National	• Somewhat appropriate at a national scale.
Pan European	• Somewhat appropriate at a Pan-European scale, assuming that it is possible for local experts to engage with ES users.
6. EXAMPLES OF POLICY QUESTION	
	• How do existing land uses contribute to this ES? • And how does this contribution vary spatio-temporally? • What type of green infrastructure (e.g. agricultural habitat management) can enhance the delivery of this ES?

Some key points that emerged during the application of the method in the Malta case study include:

- Importance of translating “abstract” concepts into entities familiar to stakeholders;
- Maps and assessments may not fully capture all biophysical factors, including seasonal variability of the ES, fine scale variability or presence of non-continuous habitats (for a number or reasons);
- Framing the assessment as an interactive learning process with stakeholders is crucial to overcome limitations of the method.

Some key points that emerged during the discussion on the applicability to different themes:

- A trade-off between accuracy and participation may emerge, and needs to be balanced according to the policy question leading the process;
- Maps capture local knowledge (e.g. presence of pesticides), and thus can inform monitoring activities in other sectors (i.e. themes) as well;
- Assessing supply and demand of the ES is challenging (for e.g. implies considering social dynamics, synergies between ES) but more informative for policy making (e.g. designing funding schemes) also involving multiple sectors;
- National statistics and literature data can be good starting points for demand-side assessments;
- Generally, preference assessment is applicable to many other ES, which makes it suitable to a number of policy themes. However, the application made in Malta has some peculiarities, given it was combined with a spreadsheet method to actually build the map;
- Potential applicability of “Preference Assessment” to regulating services is questionable, it depends on the representativeness of the respondents, which can be improved by involving sufficient number of stakeholders and by combining methods;
- Potential applicability of “Preference Assessment” depends on the qualitative or quantitative nature of the policy question;
- Expert opinions/local ecological knowledge essential for ES assessments in data scarce contexts and marginal sectors;
- Assessments based on social methods have to be supported also by biophysical methods.

Discussion on scale issues in ES mapping

- Selected ES 2: Pollination and seed dispersal (2.3.1.1)
- Applied method 2: Spatial proxy models
- Alternative method 2: Spreadsheet method

METHOD CARD: SPATIAL PROXY MODELS Applied to: Pollination and seed dispersal (2.3.1.1)	
CASE STUDY	Malta
SCALE	Local
TYPE	Biophysical
TIER	2
DESCRIPTION	
Spatial proxy models are used to relate ES indicators to landscape units by developing an understanding of the relationships between service delivery and the ecosystem characteristics. A spatial proxy model that relates pollination ecosystem services to the land cover was developed during this study. The objective, in this case, was to analyse the contribution of different land cover categories to the diversity of pollinators in a number of points within landscapes of the Maltese Islands. Subsequently, spatial proxy models were developed to link pollinator diversity to the area cover of different land uses. The model estimates for significant variables were then used to predict the contribution of different landscape units to the delivery of pollination ecosystem services within the landscapes.	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Satellite images were used to create a land use land cover baseline map. This was validated using ground truth areas. • Pollinator diversity data was collected from a number of points. These points were characterized in terms of the predominant habitat type.
2. RESOURCES REQUIREMENT	
Time	• Medium/High - depending on data, biodiversity expertise, and land use land cover map availability.
Cost	• Low/Medium – the cost is again dependent of the availability of baseline data and/or the human resources required to obtain any necessary data.
Expertise	• Remote sensing expertise • Taxonomy and ecological expertise (pollinators) • Agricultural and ecological knowledge of the area
Tools & equipment	• GIS and classification software, and the necessary hardware. • Statistical software • Ecological sampling tools (depend on the methods used)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• The assessment and mapping of other provisioning, regulating and cultural ES was based on the developed LULC maps. This allows for the assessment of the ability of different ecosystems to deliver multiple ecosystem services (ES bundles).
Socio-cultural	• Preference assessments were carried out with beekeepers to determine the importance of different ecosystems for beekeeping and honey production.
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• Low

Non-academic stakeholders	• If the assessment of pollination ES using spatial proxy models is considered on its own, than one may say that the required collaboration level with non-academic stakeholders is low. But, in reality, and as aforementioned, this analysis complements another study during which beekeepers, and also farmers, participated in a preference assessment documenting habitats and places important for the maintenance of these ES across spatio-temporal scales.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly. This assessment/mapping exercise is considered as being a local study, even though it has been implemented at a national scale in Malta, given the small terrestrial surface area covered. The study area is characterized by a high land use heterogeneity and the small size of the landscape units.
Regional	• Highly. This method can be applied at the local and regional scales, when the required data sources are available.
National	• Somewhat appropriate at a national scale, but due consideration should be given to the natural spatio-temporal variation in pollinator diversity and ES delivery.
Pan European	• Not Appropriate. Pollinator diversity, used as a proxy of pollination ES delivery, varies considerably across Europe due to climatic variation, biogeographical phenomena and ecological aspects.
6. EXAMPLES OF POLICY QUESTION	
	• How do existing land uses contribute to the conservation of pollinators and pollination ES? • What type of green infrastructure can enhance the delivery of pollination ES? • What are the trade-offs and synergies arising from habitat management for enhancing the delivery of pollination ES?

METHOD CARD: SPREAD SHEET METHOD Applied to: Pollination and seed dispersal (2.3.1.1)	
CASE STUDY	Ecosystem services in agricultural areas in Scania, Sweden
SCALE	Local - regional
TYPE	Biophysical
TIER	2
DESCRIPTION	
Presentation of a policy synthesis (various case studies performed within the research environment "SAPES"). Dänhardt m fl. 2013. Ekosystemtjänster i det skånska jordbrukslandskapet. CEC Syntes Nr 01. Centrum för miljö- och klimatforskning, Lunds universitet. ISBN 978-91-981577-0-3. Grey report (in Swedish) http://www.cec.lu.se/sites/cec.lu.se/files/ekosystemtjanster_upplaga2_2015_lag.pdf Publications by the SAPES research environment 2010 – 2016: http://www.cec.lu.se/sites/cec.prodwebb.lu.se/files/publikationslista_sapes_mars_2016.pdf	
1. DATA REQUIREMENT	
Qualitative	• Required – data available within various research projects, available within collaborative projects
Quantitative	• Desirable
2. RESOURCES REQUIREMENT	
Time	• Long term studies
Cost	• n/a
Expertise	• High
Tools & equipment	• Official statistics, remote sensing, ecological modelling, field inventories
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Synergies and trade-offs

Socio-cultural	• Understanding land-use decisions
Economic	• Contributing to adaptive governance of agro-ecosystems
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• High
Non-academic stakeholders	• High
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Somehow – highly appropriate
Regional	• Highly appropriate
National	• Somehow may be used
Pan European	• Somehow may be used
6. EXAMPLES OF POLICY QUESTION	
	• Increased knowledge of important ES services in the region, their sustainable use and how that affects the development of profitable farming companies.

Some peculiarities, key challenges and main results in the application of the method in Malta include:

- Land cover type was considered as synonymous to habitat;
- It was difficult to obtain similar sampling locations across the different land covers in the landscape due to the scarcity and fragmentation of certain ecosystems on the island (e.g. sand beaches);
- The fact that 2016 was very dry affected the results of field visits;
- An important finding is that pollinators diversity is significantly correlated with woodland and agricultural ecosystems;
- Also other non-significant associations emerged, for example the positive relation with urban green infrastructures or the different contributions of different croplands;
- An advantage of the method is that it looks at diversity in certain points without involving other aspects, such as nesting. Yet, this is also a limiting factor in finding the explanation for the results.

Some key points that emerged during the discussion on the applicability to different scales:

- The method as applied in Malta is mostly limited to the local and regional scale, and one must be aware that pollinators' diversity varies across scale;
- The method is actually scale independent and data/resource availability seem to be the main limiting factor, which new monitoring and analysis technologies could help overcome;
- While the method is potentially scale-independent but data, validation, and policy question are not; thus the importance of data sharing;
- Temporal variations are crucial but challenging aspect to account for in ES assessment;
- Despite some peculiarities, the ESMERALDA methodology does not to need to distinguish between methods for islands and for mainland but rather highlight differences related to interpretation of results and importance of boundary conditions, among others.
- Generally, the relation between methods and scale could better captured by starting from the selection of an indicator and the pathways for its quantification.
- Supply- and demand-side assessment crucial for an actual quantification of the ES but quite complex;
- Demand side assessment of pollination services has to account for social factors, which require relying more on social and economic methods.

4.2.3. Poland: ES in Polish urban areas

This study was commissioned by the Ministry of the Environment and conducted in year 2015. It has been conducted in accordance with the MAES process promoted by the European Commission, and in particular is part of the implementation of Urban MAES pilot project. The main purpose of the study was to identify the spatial structures of ecosystems in the 10 largest urbanized areas in Poland and compare them in terms of their potential for providing ES. A second purpose was to suggest procedures for identifying and evaluating selected ES, demonstrating their spatial distribution in urban areas. Then, based on the results, to propose recommendations for spatial planning on local and sub-regional levels.

The Republic of Poland is a country in Central Europe, situated between the Baltic Sea in the north and two mountain ranges (the Sudetes and Carpathian Mountains) in the south. With a total area of 312,679 Km^2 and population of 38.5 million, it is the ninth largest and sixth most populous member of the EU.

Discussion on Methods for different themes

- ❖ Selected ES 1: Physical use of land- / seascapes in different environmental settings (3.1.1.2)
- ❖ Applied method 1: Spatial proxy models
- ❖ Alternative method 1: Survey and Choice experiment

<table>
<tr><th colspan="2">METHOD CARD: Spatial proxy models
Applied to: Physical use of land- /seascapes in different environmental settings (3.1.1.2)</th></tr>
<tr><td>CASE STUDY</td><td>Ecosystem services in Polish urban areas (WS4_cs2)</td></tr>
<tr><td>SCALE</td><td>Regional, Local</td></tr>
<tr><td>TYPE</td><td>Biophysical</td></tr>
<tr><td>TIER</td><td>2</td></tr>
<tr><td colspan="2">DESCRIPTION</td></tr>
<tr><td colspan="2">To assess ES potential for physical use of landscapes for recreational purposes, a formalized procedure was proposed that consists of selecting the green infrastructure (GI) patches and recognizing what part of the intensive development is situated within comfortable distance from it. The distance is one of the main criteria deciding about physical use for recreation.

<u>Operational main steps:</u> 1) Literature review to set analysis criteria; 2) Selection of land use types that has priority and significant level of potential to supply ES: the individual land use types were allocated with the level of ecosystem services: P – priority, I – significant, N – insignificant, B – lack. 3) Selection of green infrastructure patches with size >2ha (GIS spatial analysis). 4) Buffering selected green infrastructure patches in a distance of 300m (5-6 minutes walking route) and 1000m (15 minutes walking route) to highlight areas above this threshold (GIS spatial analysis). 5) Visualization of areas in close proximity to GI and calculation of share of the intensive development within accessible distance.

<u>Outputs:</u> 1) Maps showing residential areas in a close proximity (300 and 1000m) to green infrastructure. 2) Maps presenting residential areas further away from selected green infrastructure patches.</td></tr>
<tr><td colspan="2">1. DATA REQUIREMENT</td></tr>
<tr><td>Qualitative</td><td>• <u>Required:</u> Land use vector data with delineated green infrastructure and residential areas. (Sources: Urban Atlas, part of the local component of the GMES/Copernicus land monitoring services. It provides land use maps for 305 Large Urban Zones and their surroundings (more than 100.000 inhabitants) for the reference year 2006.
• <u>Desirable:</u> Location and number of residential housing or addresses points with assign number and profile of residents.</td></tr>
</table>

Quantitative	• Digital thematic map. (Geometric resolution: 1:10 000; Min MU = 0.25 ha • Positional accuracy: + / - 5 m • Thematic accuracy (in %): - Minimum overall accuracy for level 1 class 1 "Artificial surfaces": 85%. - Minimum overall accuracy (all classes): 80%.
2. RESOURCES REQUIREMENT	
Time	• Low, time efficient
Cost	• Low
Expertise	• Medium
Tools & equipment	• GIS software, PC
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• No
Socio-cultural	• No
Economic	• No
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Low
Non-academic stakeholders	• Low
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Method can be applied for local scale only with more detail data, e.g. buffer zones around selected urban park.
Regional	• Yes, city scale.
National	• Possible to compare 27 Large Urban Zones or core cities in Poland.
Pan European	• Possible to compare 305 Large Urban Zones or core cities in Europe.
6. EXAMPLES OF POLICY QUESTION	
	• Where are areas with low accessibility to green infrastructure? • How much residential areas has poor accessibility to green spaces? • Where further improvement in green infrastructure should be targeted?

Some key points that emerged during the application of the method in the Poland case study include:

- Selecting the most appropriate database in terms of geometric and thematic resolution is crucial;
- Defining the usage of green spaces for recreation from a human rather a biodiversity perspective;
- Analysing and deriving key recommendation for spatial planning including minimum size of green space, accessibility, demand side analysis;
- Assessment and comparison carried out for 10 metropolitan areas and core cities;
- A more complex analysis requires data that is more consistent (e.g., about population); this initial benchmarking of cities can support national urban policies on providing green spaces for inhabitants;
- The study findings indicate Polish cities are in quite good condition and provide evidence about the cities needing more actions to improve green spaces for inhabitants.

METHOD CARD: Choice modelling Applied to: Physical use of land- /seascapes in different environmental settings (3.1.1.2)	
CASE STUDY	Based on applications in Belgium (Flanders region).
SCALE	Urban areas
TYPE	Social/economic
TIER	3

DESCRIPTION

A stated preference method that uses surveys to ask respondents to make trade-offs between different levels of ecosystem service provision and payments or willingness to perform a certain activity (e.g. willingness to visit a certain area)

Specific steps:
1. Design survey: identify attributes in the survey such as attractive characteristics of an area; travel distance to the area, availability of paths, which are potentially influencing people's willingness to pay, design the different choices the respondents need to make.
2. Statistical analysis of results
3. Apply results to maps, identify attractive areas and estimate potential amount of visitors for specific areas.

1. DATA REQUIREMENT	
Qualitative	• List of relevant characteristics: based on choice experiment or benefit transfer from literature • Levels of different characteristics used in the survey translated to the land use of the studied areas. Some data are not easy to find on a national level e.g. path density; recreational facilities such as visitor centres.
Quantitative	• Average number of visits per inhabitant based on surveys. E.g., in Belgium, every year a part of the population is asked to answer a survey on how they spend their time. Not necessary available in every country. Could be asked within the preceding questions of the choice experiment. • Willingness to pay data: choice model or benefit transfer from literature.
2. RESOURCES REQUIREMENT	
Time	• High: very time consuming • Lower if you do not perform an own choice experiment, but use literature (benefits transfer).
Cost	• High: depends on how the surveys are done: face to face or through internet • Lower if literature review
Expertise	• High: to avoid biases in the responses the survey need to be very well designed.
Tools & equipment	• Particular software (statistical packages) to analyse this type of surveys. • Required calculation capacity to run the recreation model on a national scale is very high.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Some of the characteristics influencing attractiveness need to be linked to biophysical data e.g. biodiversity data
Socio-cultural	• Amount of inhabitants and their preferences for certain characteristics of the landscape they want to visit.
Economic	• Willingness to pay for visits • Alternative: expenditures per trip or travel cost method to value trips.
4 COLLABORATION LEVEL	
Researchers own field	• high
Researchers other fields	• high
Non-academic stakeholders	• High: preferences of people
5. SPATIAL SCALE OF APPLICATION[1]	

Local	• Somehow appropriate
Regional	• Highly appropriate
National	• Highly appropriate
Pan European	• Somehow appropriate
6. EXAMPLES OF POLICY QUESTION	
	• Attractiveness of an area for walking and biking • Shortage of recreation possibilities in comparison with the demand. High recreation pressure on some areas.

Some key points based on the application of the method in Belgium (Flanders region), focusing however on entire region rather than green areas in urban context:

- Recreational services are assessed based on demand of people (e.g. based on existing behaviours evaluated with surveys) and supply of recreational areas (e.g. the availability of green spaces and attractiveness (e.g. proximity and size) of recreational facilities);
- Unfortunately, most of the available data refers to typical iconic areas, with limited information on what people do in large natural parks or surroundings of their homes. Thus, choice experiment based surveys are an interesting option to query people's preferences.
- Creative use of information collected for other scopes crucial to assess recreation (e.g. monitoring the achievement of some green standards in Belgium);
- Disaggregated analysis based on age groups and family types is essential but challenging;
- Selecting the right type of information (e.g. combing land use maps with individual buildings, specific crops types, tree species, point data of urban areas etc.) is crucial for capturing recreation ES;
- Monetary evaluation and number of jobs, as prominent aspects for policy makers, can effectively communicate value of ES.

Some key points that emerged during the discussion on the applicability to different themes:

- There is need of platforms and guidelines for efficient data sharing among institutions;
- Limited institutional capacity of stakeholders hinders knowledge transfer;
- Applicability of methods (spatial proxy models or proximity analysis) for assessing recreation ES is also affected by the type of ecosystem; for e.g. Spatial proxy models or proximity analysis do not seem to be much appropriate in the assessment of grasslands, contrary to urban areas;
- Many methods are available (e.g. ESTIMAP) but need adaptation the local context;
- A clear understanding of whether the supply- or demand-side of recreation is assessed is crucial;
- Demand for recreation ES is highly dynamic, and monitoring activities can help capture this aspect; recreation is one of the quickest changing ES, given people come up with new ways of using nature.

Discussion on scale issues in ES mapping

- Selected ES 2: Filtration/ sequestration/ storage/ accumulation by ecosystems (2.1.2.1)
- Applied method applied 2: Spatial proxy models
- Alternative method 2: Process-Based Models & Hydrological Modelling + Replacement cost & Cost-effectiveness analysis

<table>
<tr><th colspan="2">METHOD CARD: Spatial proxy models
Applied to: Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)</th></tr>
<tr><td>CASE STUDY</td><td>Ecosystem services in Polish urban areas (WS4_cs2)</td></tr>
<tr><td>SCALE</td><td>Regional, local</td></tr>
<tr><td>TYPE</td><td>Biophysical</td></tr>
<tr><td>TIER</td><td>2</td></tr>
<tr><td colspan="2">DESCRIPTION</td></tr>
<tr><td colspan="2">To assess ES potential for filtration of surface pollution by ecosystems, a formalized procedure was proposed. Based on a literature review and taking into account:
• the contact/lack of contact with water bodies and watercourses,
• location in/out the flood zones,
The proper level of ES potential was assigned to different types/classes of land cover. Type of vegetation and spatial configuration of land cover patches are one of the most important factors that influence on effectiveness of biogeochemical barriers.

<u>Operational main steps: </u>1) Literature review to set analysis criteria. 2) Selection of land use types that have priority and significant level of potential to supply ES: the individual land use types were allocated with the level of ecosystem services: P – priority, I – significant, N – insignificant, B – lack. 3) Grouping the land cover patches taking into account distance to water bodies and watercourses (contact with water bodies or lack of contact with water bodies) and location in/out flood zones - GIS spatial analysis. 4) Assigning the above mentioned “levels of potential to supply ES” to land cover patches in given research area (GIS spatial analysis). 5) Visualization of areas of different potential to supply analysed ES and calculation of their share in given research area.

<u>Outputs: 1) </u>Maps showing spatial distribution of ecosystems potential to filtration of surface pollution</td></tr>
<tr><td colspan="2">1. DATA REQUIREMENT</td></tr>
<tr><td>Qualitative</td><td>• Literature</td></tr>
<tr><td>Quantitative</td><td>• <u>Required:</u>
o Land use/land cover (LULC) vector data
Sources: Urban Atlas - http://www.eea.europa.eu/data-and-maps/data/urban-atlas, The European Urban Atlas is part of the local component of the GMES/Copernicus land monitoring services. It provides land use maps for 305 Large Urban Zones and their surroundings (more than 100.000 inhabitants as defined by the Urban Audit) for the year 2006.
Corine Land Cover 2006 - http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version;
A Corine land cover map for the year 2006 (CLC2006) was produced by integrating the data of land cover changes 2000–2006 with the land cover map from the year 2000 (CLC2000).
Access to data: open, free.

o Flood risk/threat maps (vector datasets)
Sources: National Water Management Authority (Poland)
Access to data: open – only for maps in PDF format (http://mapy.isok.gov.pl/imap/), on request – vector datasets (payable).
• <u>Desirable:</u>
o Land use/land cover (LULC) vector data – current detailed data in scale 1:10 000 or larger with open access (free).</td></tr>
</table>

	o Flood risk/threat maps (vector datasets) – current detailed data in scale 1:10 000 or larger with open access (free).
2. RESOURCES REQUIREMENT	
Time	• Low to high (e.g. if raster data should be digitalized to vector model)
Cost	• Low to medium (e.g. need for flood maps acquisition)
Expertise	• Low
Tools & equipment	• Low (e.g. need for GIS software, PC)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• No
Socio-cultural	• No
Economic	• No
4 COLLABORATION LEVEL	
Researchers own field	• Low to medium
Researchers other fields	• Low to medium (optional consultations with e.g. biologist, geomorphologist, hydrologist)
Non-academic stakeholders	• Medium (need for data acquisition from public institutions, e.g. National Water Management Authority)
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Yes (use of more detailed data is recommended)
Regional	• Yes
National	• Possible to compare 27 large urban zones or core cities in Poland.
Pan European	• Possible to compare 305 Large Urban Zones or core cities in Europe.
6. EXAMPLES OF POLICY QUESTION	
	• Which water bodies/watercourses and flood risk areas are better protected by natural biogeochemical barriers? • Which surroundings of water bodies and watercourses should be improved to be more efficient as a biogeochemical barrier? • Where further improvement in land use should be targeted to strengthen the supply of analysed ES? • Where are the hotspots of analysed ES?

METHOD CARD: Replacement cost (marginal abatement costs) Applied to: Filtration, sequestration/storage/accumulation by ecosystems (2.1.2.1)	
CASE STUDY	Poland
SCALE	Urban areas
TYPE	Economic
TIER	2
DESCRIPTION	
This approach considers the cost savings due to nutrient reduction in the water, when a specific water quality objective has to be met. An advantage is the possibility to use values based on local abatement costs, which might be acceptable for local stakeholders. A risk however is that there is no direct relation to ES benefits. It is mainly driven by legal requirements (e.g. Water framework directive) which do not necessarily reflect the societal benefits of good water quality. Marginal abatement costs are the cost (€ per kg removal) of the measure required to meet a given target. They can be based on existing model outputs at the national scale. In Belgium for example we have the “environmental cost model” that generates cost curves for e.g. N. We are not aware of numbers available specifically for Poland.	
1. DATA REQUIREMENT	
Qualitative	•

Quantitative	• Unit values (€/kg removed pollutant), based on a literature review (benefit transfer) or location specific information: kg N filtered; stored or accumulated in the ecosystem, location specific reduction target, costs and effects of potential measures to reduce emissions. • Alternative metric instead of €: equivalent to emissions of x households
2. RESOURCES REQUIREMENT	
Time	• Low (if based on literature review) • High (if based on location specific estimate, not yet available yet).
Cost	• Low (if based on literature review) • Very high (if based on location specific estimate, not yet available yet).
Expertise	• Literature review on marginal abatement costs + experts to estimate biophysical impact of ecosystem on pollutant removal • Technological expertise, economic modelling expertise
Tools & equipment	•
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Input: kg of N filtered/accumulated yearly and evolution in time.
Socio-cultural	•
Economic	• Cost effectiveness analysis N reduction on national or local scale.
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• High
Non-academic stakeholders	•
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly appropriate
Regional	• Highly appropriate
National	• Highly appropriate
Pan European	• Somehow appropriate: location independent (except if national marginal abatement costs are used.
6. EXAMPLES OF POLICY QUESTION	
	• Where is the demand for nutrient retention the highest? • Where the ecosystem provide the service of nutrient retention?

Some points that emerged during the discussion on the applicability to different scales:

- Process-based models are difficult to apply at national scales due to the complexity of the process, but there are also models with intermediate level of complexity (e.g. INVEST).
- Stakeholders' attitude (e.g. people with long tradition in hydrological modelling) can affect applicability of methods, hence importance of communications in defining the ultimate goal of the assessment.

4.2.4. Netherlands: ES-based coastal defence

The Haringvliet used to be the most important river mouth of the rivers Meuse and Rhine. When in 1971 the rivers were closed from the sea by the Haringvliet dam, the rich estuarine ecosystem heavily deteriorated. In 2018, the Haringvliet dam will be opened (a little) by the Dutch government. Six large Dutch nature organizations have joint forces to optimally use this development and think beyond 2018. They aim to bring back dynamics for real estuarine nature, migratory fish and birds.

In 2010, Anne Böhnke-Henrichs and Dolf de Groot conducted a total economic valuation study of the current and the future "restored" situation of the Haringvliet. This study is based on secondary valuation, using benefit transfer techniques. The results of this study are used here to explain the past valuation efforts. While a new primary valuation study is about to start in 2017, building upon the above benefit transfer study of the Haringvliet. This new study focusses on the potential future state of the Haringvliet and aims at measuring the changes in economic, social and environmental terms (in line with the triple bottom-line approach of People, Planet and Profit). The study is highly policy relevant by addressing the following questions: *What are the trade-offs involved in allowing more natural flooding in the Haringvliet (i.e. ecological benefits versus changes in flood perception of local citizens)? What are the costs & benefits of different measures for ecosystem restoration of the Haringvliet? Who are the winners and losers of different scenarios in the Haringvliet and are there ways in which the losers could be accommodated?*

Discussion on Methods for different themes

- Selected ES 1: Flood protection (2.2.2.2)
- Applied method 1: ***[14]
- Alternative method 1: SWAT/Kineros-Model

METHOD CARD: Input-output modelling + Benefit transfer* + Damage cost avoided + Choice modelling & Benefit transfer* + Travel cost method / Applied to: Flood protection (2.2.2.2) Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)	
CASE STUDY	Haringvliet
SCALE	Local
TYPE	Socio-economic
TIER	t.b.d.
DESCRIPTION	
The Haringvliet used to be the most important river mouth of the rivers Meuse and Rhine. When in 1971 the rivers were closed from the sea by the Haringvliet dam, the rich estuarine ecosystem heavily deteriorated. In 2018, the Haringvlietdam will be opened (a little) by the Dutch government. Six large Dutch nature organizations have joint forces to optimally use this development and think beyond 2018. They aim to bring back dynamics for real estuarine nature, migratory fish and birds. The present study builds upon a previous benefit transfer study of the Haringvliet and focusses on the potential future state of the Haringvliet and aims at measuring the changes in economic, social and environmental terms (in line with the triple bottom-line approach of People, Planet and Profit). The study will use various methods (e.g. surveys, mapping) and will generate a range of outcomes (e.g. CBA, value maps).	

[14] In this case the Method Cards have a different structure, reflecting the ongoing nature of the study.

1. DATA REQUIREMENT	
Qualitative	• Perception of citizens of proposed changes to the Haringvliet [available from previous poles], visions that have been developed by local stakeholders [available in published scoping documents and plans].
Quantitative	• **People**: resident and tourist surveys (each a sample of 400 respondents). **Planet**: spatial information of ecosystems, population, plans, interventions, biodiversity. **Profit**: economic baseline data, recreational trends, real estate data.
2. RESOURCES REQUIREMENT	
Time	• 2 years
Cost	• €170,000
Expertise	• Economists (e.g. input output modelling), social scientists (e.g. stakeholder analysis), GIS experts (e.g. value mapping), ecologist (e.g. restoration analysis)
Tools & equipment	• Online surveys, choice experiment analysis software, GIS.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• The scenario analysis drives the People, Planet and Profit studies and result in an integrated assessment in which the three dimensions are combined.
Socio-cultural	• Idem
Economic	• Idem
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• High
Non-academic stakeholders	• High
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly local (i.e. effects are mainly local)
Regional	• Somewhat regional (i.e. for the province this is a really prestigious and influential project and may be considered as an example for other estuaries)
National	• Somewhat national (i.e. the Haringvliet has an symbolic function on how the Netherlands deals with flood risks and in that way is of interest to the whole country)
Pan European	• Hardly Pan European (i.e. the restoration project of the rivers may lead to more fish migration to upstream European countries)
6. EXAMPLES OF POLICY QUESTION	
	• What are the trade-offs involved in allowing more natural flooding in the Haringvliet (i.e. ecological benefits versus changes in flood perception of local citizens)? • What are the costs and benefits of different measures for ecosystem restoration of the Haringvliet? • Who are the winners and losers of different scenarios in the Haringvliet and are there ways in which the losers could be accommodated?

METHOD CARD: KINEROS flood modelling Applied to: Flood protection (2.2.2.2)	
CASE STUDY	KINEROS flood modelling
SCALE	Local - regional
TYPE	Biophysical
TIER	2
DESCRIPTION	

The kinematic runoff and erosion model KINEROS is an event oriented, physically based model describing the processes of interception, infiltration, surface runoff and erosion from small agricultural and urban watersheds[15]. Input required: Land use information (raster); Precipitation (raster and amount of precipitation during storm event); Soil information (shapefile, FAO); DEM (Raster, projected coordinates) + Configuring model parameters: Channel characteristics	
1. DATA REQUIREMENT	
Qualitative	• Land use / land cover + Soil type + DEM
Quantitative	• Precipitation
2. RESOURCES REQUIREMENT	
Time	• Model configuration and calibration is time consuming (weeks), model runs are fast once the model is setup.
Cost	• Software is free
Expertise	• Expertise in GIS, in AGWA GIS (SWAT/ KINEROS), basic understanding of flooding and related issues is a plus
Tools & equipment	• AGWA GIS (Plugin to ArcGIS)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	• Link with choice experiments or willingness to pay to evaluate the social value of flood regulation (e.g. asking for preference or willingness to pay for flood regulation measures)
Economic	• Include consideration of avoided damage/ risk to estimate economic value
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Low (hydrologists or meteorologists would be beneficial yet not necessary)
Non-academic stakeholders	• Low
6. EXAMPLES OF POLICY QUESTION	
Local	• Appropriate (if the quality/scale of the habitat map allows)
Regional	• Appropriate (if the quality/scale of the habitat map allows)
National	• Appropriate
Pan European	• Appropriate

Discussion on scale issues in ES mapping

- Selected ES 2: Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)
- Alternative model 2: Recreation model
- Alternative mode 2l: Choice modelling

METHOD CARD: Recreation based on green space typology Applied to: Experiential use of plants, animals and land- / seascapes in different environmental settings (3.1.1.1)	
CASE STUDY	Recreation in Schlieren, Switzerland
SCALE	local

[15] http://www.tucson.ars.ag.gov/kineros/

TYPE	Biophysical
TIER	3
DESCRIPTION	
Mapping recreation based on green space typology – considering accessibility and capacity of the green space for different user groups (inhabitants and employees)	
1. DATA REQUIREMENT	
Qualitative	• Green space typology • Buildings
Quantitative	• Population census data
2. RESOURCES REQUIREMENT	
Time	• days
Cost	• Low
Expertise	• GIS
Tools & equipment	• GIS (e.g. Field survey needed to derive green space typology)
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	• Could be linked to surveys about preference of specific areas
Economic	• Could be linked to valuation of green space
4 COLLABORATION LEVEL	
Researchers own field	• Low
Researchers other fields	• None
Non-academic stakeholders	• None
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate
Regional	• Not appropriate
National	• Not appropriate
Pan European	• Not appropriate
6. EXAMPLES OF POLICY QUESTION	
	• How is the supply rate of green space in a certain district NOW (where is it high/low)… • How is the supply rate of green space in a certain district under future scenarios (more people) • How is the supply of green space for inhabitants and for employees?

Some points that emerged during the discussion on the applicability to different scales:

- Recreation model is theoretically possible to apply pan European, regionally and locally with different tiers. It was tested in regional scale (Zurich area), but lack of harmonized dataset was a problem.
- ESTIMAP is similar approach as recreation model and it has been applied to map recreation in Pan-European and local scale (local scale includes also other cultural ES according to CICES 4.3). This involves stakeholder groups for valuations of landscapes.
- Photo Series analysis could be applied parallel in NL case as it is possible to use in different spatial scale (local (points) – regional (clusters)). Other options include mobile phone tracking, big data and data mining that has a huge potential for ES mapping and assessment. We must bear in mind that social media data can be biased over emphasizing certain age groups.

- Combining choice experience and PPGIS could potentially help to discover most valuable ES in economical point of view. Results could be usable to convince the politicians of the ES valuation.

4.3. ESMERALDA methods development

4.3.1. ESMERALDA method compendium development

The aim of the session was to discuss and finalize the method compendia that will be the base for the final version the merge database. Thus, the list of methods found in ESMERALDA database for each dimension analysed (i.e. biophysical, social, and economic) was presented to the participants. The discussion focused on developing a classification system nested within methods that could be applied.

Break-out session on biophysical methods

The aim here was to finalize the list of biophysical methods, agree how to group them and identify ESMERALDA consortium partners who could provide some information about particular methods. Key points discussed and agreed were, e.g.

- Possibly, try to group methods under OPERAs[16] categories;
- Categorization is just one task, but a code should be given for each method to be identifiable in the database;
- Conceptual models, input data, supporting tools as well as methods for analysing results, which are not biophysical mapping methods on their own, probably shall be removed and explained in the ESMERALDA Glossary. One biophysical method can include, for example, multiple input data and supporting tools and including them to method list can create contradictions and inconsistency;
- For the integrated tools like INVEST we should check in the papers which models they apply and then refer to those models, instead of tools. Perhaps, indicate beside the method, which supporting tool (including Arc GIS) can be used for this method.
- Such methods as literature review, statistical analysis, spreadsheet, etc. perhaps cannot be considered as methods on their own. Instead, their role could be illustrated by applying the "building blocks" approach. An option would be to develop "boxes" (e.g. conceptual models, tools, input data, statistical models, methods for assessment of results, scenario building etc.), which could be used for categorization and describing of the methods/elements of the mapping and assessment process. In any case, it was suggested to reflect on those methods/elements of the biophysical mapping or assessment which were exclude from the list, in the descriptive part of the report.

Table 4.2 shows the final compendium of biophysical methods after WS 4.

Table 4.2. Compendium of Biophysical Methods after WS 4 (contact: Petteri Vihervaara, SYKE)

code	Method Name	Short explanation
B1	2D Avalance model	Process based model
B2	APLIS	Aquifer recharge model, Process based model
B3	ARIES	ARIES is an artificial intelligent modeler rather than a single model or collection of models. ARIES chooses ecological process models where appropriate, and turns to simpler models where process models do not exist or are inadequate.

[16] FP7 and sister project to OpenNESS for OPERAs see http://operas-project.eu/

		Based on a simple user query, ARIES builds all the agents involved in the nature/society interaction, connects them into a flow network, and creates the best possible models for each agent and connection. The result is a detailed, adaptive, and dynamic assessment of
B4	BalanceMED	Hydrologic model (Madrid)
B5	Bayesian Belief Network (Spatial)	A probabilistic graphical model for reasoning under uncertainty, consisting of an acyclic, directed graph describing a set of dependence and independence properties between the variables of the model represented as nodes, and a set of (conditional) probability distributions that quantify the dependence relationship. Adapted from Kjærulff & Madsen (2013)
B5	Carbon accounting model	Carbon accounting
B7	CESAR	European model of flows of carbon sequestered by various land uses (Vleeshouvers & Verlaagen 2002)
B8	Convergence-evidence mapping	Relates to mapping coincidence of a feature which underpins a service (or suite of features) such as species coincidence. See publication: https://www.unep-wcmc.org/system/comfy/cms/files/files/000/000/792/original/Exploring_Approaches_for_constructing_Species_Accounts_in_the_context_of_the_SEEA-EEA_FINAL.pdf
B9	Damage Scanner Model	Flood damage evaluation, flood protection
B10	EcoServ-GIS	It is ArcGIS based toolkit for mapping ecosystem services in UK.
B11	ENVI-met model	ENVI-met simulates the micro-climate in cities and can be used to model at street level variables such as temperature and air quality. http://www.envi-met.com/
B12	ESTIMAP	Assess the supply, demand and flow of different ES at different scales. Simple, easy to understand, spatially-explicit approach that can be tailored to particular case studies.
B13	For-Est	?
B14	Fragmentation analysis	Spatial statistical analysis technique. Fragstat software is used often.
B15	GISCAME	Land cover spatial proxy model
B16	Green and blue space availability models	?
B17	GREEN model	GREEN is a geostatistical model developed to estimate nitrogen and phosphorus flows to surface water in large river basins. The model is developed and used in European basins with different climatic and nutrient pressure conditions.
B18	Habitat modelling	?
B19	HIRVAC-2D	Urban vegetation structure model, climate modelling, cooling effect
B20	IMAGE	Integrated modelling framework
B21	Integrated modelling framework including: ACLiRem, CALDIS VÂTIS, BeWhere, PASMA, EPIC, CropRota, Austr-10	Integrated modelling framework
B22	INVEST	Used to do ES trade-off assessment of certain land use or management scenarios. Set of models for mapping and valuing the ecological or economic value of multiple ES at a local to regional scale.
B23	LUISA	LUISA is a dynamic, spatial modelling platform which simulates future land use changes based on biophysical and socio-economic drivers. Its core was initially based on other land use models, namely the Land Use Scanner, and the CLUE and Dyna- CLUE models, but its current form is the result of a continuous

		development effort by the Joint Research Centre. LUISA has been specifically designed to assess land-use impacts of EU policies.
B24	MAPPE model	MAPPE is a model that allows computing maps of predicted environmental concentrations (PECs) in soil and surface water as well as atmospheric deposition of chemicals and loads through rivers to the coastal zone, due to both point and diffuse emissions of pollutants. MAPPE can be used to assess water and air purification by vegetation.
B25	MESALES model	The MESALES model estimates the risk on soil erosion based on land cover and crust formation on agricultural soils
B26	MIUU model	Abiotic wind model - The MIUU model show good agreement with wind measurements. The model has however not been thought to correctly capture the wind speeds at low heights since these are more influenced by local topography and vegetation.
B27	MONERIS	Statistical model applied for water quality
B28	Multi-criteria ESA model (ES assessment) LEENA, synonym: Spatial multi-criteria ES analysis)	It can be based only on biophysical criteria, but often used together with social and economic data, and for assessment/integrated methods.
B29	Network analysis	To perform accessibility analyses on network (e.g. road network) using e.g. ArcGIS extension. Used for (potential) demand mapping mostly. Under travel cost maybe (economic methods) as used for example to calculate most cost-effective route from A to B using e.g. time as indicator.
B30	Nutrient transport model	?
B31	QuickScan	Used to assess societal and environmental conditions and evaluate the impacts of potential responses. Participatory approach that can be applied to a selected area, to identify which options would be applicable and what would be the costs and benefits of them.
B32	SENCE	See: http://www.envsys.co.uk/news/introducing-sence/ The acronym stands for Spatial Evaluation for Natural Capital Evidence as developed by Environment Systems Ltd for the JNCC as a 'Spatial Framework'. It is a participatory GIS system which combines spatial data in a raster additive model using user defined weightings stored within a related rules base.
B33	Spreadsheet matrix methods	Simple methodology that provides a quick output in a spatial explicit manner and can involve different stakeholder/expert perceptions (Tier 1). Can be used in data-scarce areas.
B34	STREAM	Hydrological model, flood regulation services (Stürck et al. 2014, Ecol. Ind.)
B35	SWAT (Soil and Water Assessment Tool)	Process based models (it is incorporated in at least two tools)
B36	Trend-surface generalized additive model (GAM)	Statistical model to estimate relationship between response and predictor variable.
B37	USLE, RUSLE	Models which can be used for mapping, both are used in INVEST
B38	Variogram models, geostatistical simulations	Statistical models

Break-out session on socio-cultural methods

The final list of socio-cultural methods encountered in the database was presented. While in general, the names and definitions were approved, a few comments were made to improve the final list. In the discussion, especially the need for further clustering, grouping and nesting of the methods was emphasized and it was considered important that the compendium would contain examples of research (and policy) questions that the methods can be used to answer to.

Table 4.3 shows the final compendium of socio-cultural methods after WS 4.

Table 4.3. Compendium of Social Cultural methods after WS 4 (contact: Fernando Santos, UAM)

code	Method Name	Short explanation
S1	Preference assessment	Preference assessment is a direct consultative method to demonstrate the social importance of ecosystem services by analysing social motivations, perceptions, knowledge and associated values of ecosystem services demand or use. Data can be collected through free-listing exercises, ecosystem service ranking, and rating or selection mechanisms.
S2	Narrative analysis	Narrative methods aim to capture the importance of ecosystem services to people through their own stories and direct actions (both verbally and visually) (see de Oliviera & Berkes 2014).
S3	Time use assessment	This method estimates the value of ecosystem services by directly asking people how much time they are willing to invest (WTI) for a change in the quantity or quality of a given ecosystem service or conservation plan. Methodological is in the same line as preference assessment, but with the objective to create a new indicator to measure social support towards conservation, time use studies create hypothetical scenarios for willingness to invest time
S4	Photo-elicitation surveys	**A**lthough still quantitative by nature, follow a different logic to explore and translate people's visual experiences and perceptions of landscapes related to ecosystem services. Photo elicitation is based on the simple idea of inserting a photograph into a research interview. The difference between interviews using images and text, and interviews using words alone lies in the ways we respond to these two forms of symbolic representation. This is some of the reasons why photo elicitation interview are not simply an interview process that elicits more information, but rather one that evokes a different kind of information
S5	Geo-tagged social media analysis.	Geotagging (also written as GeoTagging) is the process of adding geographical identification metadata to various media such as a geotagged photograph or video, websites, SMS messages, QR Codes or RSS feeds and is a form of geospatial metadata. In nature conservation, there is an increasing need to understand the patterns of human activities from the viewpoint threats and opportunities for conservation planning and management. In particular Photo-sharing websites such as Flickr, Panoramio and Instagram are used to provide revealed preferences for cultural ecosystem services, assuming that visitors are attracted by the location where they take photographs e.g. Richards & Friess, 2015).
S6	Deliberative methods	An umbrella term for various tools and techniques engaging and empowering non-scientist participants – ask stakeholders and citizens to form their preferences for ecosystem services together through an open dialogue. Deliberative methods (e.g. valuation workshops, citizens' juries, photo-voice, etc.) allow for the consideration of ethical beliefs, moral commitments and social norms beyond individual and collective utility, and are often used in combination with other approaches (e.g. mapping or monetary valuation).

S7	Deliberative mapping	is a specific group of deliberative methods which aim to include stakeholder's local knowledge, values and preferences in creating ES maps. Several deliberative mapping methods were applied or developed including: (i) Participatory GIS (see below); (ii) MapNat App, a Smartphone app for mapping mainly cultural, but also some provisional and regulating, services and disservices; and (iii) BGApp, a Smartphone app for scoring different green and blue 'elements' of the landscape based on their importance for an ecosystem service, or a bundle of services, and an area-weighted score is calculated for a proposed property development.
S8	Participatory mapping (PGIS)/Participatory mapping of ecosystem services (PGIS)	**It** evaluates the spatial distribution of ecosystem services according to the perceptions and knowledge of stakeholders via workshops and/or surveys. PGIS allows for the participation of various stakeholders in the creation of an ES map (e.g. community members, environmental professionals, NGO representatives, decision-makers) and integrates their perceptions, knowledge and values in the final maps of ecosystem services. Frequently used in social assessment methods it focus on the integration across knowledge sources, disciplines and data types.
S9	Participatory Scenario	applies various tools and techniques (e.g. individual interviews, brainstorming or visioning exercises in workshops, often complemented with modelling) to develop plausible and internally consistent descriptions of alternative future options. Assumptions about future events or trends are questioned, and uncertainties are made explicit to establish transparent links between changes of ecosystem services and human well-being.
S10	Multi-criteria Decision Analysis (MCDA)	MCDA is an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter. Spatial MCDA are carried out in GIS in order to enable a visualization of the multiple criteria.
S11	Q-Methodology	is particularly useful when researchers wish to understand and describe the variety of subjective viewpoints on an issue. The name "Q" comes from the form of factor analysis that is used to analyse the data. Normal factor analysis, called "R method," involves finding correlations between variables (say, height and age) across a sample of subjects. Q, on the other hand, looks for correlations between subjects across a sample of variables. Q factor analysis reduces the many individual viewpoints of the subjects down to a few "factors," which are claimed to represent shared ways of thinking. It is sometimes said that Q factor analysis is R factor analysis with the data table turned sideways.
S12	SOLVES	A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. It integrated with the Maxent maximum entropy modelling software to generate more complete social-value maps and to produce robust models describing the relationship between social value intensity and explanatory environmental variables. Maxent also more readily permits the transfer of social-value models to physically and socially similar areas where primary survey data are not available.
S13	Agent Based Model	Consist of dynamically interacting rule-based agents. The systems within which they interact can create real-world-like complexity. Typically, agents are situated in space and time and reside in networks or in lattice-like neighbourhoods. The location of the agents and their responsive behaviour are encoded in algorithmic form in computer programs.
S14	Decision support games	ES card games (The ecosystem services card game is a method developed to capture the sociocultural values related to ecosystem services through combining photo-elicitation with a rating exercise) or Balance score card or Role games.
S15	Stakeholder analysis	Two examples: 1) Stakeholder Matrix Analysis is a systematic way to analyse stakeholders by their power and interest. 2) The New Ecological Paradigm scale is a measure of endorsement of a "pro-ecological" world view. It is used extensively in environmental education, outdoor recreation, and other realms where differences in behaviour or attitudes are believed to be explained by underlying values, a world view, or a paradigm. The scale is constructed from individual responses to fifteen statements that measure agreement or disagreement.

Break-out session on economic methods

The discussion focused on defining a final list of economic methods to be used in ESMERALDA methods compendium. The discussion included key points and remarks regarding some specific methods that are presented hereafter:

Social Cost of Carbon Method: It was discussed whether it is necessary to keep the Social Cost of Carbon method in the list as a separate method, as it is in fact a specific application of the Damaged Cost Avoided method. In the end, it was agreed to keep it on the list as a separate method, since it is a popular approach, which if missing on the list could be confusing for some people. We will extend the description of this method to note that it is a specific case of the Damage Cost Avoided method.

Production Function Method: The question was raised as to whether Cost Function and Profit Function Methods should be also included on the list as separate methods, or should be treated as an alternative name for Production Function Method. It was agreed to clarify this in the description of the Production Function Method.

Opportunity Cost Method: We discussed if Opportunity Cost should be treated as a Mapping Method (Monetary Valuation Method) only, since it is also possible to describe Opportunity Costs in non-monetary units. It was agreed that the method description should be extended to explain the issue.

Multi-Criteria Analysis (MCA): It was discussed whether MCA should be included as an Assessment Method only, or should be considered also as a Mapping Methods since the MCA process itself might involve valuation of ecosystem services through participatory or expert input. Regarding finalization of the methods list, it was agreed that the list would be revised again following the comments outlined above. In a few cases an additional description will be added. Nonetheless, the proposed Method List in general was very well evaluated by members of the meeting.

Table 4.4 shows the final compendium of economic methods after WS 4.

Table 4.4. Compendium of Economic Methods after WS 4 (contact: Luke Brander, VU)

code	Method Name	Short explanation
E1	Choice modelling	A stated preference method that uses surveys to ask respondents to make trade-offs between different levels of ecosystem service provision and payments to elicit willingness to pay for changes in ES.
E2	Contingent valuation	A stated preference method that uses survey approaches to ask respondents how much they are willing to pay (or accept) for specified changes in the provision of ES.
E3	Corporate Ecosystem Service Review	A structured methodology that helps private sector decision-makers to develop strategies to manage business risks and opportunities arising from their company's dependence and impact on ecosystems.
E4	Cost-Benefit Analysis (CBA)	An evaluation method that involves summing up the value of the costs and benefits of each option/policy/investment and comparing options in terms of their net benefits (i.e. the extent to which benefits exceed costs).
E5	Cost-Effectiveness Analysis (CEA)	An evaluation method that involves identifying the least cost option that meets a particular goal.
E6	Defensive expenditure	Expenditure on the protection of ecosystems and ES is used as a proxy of the value of ES.

E7	Damage cost avoided	Calculates the damage costs that are avoided due to the regulation of environmental flows by an ecosystems (e.g. flood attenuation, storm buffering).
E8	Ecosystem Service Accounting	A structured way of measuring the economic significance of nature that is consistent with existing macro-economic accounts. Ecosystem service accounting involves organizing information about natural capital stocks and ecosystem service flows, so that the contributions that ecosystems make to human well-being can be understood by decision makers and any changes tracked over time. Accounts can be organized in either physical or monetary terms
E9	Ecosystem service assessment	An appraisal of the status and trends in the provision of ecosystem services in a specified geographic area. The general aim of an ecosystem service assessment is to highlight and quantify the importance of ecosystem services to society. Ecosystem service assessments are multidisciplinary in nature, applying and combining biophysical, social and economic methods.
E10	Group / participatory valuation	A stated preference method that asks groups of stakeholders to state their willingness to pay for specified changes in the provision of ES through group discussion
E11	Hedonic pricing	A revealed preference method that estimates the influence of environmental characteristics on the price of marketed goods to identify the marginal willingness to pay for changes in those environmental characteristics
E12	Input-Output analysis	Quantifies the interdependencies between economic sectors in order to measure the impacts of changes in one sector to other sectors in the economy. Ecosystems can be incorporated into input-output models as distinct sectors.
E13	Market price	Prices for ES that are directly observed in markets. Very often such prices need to be adjusted for market distortions.
E14	Multi-Criteria Analysis (MCA)	An evaluation method that involves computing weighted standardized scores across multiple criteria for each option/policy/investment. Criteria can be measured using either quantitative or qualitative information.
E15	Net factor income	Revenue from sales of a marketed good to which the ES is an input, minus cost of other inputs.
E16	Opportunity cost	The next highest valued use of the resources used to produce an ecosystem service. As an economic method for quantifying value, the opportunity cost is the monetary value of the foregone alternative use of resources. For example, the opportunity cost of ecosystem services from a natural ecosystem might be the value of agricultural output if the land is converted to agricultural instead of conserved in a natural state.
E17	Production function	Statistical estimation of a production function to quantify the contribution of an ecosystem input in the production of a marketed good. Cost function and profit function methods follow a similar approach and form of analysis.
E18	Public pricing	Public expenditure or monetary incentives (taxes/subsidies) for an ES is used as a proxy of the value of the ES.
E19	Replacement cost	The cost of replacing an ES with a man-made service is used as a proxy of the value of the replaced ES.
E20	Restoration cost	Estimates the cost of restoring degraded ecosystems to ensure provision of ES as a proxy of the value of the ES.
E21	Social Cost of Carbon	The monetary value of damages caused by emitting one tonne of CO_2 in a given year. The social cost of carbon (SCC) therefore also represents the value of damages avoided for a one tonne reduction in emissions, in other words, the benefit of a CO_2 reduction. SCC is a specific application of the "damage cost avoided" method
E22	Travel cost	A revealed preference method that estimates a demand function for recreational use of a natural area using data on the observed costs of travelling to that destination.
E23	Value transfer	The use of research results from existing primary studies at one or more sites or policy contexts (“study sites”) to predict welfare estimates or related information for other sites or policy contexts (“policy sites”).

4.3.2. ESMERALDA database definition

The aim of the session was update on the process of merging the two previous databases (ESMERALDA 'Google doc' and literature review); hence, to discuss and agree on the draft final version of the merged database structure. Ultimately, to develop a plan on how the information of all ESMERALDA partners will be included into the new database.

All column headings (of the method database) were introduced and discussed, and additional remarks collected with a written questionnaire. The results of the discussion will feed into the update of the excel spreadsheet (merged database version 4.0). Thus, the structure of the final version of the merged database was decided; the database will be created using Webropol[17] questionnaire that will be sent to participants before the next workshop in Madrid.

Some key points discussed and agreed upon are presented hereafter.

- **Policy and other questions the Database and Flexible methodology is supposed to answer.**
  - A classification of question cannot be proposed yet. This needs to be elaborated further in a small team and will be taken forward to the Madrid workshop to be finalized in the Trento workshop.
  - It would be very useful to ask whether there has been any actual policy uptake-taking (e.g. national accounting system to local development plan referring to the assessment). However, the method database may not the "best" place to include it, so the WP2 survey can also be considered.
  - Policy questions could be linked to the "tier" idea where you may want to find studies, which facilitate a hierarchical approach (national policy/regional planning/ local decision-making).
  - Besides policy, business questions and other technical questions also need to be considered.
  - Respective columns will be added to the database asking: "Has a policy/business questions be considered?" to be answered yes or no followed by a columns of free text.

- **Tiers classification and link to the purpose of the study**
  - It was still not clear for all participants what the 'tier classification' will add to the flexible methodology. On the other hand, it was still open that it might add something, so to not loose potentials but eliminate confusion (or room for interpretation) it was decided that the database will not use tiers terminology. Instead, information on further aspects of the studies will be collected (with or without tier classification). Eventually, later on a rule-based link could be created to link between the information collected and potential tiers.
  - Tiers could be linked to the "policy idea".
    1. Tiers could be linked with 'equipment' and knowledge needed to conduct ES assessment.
    2. Tiers could it be linked with purposes/uses instead of with more open policy questions.
    3. It is difficult to incorporate the tiers approach in the flexible methodology as a whole but we can try to define tiers for the case studies. Therefore, the multi-tiered approach can still remain in the methodology but at case study level where it will be easier to define meaningful criteria with input from partners who know very well the particular case and can provide reliable data. This could be a good starting point for further integration of this approach.

[17] https://www.webropolsurveys.com/S/85E71B9D58A30304.par

❖ **Method interlinkage**

Following the introduction of the topic, it was decided that this point will be picked up in the method deliverables and described per methods and no further columns will be added to the merged database (questionnaire). A suggestion was to refer to a conceptual framework (e.g. Cascade, DPSIR used at a strategic point), and accordingly define approached that link methods across the framework. Similarly, specifying inputs and outputs of every methods (bio-, socio- econ-) would help to combine different methods (e.g., output from bio-methods is often the input for using same of economic methods). Finally, it was suggested to keep the distinction between “chained” method and “compared” method.

❖ **Indicators and stakeholder information**

It was explained why the questions about indicators will no longer be in the merged database. There are already 278 entries so far and Task 4.1 (MS20 and Deliverable 4.1) has developed a rule based relation between indicators and ecosystem services, so to save time no further request to take notes of indicators is necessary. It was decided that the merged database would not ask for stakeholder related information regarding the methods investigated. It was suggested that this would be picked up in the methods themselves (e.g. Method Cards).

❖ **Some personal written reflections from participants**

- It would be good to have a clear strategy of the database, in terms of structure (variables, nested organization …) and ergonomics. Storage and technical issues are crucial;
- Regarding the methods: add a column indication whether the method encompasses the whole ES assessment process or whether the method is used at the beginning or end of the process (e.g. conceptual frameworks at the beginning, summarizing indices at the end;
- Concerning the scale issue, I think it will be tricky to fix size at each level for all countries - size for local scale in Germany will be larger than national in Malta. My proposal is the national scale to be fixed as the size of the country and the subsequent sub-national and local to be defined individually for each country. We have now partners from each EU country and they can do this. As the methodology main objective is to help member states in their work on ES mapping and assessment this could be the most useful approach.”

4.3.3. ESMERALDA flexible methodology

In the session ideas on the **ESMERALDA flexible methodology** and what could be included in it were presented and discussed based on the outcomes of the workshop(s) and ongoing ESMERALDA activities. Several alternatives for developing the tools and products as well as interfaces were presented and their pros and cons discussed. The abstracts of the presentation (also available in the ESMERALDA website) and some key points that emerged reported hereafter.

Idea for the flexible ESMERALDA Methodology

ESMERALDA aims to deliver a 'flexible methodology' that can simultaneously provide innovative building blocks for pan-European, national and regional ES mapping and assessment to ensure the timely delivery by all EU member states of Action 5 (ESMERALDA DoA 2015). This will be achieved based on reviewing related ongoing activities (in Europe and worldwide) and enhancing of ES mapping and assessment methods. The methods need to be flexible enough to be applied in all EU member states (including outermost regions, marine areas and specific biomes). The multi-tiered approach considers different methods (biophysical, social, and economic) at different levels of detail and complexity that can be applied according to specific needs, data and resources availabilities.

Gaps in capacity and technical support were two of the main gaps hampering MAES implementation in EU member states identified by ESMERALDA. ESMERALDA will provide guidance for ES mapping and assessment in order to harness available approaches. An online database of methods will help to find solutions for people who, for example, want to map ES **A** in ecosystem type **B** on scale **C** using a method on tier **D**. The guidance documents will deliver detailed descriptions of the methods, their application and further background information for ES mapping and assessment. The combination of the components makes existing know-how available to a broad range of people and can be used for mapping and assessing ecosystems and their services.

Using the existing methods compendium and related data base

The talk provided a short overview of how information can be queried from the existing database to highlight its usability and the added value. In particular, the application of a simple filtering function in Excel to structure the information is demonstrated. Quite interestingly, the demonstration revealed inconsistencies in the entries. As a way forward, ideas for the further development of the database into more user-friendly tools were proposed, discussing advantages and limitations of "real" database structures such as Microsoft Access as well as the requirements and benefits of different existing tools. To conclude suggestion was provided on how to integrate existing products of the ESMERALDA project (factsheets and method cards) into such a tool.

Possible web tool example for ESMERALDA

Building on previous projects, a web tool for the ESMERALDA methods was proposed by the partners from Paris-Lodron-Universität Salzburg (PLUS). Most interestingly, the proposed tool has been originally designed in a participatory process driven by the user community of the Alpine climate change adaptation. The tool is characterized by open source development, based on state-of-the-art techniques and tools. A major advantage of the tool is its interoperability, given it is based on internationally accepted standards. In addition, it is platform-independent, which means it can be used with Windows, Mac, and UNIX and is supported by many browsers. (See presentation in the ESMERALDA website).

Some of the key open questions

- What is the need for the ESMERALDA products and services of the project, who are the target users of each product and service?
- How to best respond to the needs of the end-users in the product design and dissemination? What kind of information different target groups require and how the project can meet their needs?
- How to secure the continuity of the products and services also after the project timeframe? For instance, where the database should be hosted and maintained and by whom?
- How to fit the ESMERALDA products and services into other similar products already available and currently being developed?

The discussion paved the way for a joint vision on what the key final ESMERALDA products can be and how to best integrate the expertise and contributions of the project partners, and developing a plan on how existing ESMERALDA Deliverables and products can be integrated into the flexible methodology.

4.4. Stakeholder involvement and training

4.4.1. ESMERALDA: Current status and update

In WS 3, the focus was more on the ESMERALDA methods development, while stakeholders were mainly involved in the case study related session. However, all participants were updated of the general progress of ESMERALDA, including addition of new partners listed below and activities in different work Packages.

- Croatian Agency for Environment and Nature (CAEN): Petra Kutlesa, Tamara Kirin, Luka Katusic
- Cyprus Institute (CYI): Manfred A. Lange
- Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Ireland (AHG): Gemma Weir
- Estonian University of Life Sciences (EMU): Kalev Sepp, Bob Bunce, Miguel Villoslada
- Institute of the Republic of Slovenia for Nature Conservation (IRSNC): Tadej Kogovšek, Suzana Vurunić, Gregor Danev
- Ministry for Sustainable Development and Infrastructures Luxembourg: Nora Elvinger, Eric Schauls
- Mykolas Romeris University, Lithuania (MRU): Paulo Pereira, Daniel Depellegrin, Ieva Misiune
- Nature, Biodiversity & Landscape Protection Directorate Ministry of Environment of the Slovak Republic: Rastislav Rybanič, Simona Stašová
- Norwegian Institute for Nature Research (NINA): Graciela Rusch, David Barton, Jiska van Dijk
- Tel Aviv University (TAU): Tamar Dayan, Alon Lotan
- University of Patras, Greece (UPAT): Panagiotis Dimopoulos, Ioannis Kokkoris
- Leibniz Universität Hannover, Germany (LUH): Benjamin Burkhard, Lisa Waselikowski, Sabine Bicking
- Fabis Consulting, UK (FAB): Marion Potschin, Roy Haines-Young.

4.5. Conclusions of WS 4

WS 4 was designed based on experiences and participant feedback from the WS 3. Compared to WS 3, more emphasis was given to the technical and practical details of the methods, illustrated by detailed presentations by the case study coordinators and supporting experts during plenary and break-out sessions. The aim was to give the participants hands-on experience of the mapping and assessment of different ES and initiate discussions on the suitability of different methods across different themes. In addition, alike to the previous workshops, WS 4 functioned as a platform to take stock of the progress of the different work packages of ESMERALDA and the development of the flexible methodology.

According to discussion emerged during the break-out sessions the main challenge for applying different methods across different spatial scale is the lack of harmonized data. ES mapping and selected mapping method is depending on the availability of adequate datasets at the scale of observation. In local scale, data should include more detailed features and attributes representing the environment increasing the amount of required data. In national scale less detailed information is needed as the target is in the most important general aspects of the feature enabling to map more extensive area. ES are place-based and context specific, and that the right scale depends on the policy question. Results are valid if their scale and resolution is enough to answer the policy question.

A new ESMERALDA database including two previous databases ESMERALDA 'Google doc' and literature review will provide a base for the ESMERALDA web tool. This database will be created using Webropol and send to participants before the next workshop in Madrid. For more information see conclusion of the WS 5.

The feedback survey conducted after the workshop showed that WS 4 was well-received by the participants and met their expectations. The participants liked especially the sessions that provided updates on the progress of the different work packages and the general development of the consortium. Also the break-out sessions were reviewed positively, but also received critical comments on the lack of clear objectives and too much emphasis on single case studies at the cost of testing the methodology.

The workshop concluded on a discussion on the development of ESMERALDA products and tools. Several alternatives for developing tools and interfaces were presented and discussed, but also several questions were raised that still need to be answered. These questions as well as the experiences and feedback of the WS 4 paved the way to the next testing workshop WS5 in Madrid.

5. WS 5 "Testing the methods across biomes and regions", April 2017, Madrid (MS 26)

5.1. Aim and structure of WS 5

This workshop was the last of the first series of ESMERALDA workshops aimed at testing the flexible methods under development in real-world case studies. It continued the work of the testing workshops in Prague (September 2016) and Amsterdam (January 2017) as well as built on the efforts achieved in the workshop in Nottingham (April 2016) and subsequent activities, where methods for biophysical, social and economic studies of ES have been reviewed, discussed and classified. This has led to outputs being developed including a methods compendium, a final structure for the ESMERALDA database, as well as preliminary definitions and possible examples for the Flexible Methodology.

The overall aim of the third workshop was to explore whether the methods have the flexibility required to promote the integration of ES in a variety of biomes and regions across the EU and the outermost EU regions (DoA). WS 5 included case studies from Spain, Bulgaria and the Azores mainly representing the variety of terrestrial biomes ranging from temperate broadleaf and mixed forests to temperate grasslands, to Mediterranean forest woodlands and scrublands. In order to explore further marine biomes, a special break-out group was arranged focusing on methods and challenges related to the mapping and assessment of ES in marine ecosystems including examples of different case studies.

At the same time, WS 5 also served to update the consortium about the latest developments on the flexible methodology, and discussed burning questions and the applicability of the project outcomes. The workshop participants included both project partners and stakeholders, who have been directly involved in the case studies. Stakeholders provided feedback on the suitability of the methods to be used in different decision-making processes.

Figure 5.1. ESMERALDA Workshop 4 in Amsterdam, Netherlands - Participants Group Picture (By Pensoft)

In terms of content, WS 5 also consisted of three types of plenary/breakout sessions: one focusing on the case studies, one related the development of the ESMERALDA flexible methodology, and another one specifically addressing stakeholders. The participants were introduced to the three ESMERALDA case studies and a range of different marine case studies. After the introduction, the participants were divided into four groups (Spain, Bulgaria, and Azores, plus marine case studies). Further information in Appendix: Case Study Booklets. During the three country breakout sessions, each case study focused on two ES and two related methods; resulting in a total of six ES and methods covered during the three sessions (see Table 5.1 in the next section). The aim of the sessions was (1) to learn from the process of ES mapping through the concrete case studies using the illustration of input and output data, challenges and examples of concrete applications, and (2) to discuss the methods' flexibility in the context of different biomes and regions. In line with the previous workshops, Case Study Booklets and Method Cards were prepared to provide more detailed technical information and support the discussion (see Appendix: Case Study Booklets). In the marine break-out session, five different marine case studies were presented, followed by a discussion on the challenges of the marine context.

Concerning the ESMERALDA methods development, the participants were updated on the currents status and recent developments of the project, method compendium, and ESMERALDA Flexible Methodology. To collect feedback and further ideas and take advantage of the participants experience and knowledge, the participants worked in three break-out groups discussing aspects related to tiers, methods interlinkage and policy questions. The workshop day ended in a plenary session focusing on the integration of the project results from the different work packages.

Finally, a stakeholder panel was organized during the workshop, starting from the findings of WP 2. Moreover, a day of the workshop was an excursion day: spent at the Guadarrama National Park, one of the largest national parks in Spain and an important recreational destination of Madrid citizens containing ecologically valuable high Mediterranean mountain areas. During the excursion, researchers of UAM presented examples of their recent research activities in the national park region.

In the remainder of this section, we report the main results of the workshop organized as follows:

- ESMERALDA case studies related results
- ESMERALDA methods development
- Stakeholder involvement and training

5.2. ESMERALDA case studies related results

5.2.1. Introducing WS 5 case studies and aim of the breakout discussions

The salient elements of the three case studies were presented to pave the way for the discussion in the breakout sessions. The objectives and the general process of the ES mapping and assessment in the case studies were introduced, based on the Case Study Booklets (see Appendix: Case Study Booklets). Key questions addressed include: "*What are the objectives of the ES mapping and assessment?", "How were ecosystems identified?*", "*How were ES selected, and which mapping and assessment methods were selected and applied*?", "*Did the specific biomes/ecoregion affect the selection of the methods?*", "*What were the main outputs (maps, reports, table etc.) and how they have been used/can potentially be used to support policy and decision-making*?", "*What has been the role of stakeholders and other actors*?".

Figure 5.2: Pictures representing the Spain, Bulgaria, and Azores case studies (left to right)

Table 5.1: Overview of the case studies used in Workshop 5, Madrid.

	SPAIN	BULGARIA	AZORES
Title	Spanish National Ecosystem Assessment.	Mapping and assessment of ES in Central Balkan area at multiple scales.	BALA - Biodiversity of Arthropods from the Laurisilva of Azores.
MAES status	Stage 1	Stage 2	Stage 1
Scale	National	Regional	Local
ES 1	Food provisioning (1.1.1.1)	Surface water for drinking (1.1.2.1)	Pollination and seed dispersal (2.3.1.1)
Method 1	Production function	SWAT model & water footprint	Macro-ecological Models
ES 2	Water provisioning (1.1.2.1)	Aesthetics (3.1.2.5)	Maintaining nursery populations and habitats (2.3.1.2)
Method 2	INVEST	Narrative assessment	Macro-ecological Models
Coordinator	F. Santos Martín (UAM)	S. Nedkov (NIGGG BAS)	P. Borges (cE3c)
Stakeholders	Tania López (Ministry of Environment); Amanda del Rio (Global Nature)	Diana Bakalova (Ministry of Environment and Water)	Paulo Pimentel (Services of Biodiversity and Conservation, Azores); Sonia Alves (Director of Terceira Island Natural Park)
Supporting experts	Cristina Marta-Pedroso (IST/UL)	Cristian Mihai Adamescu (UB)	Ola Inghe (SEPA)

In addition to the three case studies, five other case studies were introduced focusing on marine ES:

- BACOSA II and SECOS Syntheses. Marine and coastal ecosystem services in the German Baltic Sea.
- ES identification & economic evaluation of the goods and benefits related to the seagrass *Posidonia oceanica.*
- ES mapping and assessment of the Finnish Archipelago Sea and Nordic IPBES-like assessment of marine areas.
- VIBES. Assessment of marine ES in Ireland.
- ES assessment applied in fisheries management in Spain.

As a result, the participants were exposed to the policy questions, and range of methods applied in the three ESMERALDA case studies as well as to an introduction to the five case studies on marine areas. Stakeholders were exposed to different methods. At the end of the session, it was clear which ES, related methods as well as which aspects were to be discussed during the breakouts (see Table 5.1, Figure 5.2 and further information in Appendix: Case Study Booklets).

In the three country breakout sessions that followed, for each ESMERALDA case study, the selected ES and related methods for mapping and assessment were discussed. The objectives here was to understand technical challenges and concrete applications of the methods applied; thus, learn from the process of ES mapping in the case studies through the illustration of the main challenges and examples provided. Ultimately, to discuss the applicability of the ES mapping methods in the case study also in other biomes and regions. The session also served to identify the main issues relevant for adaptation of the selected methods to different biomes and regions, and definition of viable ways of how to include them in the ESMERALDA methodology.

In the additional breakout session on ES mapping and assessment in marine areas, different from the other breakout session, the aim was to gain an overview on the application of various methods throughout different cases studies with focus on marine ecosystems; hence, to discuss the main challenges faced by the cases studies in mapping and assessment of marine ecosystems; ultimately, to identify the most suitable mapping and assessment methods for marine ecosystem as well limitations for application of particular methods.

Following are the main results of the breakout sessions on the three ESMERALDA case studies and the additional breakout session on marine areas

5.2.2. Spain: Spanish National Ecosystem Assessment.

The Spanish National Ecosystem Assessment (SNEA), supported by the Biodiversity Foundation of the Ministry of Environment, provides the first analysis at national level that evaluates the ability of the Spanish ecosystems and biodiversity to maintain our human well-being. It follows the initiative of the Millennium Ecosystem Assessment promoted by the United Nations. SNEA began in 2009, and completed its biophysical assessment in 2012 and started a new phase in 2013 with the purpose of carrying out an economic and socio-cultural valuation of ES supplied by priority ecosystems in Spain. The aim of the project is to visualize the contribution that ecosystems and biodiversity make to human well-being not only in ecological terms but also in social and economic terms.

The project has taken into account the different types of services (provisioning, regulating and cultural), and the various methodologies to estimate ecological, social and economic values. It is the first nationwide ES valuation, which also capture services outside conventional markets and include social and cultural aspects, for both use and non-use values. As part of the philosophy of the project we have tried to emphasize the importance of the services through their value of use, far from logic exclusively associated with the value of change. Therefore, we seek to understand the degree of usefulness or the aptitude of the services to satisfy needs and provide well-being. In this way the values with a direct use normally have a repercussion on recently mentioned human well-being, whereas the values with an indirect use, option values or values of non-use have a connotation of collective value, with a social repercussion on human well-being. All the information generated in the project, reports, maps, are available at the website (www.ecomilenio.es).

The main goal of the SNEA in Spain is to help break down barriers and build bridges between interdisciplinary scientific knowledge and decision making to visualize the complex relationships that exist between the conservation of ecosystems and human wellbeing based on empirical data. It is also expected to increase the awareness of Spanish society, including the business sector, regarding the importance of ecosystems and biodiversity for different components of our human wellbeing.

This project is organized around the core questions originally posed to structure the assessment: "*How is biodiversity changing*?", "*How have ecosystems and their services changed*?", "*What are the main direct and indirect drivers of change*?", "*How these changes affect our human wellbeing*?", "*What is the public´s current understanding of ES*?", "*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*?", "*Why is important to map and assess the value ES at national level*?", "*Which are the priority ES for its valuation*?".

Discussion on Methods for specific biomes and regions

- Selected ES 1: Food provisioning (1.1.1.1)
- Applied method 1: Production function

- Selected ES 2: Water provisioning (1.1.2.1)
- Applied method 2: INVEST

First example was national level mapping and assessment of agricultural crops (kg /ha/year) in Spain. The method applied was market based economic method, production function, where crops were valuated using market prices (€). Mapping was conducted for multiple (~100) crops and final output included mean value at municipal of all crops to describing total agricultural production and the market value assigned i.e. Food provisioning (1.1.1.1).

Second example focused on assessing ES flows and analysing trade-offs and mismatches between supply and social demand in urban-rural environment. This included two pilots study areas:

1. Sierra Nevada mountains (area of1131 km2)
    - Total of nine different ecosystem services were mapped (three in every CICES 4.3 class) using PPGIS methods.
2. Sierra de guamadarra
    - Same nine ES was mapped using Invest model
    - Most challenging was InVEST water yield model (Water provisioning (1.1.2.1)) where difficulties are in data gathering. Model itself is quite easy to run.

Application of the results: the analysis suggest that main economic value (€) can be found from permanent crops in Spain (e.g. planted trees as olive). Crop production of annual crops (e.g. cereals) is higher, but market value is lower comparing to permanent crops.

Results were used to locate the mismatch between supply and demand at the municipality level and provided important spatial information to understand geographical value in ecological and economic terms in different parts of Spain. This provides good data input for future studies e.g. municipality level data can be upscale to provide national assessment.

Challenges and limitations: data availability created main challenges in mapping especially in "Invest water yield model". Data extrapolation was used to create input variables, but there might be some inaccuracies involved. Validation of the results is needed but difficult and time consuming if applied in different biomes.

At the Ministerial level, the representative from Spain stressed that they are usually concentrating efforts at national level, therefore methods need to be simple to understand and support future planning. National level could be first step to map ES using sort of general aspect and then go to local level with more precise analyses. After this it would be possible to make more complex models as people already understand general models. National mapping also provides information of the ES in different biomes and can be done using more spatially coarse data.

Link to Esmeralda flexible methodology: More communication with other projects and studies related to ES (e.g. OpenNESS) is needed and we must share our results and thoughts more with other experts and researchers in different projects. We have to find the balance between scales, tools, complexity in ESMERALDA to achieve a flexible methodology.

The stakeholder representative from the NGO stressed the myriad of projects at different levels -from regional, national, EU- that exist on similar issues but there is no synergies or events that will allow to share experiences

Conclusion: Results provided important spatial information to understand geographical value in ecological and economic terms in different parts of Spain. This provides good data input for future studies e.g. municipality level data can be upscale to provide national assessment.

Some key points that emerged during the discussion on the application of the method in the Spain case study include:

Main technical challenges: Data availability creates main challenges for mapping in different spatial scales. Local mapping requires more spatially explicit data that highly correlates with time requirements. In national mapping more general data is enough, however data must be harmonized.

Applicability: Methods, tools and maps are needed at different scales, but there is a need to match policy and research questions. National level could be a first step to model general aspect and then go to more local level and precise analyses. General more simple models could provide the basis to move into more complex models needed at regional level

ESMERALDA flexible methodology: We have to find the good balance between scales, tools and its complexity to create a flexible methodology. This requires dialogue improvement and co-operation with related projects at different levels

5.2.3. Azores (Portugal): BALA - Biodiversity of Arthropods from the Laurisilva of Azores

The Azores are an oceanic isolated Northern Atlantic archipelago made of nine main islands and some small islets, distributed from Northwest to Southeast, roughly between 37º and 40º N and 24º and 31º W. The Azorean islands extend for about 615 km and are situated across the Mid-Atlantic Ridge, which separates the western group (Flores and Corvo) from the central (Faial, Pico, S. Jorge, Terceira and Graciosa) and the eastern (S. Miguel and S. Maria) groups. All these islands have a relatively recent volcanic origin, ranging from 8.126 Myr B.P. (S. Maria) to 300 000 years B.P. (Pico) (Feraud et al. 1980; Ramalho et al. 2016). The climate is temperate humid at sea level, and cold oceanic at higher altitudes. The atmospheric humidity is high with small temperature fluctuations throughout the year.

The present ES assessment has been mainly scientifically-driven, with the main objective of performing the first assessment of ES, based on arthropod diversity, distribution and ecological data in an Azorean island. We selected one of the best studied Azorean islands (Terceira) and investigated two ES: *Pollination and seed dispersal* and *Maintaining nursery populations and habitats*. The results obtained for *Maintaining nursery populations and habitats* were already used to implement protected areas in Azores (see Borges et al. 2011; Gaspar et al. 2011). The results obtained for *Pollination and seed dispersal* can be used to identify key ES for Azorean agro-ecosystems.

Pollination services are essential to sustain fruit production in orchards, as well as for endemic flowering plants by ensuring reproduction and dispersal. There are some ongoing proposals in Azores to assess the effect of different ecological intensification techniques on pollination efficiency and related increase in crop yield. Mapping pollinator ES in agroecosystems and quantify its economic value is therefore a priority. This objective is highly relevant in the context of several important international policies such as the International Initiative for the Conservation and Sustainable Use of Pollinators, implemented by the United Nations and established by the Convention on Biological Diversity at the 5th Conference of Parties (COP V) in 2000[18]. The above objective is equally relevant in the context of other international policies like the FAO's Global Action on Pollination Services for Sustainable Agriculture[19]. Moreover, this objective is pertinent within the goals of the Intergovernmental Science-Policy Platform on Biodiversity and ES (IPBES) on pollinators, pollination and food production[20].

Discussion on Methods for specific biomes and regions (Session 7)

- Selected ES 1: Pollination and seed dispersal (2.3.1.1)
- Applied method 1: Macro-ecological modelling

METHOD CARD: Macro-ecological modelling Applied to: Pollination and seed dispersal (2.3.1.1)	
CASE STUDY	Azores
SCALE	Local/Regional
TYPE	Biophysical
TIER	2
DESCRIPTION	

[18] https://www.cbd.int/agro/planaction.shtml
[19] http://www.fao.org/pollination/en/
[20] http://www.ipbes.net/work-programme/pollination

In this work, we assess the Ecosystem Services (ES) provision and values provided by insect pollinators (IP) in Terceira Island, in the Azores archipelagic region (Portugal) where few studies on ES assessment or related to pollination and seed dispersal services have been undertaken. Our goals were to determine: (I) the spatial variations of the pollination services; and (II) whether the variations of the pollination services were influenced by the different land-uses and/or level of disturbance. We used a database on the spatial distribution of insect pollination in Terceira Island (Azores) recently collected to provide the first insight of the bees and other insect pollinators (IP) contribution to the pollination services and for assessing pollination-related ES in a small oceanic island. The insects were observed from five relevant habitat types, corresponding to an increasing gradient of disturbance, namely natural forests (NatFor), naturalized vegetation areas (NatVeg), exotic forests (ExoFor), semi-natural pastures (SemiPast) and intensively managed pastures (IntPast). These habitat types were previously selected according to the landscape disturbance index proposed by Cardoso et al. (2013), with the aim to assess the impact of land-use change on flower-visiting insect species community structure in Terceira Island (Picanço et al. 2017). In each habitat type, 10 sites were selected. In each site, 10 meters' linear transects with 1 meter width were set up, making a total of 50 transects located across the entire island. The pollination service mapping was performed with the ArcGIS10© software, by applying the "Topo to Raster" interpolation technique, which was designed for the creation of hydrologically correct Digital Elevation Models (DEM). This method uses an iterative finite difference interpolation technique. It is essentially a discretized thin plate spline technique for which the roughness penalty has been modified to allow the fitted DEM to follow abrupt changes in terrain. The quantity of input data can be up to an order of magnitude less than that normally required to adequately describe a surface with digitized contours, further minimizing the expense of obtaining reliable DEM. In this work, DEM were generated using respectively as elevation data the bees and insect pollinators' abundance and richness quantitative information collected from field surveys, of the 10 transects of each habitat type (or land use). We separated the bees and total insect pollinators data, because many studies about pollination services are more related to bees than to the insect pollinators in general, and also, to analyse if there would be differences between the DEM of the possible pollination services contribution from these two groups of data. This latter also applies relating to the abundance (i.e. number of individuals) and richness (i.e. number of species) information on both groups. In this way, by applying all the fieldwork data, we intend to be more accurate as possible while developing DEM that deliver information on pollination services. To complement this spatial analysis, we applied the formerly mentioned index of landscape disturbance metric based on the attributes of the landscape matrix (Cardoso et al. 2013). This index, ranging from 0 to 100, corresponds to a local index of disturbance by taking into account the level of disturbance in the surrounding areas. Disturbance index (D) was obtained by ranking the different land uses attributing a value of "local disturbance" (L) on a land use map of 100 x 100 m resolution built from aerial photography and fieldwork, and for each 100 x 100 m cell the D was calculated. For each analysis, we overlaid the respective pollination services' interpolation maps delivered by the fieldwork data on bees and other insect pollinators from Picanço et al. (2017) with the land use and the disturbance index D. We have created thresholds to analyse disturbance index D influence on the amount and diversity of bees and other insect pollinators and mapped these categories in eight classes for bees' abundance (N) and richness (S); and in 12 classes for insect pollinators' abundance (N) and richness (S). The disturbance level was organized in four classes, including a first one with very low disturbance level typical of high altitude native forests (D<20), two intermediate classes and finally a class with high levels of disturbance (D>40). The number of individuals of bees was divided in two classes in a logarithm scale (less than ten and more than ten individuals). The number of species of bees was divided in two classes with one species and two or more species. For insect pollinator abundance and richness three classes were prepared: for abundance we created one for the rarest species, one for intermediate and one for the most abundant; for species richness we divided the classes arbitrarily in less than 10 species, 10 to 15 and more than 15. These created classes were evaluated through a quantitative analysis of the area covered by each class in Terceira Island. The numbers of classes established follow the minimum and maximum abundance and richness values obtained by Picanço et al. (2017) for the different habitat types - natural forest, naturalized vegetation areas, exotic forest, semi-natural pasture and intensively managed pasture.

1. DATA REQUIREMENT	
Qualitative	• Land Use / Land Cover map that constituted the baseline to derive the Landscape Disturbance Index Map, produced through orthophotomaps' GIS-based photo-interpretation combined with ground truth validation. • Landscape Disturbance Index Map based on a qualitative assessment of LULC map s(Cardoso et al. 2013)
Quantitative	• Spatial database on the distribution of insect pollinators. For e.g., in Terceira Island, Azores, in each habitat type, 10 sites were selected. In each site, 10 meters' linear transects with 1 meter width were set up, making a total of 50

	transects located across the entire island. The bees and insect pollinators' abundance and richness quantitative information was collected from 10 transects of each habitat type (see Picanço et al., 2017).
2. RESOURCES REQUIREMENT	
Time	• High - depending on data, biodiversity and GIS expertise, LULC map and Landscape Disturbance Index Map availability.
Cost	• Medium/High – the cost is again dependent of the availability of baseline data and/or the human resources required to obtain any necessary data.
Expertise	• GIS expertise (geostatistical methodological approach); • LULC assessment expertise (Landscape Disturbance Index Map); • Taxonomy and ecological expertise (pollinators); • Agricultural and ecological knowledge of the area.
Tools & equipment	• GIS software with the necessary hardware; • Statistical and Data Management software; • Ecological sampling tools and handheld GPS for field work.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Mapping and assessment of many other provisioning and regulating ES may be based on the LULC map, providing therefore a common and coherent baseline; • This task could especially benefit from adding/using an ecological modelling approach (e.g. MAXENT) to map pollination services, integrating therefore more environmental complexity and other relevant variables as terrain (elevation, inclination, orientation), climatic (temperature, rain, humidity, incident solar radiation, wind), soil (type, moisture, salinity) and man-made features (settlements, infrastructures), besides LULC.
Socio-cultural	• The mapping and assessment of many other socio-cultural ES may be based on the LULC map, providing therefore a common and coherent baseline;
Economic	• This ES mapping and assessment is especially important for the implementation, assessment, and management and monitoring of agricultural and horticultural activities. Therefore its theoretical basis and methodological development might be improved by integrating more operational data at the field level, namely by intensifying (in both number and area coverage) survey data on bees and IP abundance and richness, as well as incident land-use.
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• High (Geography, Agronomy, Economy)
Non-academic stakeholders	• This ES mapping and assessment outputs might be especially relevant for apicultural, agricultural and horticultural managers, as well as for land planners/managers and decision-makers. Therefore their direct involvement in the field data collection and/or outputs assessment phases might enhance the impact and follow-up of this study, in order to become periodical and effectively policy-making supportive.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES exercise must be considered as being a local/regional study.
Regional	• Highly. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES exercise must be considered as being a local/regional study.
National	• Not Appropriate. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES exercise must be considered as not appropriate for being projected at the national scale.
Pan European	• Not Appropriate. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES

	exercise must be considered as not appropriate for being projected at the pan-European scale.
6. EXAMPLES OF POLICY QUESTION	
	• How do current land use policies contribute to the conservation of pollinators and pollination ES? • What type of land use policies might improve the conservation of pollinators and pollination ES? • What will be the impact of climatic changes on pollinators' adaptation and agriculture productivity?

Some key points that emerged during the application of the method in the Azores case study include:

- Need for detailed knowledge of the real location and real abundance of species of pollinators, which could be achieved only with extensive field work using standardized techniques;
- Azores landscape disturbance index was used to investigate whether sites with high human impacts have less diversity of pollinators or not;
- The disturbance index and fieldwork data were combined to create a more complex indicator, distinguishing between eight classes of bees' abundance and richness;
- Actual mapping done with ArcGIS "Topo to Raster", a discretized thin plate spline technique found to be more reliable than other interpolation techniques (e.g. IDW, Kriging, Spline and Natural Neighbour);
- An interesting finding, contrary to initial expectations, richness and abundance of native pollinators were high not only in protected areas but also in sites with high disturbance, such as orchards;
- A limitation of the method as applied in the case study is that it dealt with a rather small spatial scale, given the reliance on extensive fieldwork;
- Future improvement of the method could include more sophisticated spatial modelling of the distribution of each insect pollinator (e.g. MARXAN).

Some key points that emerged during the discussion on the applicability and transferability of the method:

- Did indigenous and exotic species of bees behave differently in this analysis? Actually, the native bees and native pollinators are dominating the system not only in protected area but also in highly disturbed areas. Moreover, the introduction of bumblebees in the island did not result in any conflict with native species so far. A more detailed characterization of the pollinators, for example, in terms of their resistance or tolerance to changes would be crucial, but would add an additional level of complexity to the method.

- Importance of investigating the role of different (orchard) management types and their impact on pollinator richness and abundance. Ultimately, to identify the specific characteristics in extensive orchards that contribute the most in terms of richness and abundance. For example, previous results in the case study highlighted that the insects and pollinators are less diverse in intensively managed orchards in comparison with organic ones. Such scientific evidence could then be used to introduce new management and regulations; for example, payments for farmers that extensify their farms could be introduced as a complementary measure to establish new conservation areas. However, a major issue is that on small islands, land is a very important and a scare resource. Previous EU schemes that were financing similar extension programs (i.e. lower number of cows per hectare) on the Azores, created a situation where some farmers destroyed native forests to have more area for more cows. Thus, what would be needed are more education projects so that the next generation of farmers could be more aware of the importance of ES provided by native forests, including water. Other measures include realizing ecological corridors for native pollinators by involving farmers in planting endemic species (e.g. *Erica azorica* or *Laurus azorica*) to separate their fields; thus connecting and conserving fragments of native forest.

- *Transferability:* When applying the method in larger areas in main land Europe context, it may not be enough to consider only the biotopes or land use, but the distribution distance of pollinators (from nursery locations) should also somehow be modelled. Moreover, to have such kind of local anchorage by collecting insects, perhaps recent (electronic) methods and DNA methods could represent more affordable solutions. However, it is not possible to blindly rely on such molecular approaches because there is a risk of "losing the sense of things": knowing the biology of species disturbance requires proper study of traits. At the same time, in continental context there is fairly low taxonomic variation by distance compared to islands. Therefore, it may suffice to make fewer taxonomical observations to cover larger spatial areas.

- In general, the method as applied in the case study can easily be transferred to the other islands of the Azores because they represent similar habitats and the pollinators should not differ a lot. However, for other islands in Macaronesia, huge local taxonomic knowledge and resources for the fieldwork would be needed. In the continental context, where you have fairly low taxonomic variation by distance (e.g. northern Europe), it may suffice to make fewer taxonomical observations, while this may not be the case in Mediterranean areas. Moreover, it is possible to rely on existing databased (e.g. GBIF) to derive pollinators' richness but not abundance, for which there is no standardized sampling.

- Is a method different when applied in an island or on mainland? From an ecological perspective, mountainous areas are islands, so the classification of the methods should rather be based on biomes and geo-regions rather than islands versus mainland. At the same time, it should be kept in mind that we have thousands of islands in the world and for most of which we do not even have a good list of species. This and other peculiarities of application in islands have to be also addressed.

- *Tiers:* The method as applied in the Azores case study relies on high quality real local data (Tier 3), which are used to define indexes. However, the application does not go as far as reaching the actual decision-making processes; thus, all together the method can be classified as a rather sophisticated Tier 2 (2++).

- Selected ES 2: Pollination and seed dispersal (2.3.1.1)
- Applied method 2: Macro-ecological modelling (Proportion of Endemic Species Mapping)

<table>
<tr><th colspan="3">METHOD CARD: Macro-ecological modelling
Applied to: Maintaining nursery populations and habitats (2.3.1.2)</th></tr>
<tr><td>CASE STUDY</td><td colspan="2">Azores</td></tr>
<tr><td>SCALE</td><td colspan="2">Local/Regional</td></tr>
<tr><td>TYPE</td><td colspan="2">Biophysical</td></tr>
<tr><td>TIER</td><td colspan="2">2</td></tr>
<tr><td colspan="3">DESCRIPTION</td></tr>
<tr><td colspan="3">In this work, we assess the Ecosystem Services (ES) provision and values provided by endemic arthropods in Terceira Island, in the Azores archipelagic region (Portugal), for the ES “CICES 2.3.1.2 – Maintaining nursery populations and habitats”. We used the indicator “Proportion of arthropod endemic species”. This indicators captures the rational of the ES “Maintaining nursery populations and habitats”, since it is expected that sites with a high proportion of endemic species have also lower proportion of exotic species, and consequently are more pristine and adequate to maintain nursery populations and habitats for native fauna.
The richness of epigean arthropods was investigated in 89 sites located in four main relevant habitat types: natural forests (NatFor), exotic forests (ExoFor), semi-natural pastures (SemiPast) and intensively managed pastures (IntPast). In each site, a transect of 150 m x 50 m was setup and a total of 30 pitfall traps were used to sample epigean arthropods during two weeks in summer. These habitat types were previously selected according to the landscape disturbance index proposed by Cardoso et al. (2013), with the aim to assess the impact of land-use change on native arthropods diversity. This ES mapping was performed with the ArcGIS10© software, by applying the “Topo to Raster” interpolation technique, which was designed for the creation of hydrologically correct Digital Elevation Models (DEM). This method uses an iterative finite difference interpolation technique. It is essentially a discretized thin plate spline technique for which the roughness penalty has been modified to allow the fitted DEM to follow abrupt changes in terrain.
To complement this spatial analysis, we applied the formerly mentioned index of landscape disturbance metric based on the attributes of the landscape matrix (Cardoso et al. 2013). This index, ranging from 0 to 100, corresponds to a local index of disturbance by taking into account the level of disturbance in the surrounding areas. Disturbance index (D) was obtained by ranking the different land uses attributing a value of “local disturbance” (L) on a land use map of 100 x 100 m resolution built from aerial photography and fieldwork, and for each 100 x 100 m cell the D was calculated. For each analysis, we overlaid the respective nursery services’ interpolation maps delivered by the fieldwork data on arthropod distribution with the land use and the disturbance index D. We have created thresholds to analyse disturbance index D influence on the proportion of arthropod endemic species and mapped these categories in 12 classes. The disturbance level was organized in four classes, including a first one with very low disturbance level typical of high altitude native forests (D<20), two intermediate classes and finally a class with high level of disturbance (D>40). The proportion of arthropod endemic species was organized in three classes (>0.30; 0.20<P<0.30 and <0.20). These created classes were evaluated through a quantitative analysis of the area covered by each class in Terceira Island.
For the ES “CICES 2.3.1.2 - Maintaining nursery populations and habitats”, the overlay of the biodiversity indicator with the landscape disturbance index shows clearly that only sites with low disturbance are able to support nursery populations.</td></tr>
<tr><td colspan="3">1. DATA REQUIREMENT</td></tr>
<tr><td colspan="2">Qualitative</td><td>• Land Use / Land Cover map that constituted the baseline to derive the Landscape Disturbance Index Map, produced through orthophotomaps’ GIS-based photo-interpretation combined with ground truth validation;
• Landscape Disturbance Index Map based on a qualitative assessment of LULC maps (Cardoso et al. 2013).</td></tr>
<tr><td colspan="2">Quantitative</td><td>• Spatial database on the distribution of arthropods in Terceira Island (Azores). In each habitat type, at least four sites were selected, but for the native forest 48 sites were available. In each site, 150 meters’ linear transects with 5 meter width were set up, and a total of 30 pitfall traps were used to sample epigean arthropods during two weeks in summer. The number of individuals of each species were counted. Arthropods were grouped into three colonization categories: endemic (i.e. restricted to Azores); native non-endemic, i.e. species</td></tr>
</table>

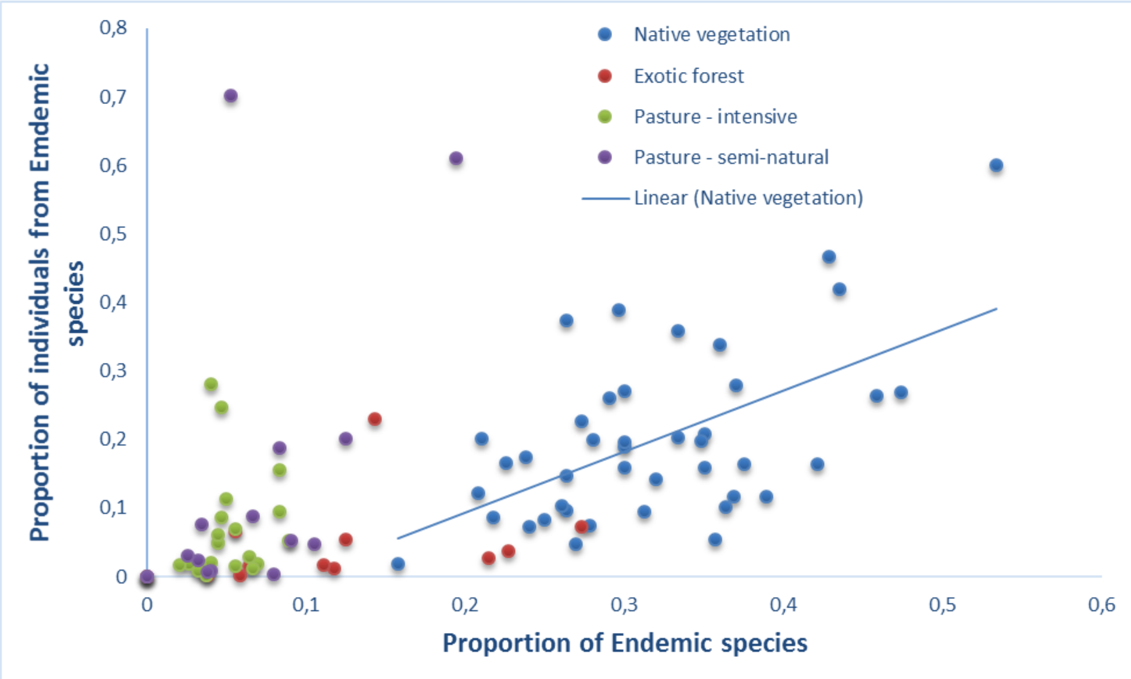
	that arrived naturally to the archipelago but are present either in the Azorean Islands and elsewhere; exotic/introduced species, i.e., species whose original distribution range did not include the Azores archipelago and believed to have been introduced in the Macaronesian region after human settlement in the 15th century. The exotic status was inferred either from historical records of detected species introductions or from their current distribution, being closely associated with human activity. For unidentified species, if other species in the same genus, subfamily or family were present in the archipelago and all belonged to the same colonization category (according to Borges et al., 2010), the unknown species would be classified similarly. Otherwise, we assumed the species to be native.
2. RESOURCES REQUIREMENT	
Time	• High - depending on data, biodiversity and GIS expertise, LULC map and Landscape Disturbance Index Map availability.
Cost	• Medium/High – the cost is dependent of the availability of baseline data and/or the human resources required to obtain any necessary data.
Expertise	• GIS expertise (geostatistical methodological approach); • LULC assessment expertise (Landscape Disturbance Index Map); • Taxonomic and ecological expertise: Parataxonomist sorted samples to orders, and posteriorly to Recognizable Taxonomic Units, RTUs. One of us (PAVB) identified to species RTUs of several arthropod orders belonging to Diplopoda, Chilopoda, Arachnida (Araneae, Opiliones, Pseudoscorpiones) and Insecta (excluding Collembola, Diptera and Hymenoptera).
Tools & equipment	• GIS software with the necessary hardware; • Statistical and Data Management software; • Ecological sampling tools and handheld GPS for field work; • Microscopes and arthropod reference collection.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Mapping and assessment of many other provisioning and regulating ES may be based on the LULC map, providing therefore a common and coherent baseline; • This task could especially benefit from adding/using an ecological modelling approach (e.g. MAXENT) to map pollination services, integrating therefore more environmental complexity and other relevant variables as terrain (elevation, inclination, orientation), climatic (temperature, rain, humidity, incident solar radiation, wind), soil (type, moisture, salinity) and man-made features (settlements, infrastructures), besides LULC.
Socio-cultural	• The mapping and assessment of many other socio-cultural ES may be based on the LULC map, providing therefore a common and coherent baseline;
Economic	• Not applicable.
4 COLLABORATION LEVEL	
Researchers own field	• High
Researchers other fields	• High (Geography, Ecology)
Non-academic stakeholders	• This ES mapping and assessment outputs is particularly useful for conservation managers, as well as for land planners/managers and decision-makers. Therefore, their direct involvement in the field data collection and/or outputs assessment phases might enhance the impact and follow-up of this study, in order to become periodical and effectively policy-making supportive. Foer e.g., this is the current case of the project SLAM Trap monitoring in Azorean Native Forests, in which we have as partners the Island Natural Parks of Santa Maria, Terceira, Faial, Pico, Flores, Graciosa and the Botanical Garden of Faial.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES exercise is very

	useful at local/regional scale, since it can be used to support decisions concerning the design of small sized protected areas.
Regional	• Highly. Due to the particularity of Azores landscapes/LULC configuration (translated by the Landscape Disturbance Index Map), this MAES exercise is adequate to a regional scale. The possibility of evaluating landscape in a similar way to the IUCN Protected Areas categories can be reflected to some extent as a gradation in terms of naturalness.
National	• Appropriate. It is possible to include most species groups in spatial conservation planning exercises for entire regions. With increasing availability of data (e.g. GBIF) and methods (SDMs) this approach could be readily extended to be applied at the national level. However, the indicators for mainland have to be chosen carefully since the island "endemism status" concept it is not easy to be applied. One possible alternative indicator can be the "area of occupancy of IUCN threatened species" as a surrogate for the maintenance of nursery populations and habitats.
Pan European	• Appropriate. It is possible to include most species groups in spatial conservation planning exercises for entire regions. With increasing availability of data (e.g. GBIF) and methods (SDMs) this approach could be readily extended to other regions worldwide. However, the indicators for mainland have to be chosen carefully since the island "endemism status" concept it is not easy to be applied. One possible alternative indicator can be the "area of occupancy of IUCN threatened species" as a surrogate for the maintenance of nursery populations and habitats.
6. EXAMPLES OF POLICY QUESTION	
	• How do current land use policies contribute to the conservation of IUCN threatened species and the maintenance of nursery populations and habitats? • What will be the impacts of climatic changes on the nursery populations and habitats and what needs to be done to identify alternative areas relevant for conservation? • How can conservation interests be best integrated with other island stakeholder interests (particularly tourism) on populated islands?

Some key points that emerged during the application of the method in the Azores case study include:

- The proportion of the arthropod endemic species was selected as a relevant indicator for the ES;
- The concept of endemic species is peculiar of island situations, which is difficult to transfer to mainland context;
- Study was mostly conducted between 1999 and 2005, with 89 transepts in Terceira Island of which 48 in native forest, with at least 30 transects for each land use type;
- Azores landscape disturbance index was used to investigate whether sites with high human impacts have less diversity of pollinators or not;
- The disturbance index and fieldwork data were combined to create a more complex indicator, distinguishing between 12 classes of bees' abundance and richness;
- Actual mapping done with ArcGIS "Topo to Raster", a discretized thin plate spline technique;
- The overall result is that the high proportion of endemic species is in the protected area; all remaining agricultural areas have no potential for these endemic species. In fact, many of the endemic species have very specific demand, they need specific habitats and they demand a very humid, dense forest, and these open habitats are not suitable as nursery population.
- As typical for small islands, the transition between areas with good and bad ecological conditions is often abrupt;
- In the case study, it was found that the number of species could be a good surrogate of abundance, at least for native forests. However, this may not always be the case and needs to be validated;

- From a policy perspective, the results of the study were crucial for creating a new protected area for a unique species that are endemic to Terceira Island.



Some key points that emerged during the discussion on the applicability and transferability of the method to other biomes and regions, including other islands and areas in the continental context:

- There was a strong doubt on whether richness could be a surrogate for abundance; in fact, this is true for naïve forests while for other habitats the relationships are not so clear;

- There were difficulties in interpreting "Maintenance of nursery population and habitats" as a unique category because quite a lot of different kinds of ES are lamped under it (e.g. genetic potential for the future or use as spawning ground) and there were difficulties in linking the ES to benefits for people. In the case study, nursery places are understood as sources of population genetic diversity.

- TRANSFERABILITY: In a larger scale, data from GBIF could be used without the need to do fieldwork. GBIF database has, at least for Europe and for North America, very good data on distribution of species. However, the indicators has to be different because the endemic concept is more difficult to apply on the mainland. Instead, the IUCN threatened categories could serve as a good surrogate for nursery population. IUCN has maps with the distribution of threatened species. Alternatively, the KBA (Key Biodiversity Areas) concept for protected areas could be applied to find nursery populations. In general, if you have the taxonomy results, you can apply the method almost everywhere. The method in fact is part of more "traditional" nature conservation prioritizing, where you look at red lists of spices, which could be endemic species as in the case of islands or other threatened species.

- TIERS: The method as applied in the Azores case study relies on high quality real local data (Tier 3), which are used to define indexes. However, the application does not go as far as reaching the actual decision-making processes; thus, all together

5.2.4. Bulgaria: Mapping and assessment of ES in Central Balkan area at multiple scales

The study area is located in Central Bulgaria and covers the central part of the Balkan Mountains (Stara Planina) and the surrounding areas. The spatial coverage is outlined by following both natural and administrative criteria including all the municipalities that have parts of their areas in the Central Balkan National Park. In total the area covers 2,998.9 km2 of which 24% is proclaimed for protected areas (37 areas in total). Although the study area is relatively small, the nature is diverse due to the influence of the Balkan Mountain Range, which leads to the formation of different hydro-climatic conditions in the higher altitudes and in the northern and southern parts of the mountain. There are three types of climate-temperate continental in the north, transitional to Mediterranean in the south and mountainous in the central part and in the areas above 1000 m. The vegetation is characterized by typical altitudinal zoning. In the lower parts, the vegetation is presented by Oak and Oak-Hornbeam forests followed by beech forests in the areas above 800 m and mountain grasslands at the highest parts of the mountain.

The study covers partially the territory of 9 municipalities – Teteven, Anton, Pirdop, Karlovo, Sopot, Sevlievo, Apriltsi, Troyan and Pavel Banya. Only two of them - Karlovo and Sopot are entirely comprised within the study area. There are 82 settlements with total population of 128,626 residents and 58% of the population lives in the urban areas. The biggest towns are Karlovo (25,715 inhabitants) and Troyan (23,623 inhabitants).The population of Karlovo municipality is estimated to 50,650 residents and has decreasing trend due to a negative growth rate.

The Central Balkan National Park occupies the higher parts of the mountain and ranges 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. The flora is represented by 2340 species and subspecies of plants. Forests occupy 56% of the total area. There are 59 species of mammals, 224 species of birds, 14 species of reptiles, 8 species of amphibian and 6 species of fish, as well as 2387 species of invertebrates. The national park includes nine nature reserves protected by strict regime and covering 28% of its territory.

Discussion on Methods for specific biomes and regions (Session 7)

- Selected ES 1: Surface water for drinking and non-drinking purpose (1.1.2.1 + 1.2.2.1)
- Applied method 1: SWAT model & water footprint

METHOD CARD: PROCESS BASED MODELS Applied to: Surface water for drinking and non-drinking purpose (1.1.2.1 + 1.2.2.1)	
CASE STUDY	Bulgaria
SCALE	Local
TYPE	Biophysical
TIER	3
DESCRIPTION	
The approach relies on GIS based hydrological modelling performed through ArcSWAT tool. It utilizes SWAT model in ArcGIS environment and is appropriate for application in medium to large watersheds. The model simulates water balance parameters within the watershed which are used to quantify the water retention of	

different ecosystems. The outputs are runoff, infiltration, sediment yield and evapotranspiration. The latter is used as indicators for surface water for drinking and non-drinking purposes. The method is applied in combination with water footprint concept (blue and green footprint). Required input: land use, DEM, soil, precipitation, runoff data (for calibration). Output: runoff, infiltration, sediments (area and stream), evapotranspiration. The main advantage of ArcSWAT tool is the option to calculate the outputs within Hydrological Response Units (HRU).		
1. DATA REQUIREMENT		
Qualitative	• Land use/land cover (raster) • Soil data (vector)	
Quantitative	• DEM (50m resolution or higher) • Climate data (daily values for at least 3 years period – precipitation, temperature, air moisture, solar radiation) • Runoff data (for calibration)	
2. RESOURCES REQUIREMENT		
Time	• Data gathering and initial processing takes time (one or two weeks to month). • Model configuration and calibration is also time consuming (weeks). • Model simulations are relatively fast once the model is setup.	
Cost	• The special software is free, ArcGIS license is required. • Climate and hydrology data could cost.	
Expertise	• Expertise in GIS (ArcGIS), ArcSWAT tool, basic knowledge in hydrological modelling (SWAT). Knowledge in water footprint concept.	
Tools & equipment	• ArcSWAT tool that works as ArcGIS extension	
3. LINKS AND DEPENDENCY ON OTHER METHODS		
Biophysical	• The results can be used for quantification of qualitative scores of the Spreadsheet method	
Socio-cultural	•	
Economic	•	
4 COLLABORATION LEVEL		
Researchers own field	• Medium	
Researchers other fields	• Low	
Non-academic stakeholders	• Low	
5. SPATIAL SCALE OF APPLICATION[1]		
Local	• Applicable	
Regional	• Mostly applicable	
National	• Possible but not tested so far and the cost could be too high	
Pan European	• Not applicable	

SWAT model is one of the process-based model that have a capacity to assess hydrological process of ecosystems. However, it is not possible to fully distinguish the differences of drinking and non-drinking water by SWAT model.

The challenges of SWAT model are: a) it is mostly applicable for local scale, it could also be applied for regional scale but it requires more resource and detailed data (which are normally not available); b) the model can be applied to national scale but it is not tested so far in Bulgaria due to the high costs of requirements. Therefore, the combination of SWAT model with other methods could be a better solution for national scale assessment; c) the model is applicable for most likely all ecoregions but it is only not tested in limited number of them for now and it can also be applied to all geographical regions; d) regarding the tier approach, SWAT model is Tier 3 method and it is important to develop how to link this model with different methods of different tiers in the future in order to make assessment to transfer the data from local to regional and national scale.

Application of the results

The most important advantages of SWAT and ArcSWAT model is to enable modelling of very small spatial units of HRU-Hydrological Response Units which is the results of overlay analysis of topography-DEM, soil and LULC data. Regarding the SWAT approach, it is possible to make scenario planning exercise with SWAT to assess the impacts of several changes such as LULC or climate change on water supply capacity. Therefore, SWAT can be applied to anywhere (to different biome) in any scale depending on the data & sources.

Figure 5.3. Synthesis of breakout discussion on ES Surface water for drinking. By Cristian Mihai Adamescu (UB)

- Selected ES 2: Aesthetics (3.1.2.5)
- Applied method 2: Narrative assessment

METHOD CARD: Photo Elicitation Surveys Applied to: Aesthetic (3.1.2.5)	
CASE STUDY	Bulgaria – Central Balkan
SCALE	Regional/local
TYPE	Cultural
TIER	2
DESCRIPTION	
The method was applied for urban aesthetic ecosystem services (AES) assessment and mapping. AES relate to the visual, sensitive and intellectual interaction with the physical environment. A representative documentation about this interaction is photos which people take and upload in the social media or other public virtual space. The ecosystems subtypes were defined according the classification of National Concept for Spatial Development (2013-2020) and Mapping and Assessment of Ecosystem and their Services (MAES) guidelines. Application of Photo elicitation method was done in following steps: 1) Review of previous studies conducted by Photo elicitation method; 2) Delineation ecosystem subtypes; 3) Integration of the urban ecosystem subtypes map with the Google Earth pictures; 4) Selection of all pictures in each polygon, excluding of the pictures with personal information and counting the number of all pictures related to each polygon; 5) Development of a data base containing number of pictures per polygon; 6) Assessment of ecosystem types using relative scale from 1 to 5 (when there are no pictures uploaded in a polygon the score is 0 which means that the ecosystem does not provide any AES; 7) Mapping of aesthetic value of urban ecosystems.	
1. DATA REQUIREMENT	
Qualitative	• Satellite or Orthophoto images provided by web-based map platform such as Google Earth
Quantitative	• Photographs uploaded in Google Earth
2. RESOURCES REQUIREMENT	
Time	• Medium (about 40 photos/hour)
Cost	• Low cost method (use freely available resources)
Expertise	• Low to Medium
Tools & equipment	• Public photos can be downloaded from Google Earth and GIS software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• E.g. INVEST
Socio-cultural	• Narrative assessment; Preference assessment; Participatory mapping and assessment; Scenario planning
Economic	• Restoration cost and Hedonic pricing
4 COLLABORATION LEVEL	
Researchers own field	• Medium (need basic GIS expertise)
Researchers other fields	• Low (but recommended for the photos selection process)
Non-academic stakeholders	• Low
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly appropriate
Regional	• Highly appropriate
National	• Somehow appropriate
Pan European	• Not appropriate

Photo elicitation is a socio-cultural method, which uses visual images, including video, paintings, cartoons and advertising materials, to qualify or quantify peoples' preferences. Qualitative assessment of aesthetic was done with the number of photos calculated individually for each polygon of geospatial database, which provide information about the urban ecosystem subtype in Karlovo city, Bulgaria. Challenges of photo elicitation method mapping aesthetic services are: at first, there are many differences between peoples' perceptions and peoples' choices which can also effect the choice of uploading the image that change the number of photos. Therefore, there is huge alteration in the accuracy of presentation, and the validation of method is very difficult. Secondly, the presence of attractive objects can also effect the peoples' choice due to its subjectivity. The distribution of different ecosystem subtypes (such as objects, recreational zones, naturel monuments, architectural heritage) have different potentials depending on their conditions, therefore, the method should be used in combination with as many elements as possible. And finally, it should not be forgotten that aesthetic is a challenging topic in order to valuate due to its unclear and subjective definition and content.

Application of the results

The result of the aesthetic value capacity of ecosystems in Karlovo show that (741 ecosystem polygons are identified; 972 photos are identified which are posted by 510 people) 5 ecosystem subtypes are most visualized that have the largest number of photos. Moreover, according to the photo/polygon results the largest results are in the residential and public areas where they have rich cultural heritage in the old town of Karlovo. Regarding the other indicator which is photo/hectare, the results indicate that urban green areas with sport and leisure facilities has the highest value in the city.

Figure 5.4. Synthesis of breakout discussion on ES – Aesthetic – Key discussion key points. By Cristian Mihai (UB)

5.2.5. Marine area case studies

An additional breakout session was organized on ES mapping and assessment in marine areas. It was concluded that despite high level knowledge pool on functioning of marine ecosystems, the quantification and mapping of the ecological functions and process that are behind many ES is still difficult. The main challenges are related to: 3D-nature of the marine ecosystems as well as dynamics of ES distribution in time and space, which makes it difficult to produce two-dimensional maps; limited data availability and accuracy on the distribution of habitats; difficulties to link cultural ES assessment to certain habitats; sensitivity of data on demand for some ES with high commercial value, etc. This leads to high level of uncertainty in marine ES assessment and maps, and thus making questionable applicability of the results in the policy and decision making context.

During the break-out session five cases studies with focus on marine and coastal areas were presented and discussed representing variety of biophysical, social and economic assessment and mapping methods:

- *Sabine Bicking* (CAU) presented two projects on quantification of ES along the German Baltic Sea Coast: BACOSA II assessing the coastal communities up to 10 m depth by using biophysical, social and economic methods; and SECOS Synthese – biophysical mapping of coastal waters from 10 m depth to EEZ by using spreadsheet matrix based on field data;
- *Sylvie Campagne* (IRSTEA) presented monetary valuation of the goods and benefits related to the seagrass *Posidonia oceanica* in the French part of the Mediterranean sea, using combination economic methods (market price, damage cost avoided; benefit transfer method; production function);
- *Petteri Vihervaara* (SYKE) introduced to a case study conducted in the Finnish archipelago, applying biophysical and social methods, including used included spatial land cover data (spatial proxy), expert-based evaluation, structured photo-assisted interviews of visitors and PGIS asking for the stated preferences of the visitors;
- *Daniel Norton* (SEMRU, NUIG, IFNC, NPWS) presented results of the recently ended project VIBES by the Irish EPA contributing to the marine planning, which assessed marine ES using the range of different data available and resulting with monetary valuation;
- *César A. López Santiago* (UAM) presented an ES assessment applied to fisheries management in Spain, which followed the design and methods of the Spanish national ES assessment.

The main outcomes of the discussion can be summarized as follows:

- Complexity of the marine ecosystem, including its dynamic 3D character should not be regarded as problem – different approaches can be applied for mapping of different components and services of marine ecosystem and it is not necessary always to use harmonized spatial units. ESMERALDA flexible methodology could assist in finding out the best tools and methods for each context.
- The methods used for terrestrial ES are not always fitting to the marine context. Therefore, cross-checking of the ESMERALDA method data bases would be needed to identify applicability of each method for marine ecosystem.
- The marine cases are underrepresented in the ESMERALDA database and there might be not enough expertise on marine issues within the ESMERALDA consortium so far.

Participants of the session agreed on the need to increase the visibility of marine ES in the ESMERALDA project. The discussion on methods for marine ecosystem service mapping should be expanded by involving marine experts from ESMERALDA project partners as well as communicating with other projects or institutions directly dealing with marine ecosystem services (e.g. Ifremer from France).

5.3. ESMERALDA methods development

5.3.1. ESMERALDA: Current status and update

The session started with general updates from the project provided by the ESMERALDA Coordinator. This update included an overview of the thematic, organizational and other developments since the last ESMERALDA WS 4 in Amsterdam in January. One key achievement in this period was the successful implementation of a comprehensive project Grant Agreement amendment, concerning the integration of 11 new consortium partners, the change of Coordinator and Project Management Office from CAU Kiel to LU Hannover and several other modifications. The new consortium partners were introduced to and welcomed by the other project partners. ESMERALDA is now covering all EU member states (except our partners from Luxemburg and Croatia, which still are to be integrated in a subsequent amendment) and Switzerland, Norway and Israel.

Other recent ESMERALDA activities relate to the creation of a MAES network in the EU overseas countries and territories and outermost regions (OCTS and ORs). A dedicated Workshop was organized by ESMERALDA in co-operation with the Azores Biodiversity Group and the voluntary scheme for Biodiversity and Ecosystem Services in Territories of European overseas initiative (BEST) at the University of Azores from February 28 – March 03, 2017.

Furthermore, the workshop participants were updated on recent progress on MAES in the EU member states, related ESMERALDA working phases, plans and questions for implementation of project results in decision making. The newly published book “Mapping Ecosystem Services” with contributions of almost all ESMERALDA partners was presented during Session 1. Another key outcome of ESMERALDA will be the “flexible methodology”, of which the next developmental steps and ideas were presented.

An update on ongoing and finalized activities in all six ESMERALDA Work Packages was given during the session. As a result, the workshop participants were updated about the developments of the project, stakeholders present were introduced to the ESMERALDA general approach, and all were introduced to the new partners in the consortium.

5.3.2. Building the ESMERALDA Method database

The aim of this session was to update participants about the progress of building the ESMERALDA method database; to present some preliminary descriptive results based on the level of information that is already integrated; to solve and discuss with the participants questions that they might have had during the process of coding the information into the database and, finally, to agree on the next steps and finalization of the data collection process.

During the session, some preliminary descriptive results based on the level of information that were already integrated into the online questionnaire[21] by 3 April 4.2017 were presented. Given that new partners participated in this workshop, a quick overview of the purpose of the database and its current progress of building the ESMERALDA method database were presented.

Frequently asked questions by partners filling in the online questionnaire were also presented and discussed. These questions as well as the latest status of the database (entries in excel file so far) is uploaded and can be found on the ESMERALDA intranet (see

Figure 5.5).

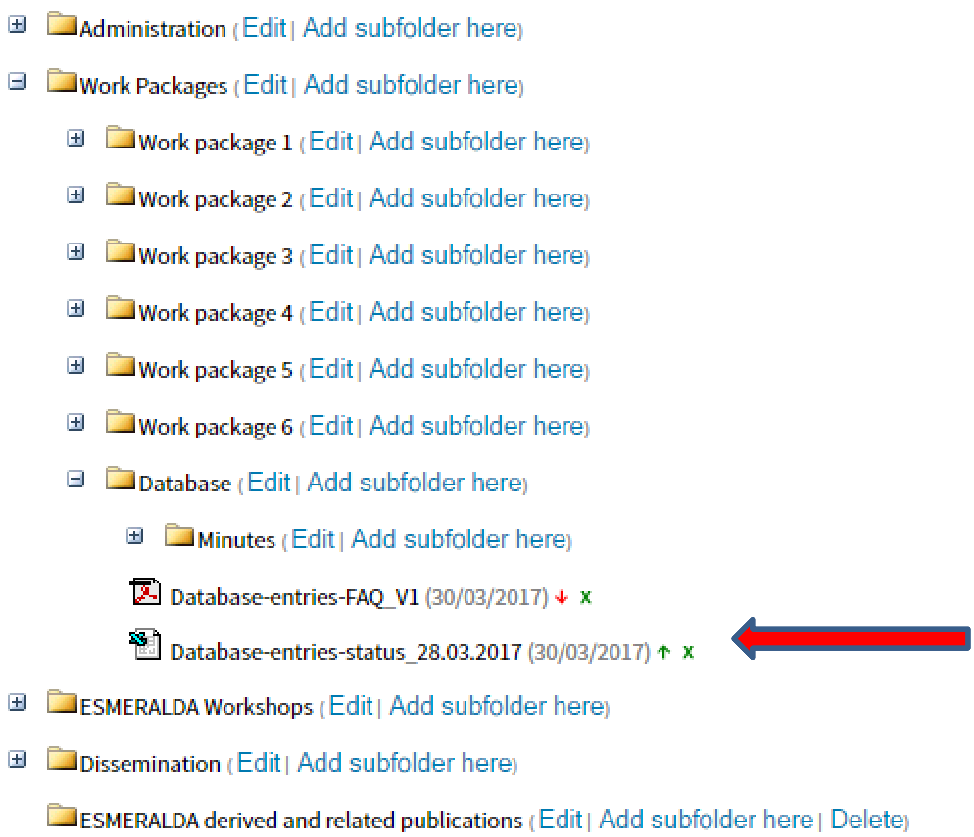


Figure 5.5. ESMERALDA intranet folder structurer

The presentations were followed by a discussion on further questions by the participants and next steps and finalization of the data collection process were agreed.

The database will need to be finalized and presented at the next workshop in Plovdiv/Bulgaria in October 2017. That means all data need to be entered into the online questionnaire by end of August 2017. As at the time of the Madrid workshop only ca 15 % of the already existing data were re-entered into the new format and hardly any new information provided, the session was closed with a call for more entries.

[21] https://www.webropolsurveys.com/S/85E71B9D58A30304.par

As an outcome of the session, participants were updated about the development of the method database; some problems and questions related to the process of coding the data were solved, and agreement on the next steps and final dates to introduce the data.

5.3.3. ESMERALDA Flexible Methodology

The aim of the session was to present and discuss ongoing work on the development of the methodology, highlighting issues of potential interoperability with other relevant related activities and project outcomes. Particularly, update the participants, collect feedback and further ideas, and engage ESMERALDA consortium members in ongoing and future activities and following breakout groups.

The session included several presentations related to the further development of the ESMERALDA flexible ES mapping and assessment methodology. The methodology will have two key components: 1) several guidance documents (of which the new “Mapping Ecosystem Services” can be seen as one first key part; complemented by several methods-focused ESMERALDA Deliverable reports and other publications) and 2) an online database of methods. Hermann Klug and Steffen Reichel from project partner PLUS presented the state of development of the ESMERALDA interactive ES mapping methods tool, an interactive web interface enabling users to browse the ESMERALDA methods data base. The aim of the tool is to enable ES map makers and users to find appropriate methods and related case study applications for the mapping and assessment of different ES.

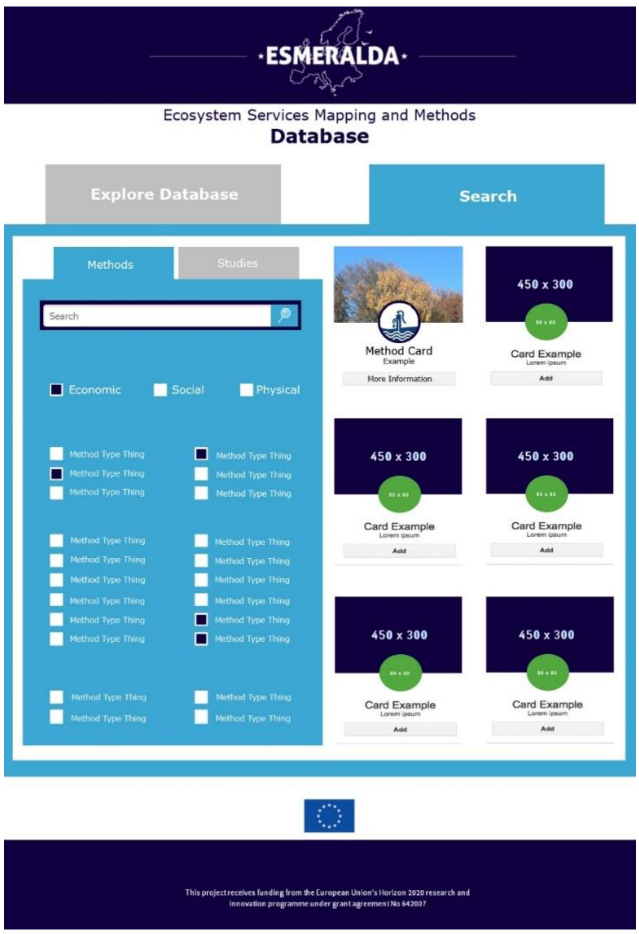


Figure 5.6. Layout draft for the ESMERALDA methods database interface developed by PLUS.

Another important component of the methodology will be the ESP visualization tool[22], which was presented by Joachim Maes (JRC). The visualization tool has been initiated by the ESP Thematic Work Group "Mapping Ecosystem Services" a couple of years ago and is now available in its Beta version. The tool enables the up- and downloading and browsing of ES maps and data behind the maps.

Joachim Maes (JRC) together with Claire Brown (UNEP WCMC) presented also the decision tree approach developed by the OpenNESS project. The approach enables the selection of methods for ES assessments, comparable to what is developed for ES mapping in ESMERALDA at the moment. Potentials of synergies of both approaches will be further elaborated in future.

The outcomes of the latest meeting (in January 2017) with Stakeholders to discuss the interoperability of ESMERALDA outputs into existing platforms (e.g. BISE, OPPLA) and the Interoperability of different projects' outcomes (ESMERALDA Milestone 31) was presented by Benjamin Burkhard (partner LUH). One key point of this Milestone is the safeguarding of perennity of ESMERALDA end products after the project has ended. Moreover, the EC wants to avoid the duplication of efforts, thus related projects (e.g. ESMERALDA, OpenNESS, and OPERAs) shall collaborate. Advantages and disadvantages of the different platforms were presented. One advantage of making ESMERALDA outputs available through OPPLA or BISE is that both systems are designed to operate longer than the project. Therefore ESMERALDA aims to provide its outputs in an interoperable way with these two information systems. Already available ESMERALDA products include the country fact sheets (published in BISE), the Open Access "Mapping Ecosystem Services" book, and several Deliverable reports (currently available on the ESMERALDA website). Future products will include the ESMERALDA case studies (fact sheets, data, Method Cards, publications), the methods database with query tool, guidance documents and further ESMERALDA publications.

It needs to be decided which ESMERALDA products shall be fed to which platform, whether real inter-operability is possible and how technical issues can be solved. Furthermore we need to figure out who the key customers of the different platforms are, how questions of data ownerships can be solved and how the different stakeholders' demands can be fulfilled in the different environments. There is consensus that no new platform shall be created, instead link with existing different platforms should be made. ESMERALDA is committed to the EC (DG RTD) and needs to deliver to MAES and BISE/EEA. Therefore, BISE seems to be the most evident platform to share results of the project. BISE is also particularly suitable for information endorsed by the Member States, such as fact sheets, mapping guidance and maps (through interoperability with the ESP-VT). OPPLA may be a suitable platform to share guidance (the flexible mapping approach) but further insights are needed to understand the business model of OPPLA in order to ensure that ESMERALDA products are open access. ESMERALDA could test different systems within its Workshops to identify stakeholder demands.

The presentations were followed by a discussion with the consortium members in order to receive their feedback, hear opinions and collect further ideas. The session ended with the introductions of the three different breakout groups for the following session.

As a result of the session, participants we updated on ongoing and future activities; potential synergies with other relevant activities were elaborated; and Consortium members got more involved in the development of the ES mapping and assessment methodology.

[22] http://esp-mapping.net/

5.3.4. Discussion on Flexible Methodology: Tiers, Methods interlinkage & Policy questions

The aim of the three break-out sessions was to present and discuss key issues on the development of the methodology relating to tiers, interlinkages between methods, and policy questions. Particularly, to update the participants, collect feedback and further ideas as well as engage the ESMERALDA consortium members in the final decisions and future activities. Following are the main points that emerged from the three breakout sessions.

Tiers

Outline: Developing a tiered approach to structure the vast variety of methods for ES mapping and assessment has been shown to be a challenging task. In this breakout session, we briefly reviewed the benefits and the necessity of a tiered approach, discussed the categorization of methods into tiers according to purpose of the study and evaluated alternative categorization criteria such as scale or data characteristics. Finally, we discussed how to best integrate the developed categorization into the flexible methodology and the database. The session started with an introduction of the concept of tiers to bring participants to the same initial level of understanding. A preliminary analysis of the database entries revealed the potential of the tiered approach and how it could be linked with the database and the flexible methodology.

Main Outcome of discussion on tiers: The presentation was followed by a lively and positive discussion. The tiered approach has already been applied by several partners who shared their experiences with the group. The definition of the concept of a tiered approach seems to be clear and the way it is currently implemented in the database through the online survey is working. It was decided to produce a short document (max. 1 page) describing the tiered approach which will be circulated amongst the consortium members for consultation and will finally serve as a guidance document for the definition of the tiered approach in the ESMERALDA project. For now, we will proceed with a manual classification of the database entries lead by ETH Zürich, ways for a rule-based classification will be tested once more entries are available in the database. By linking the tiered approach to methods and finally to the available method cards, information about the resources required will be provided.

Highlights: The tiered approach was used by several partners and found to be a useful tool for communication, particularly in stakeholder processes and to communicate the quality of a map. We discussed the question whether the tiered approach considers methods only or also data characteristics and concluded that both issues are covered as they are often interlinked. The suitability of the approach for cultural services was questioned and it was shown that it is applicable, i.e. that it is possible to categorize methods to assess cultural services according to their level of complexity yet it is not as straight forward as for biophysical or economic services.

The need to sharpen the definition together with the question of the intended users of the tiered approach was discussed in detail. The current definition is rather broad and the boundaries between the tiers are not very sharp. This has the advantage that the approach remains flexible, i.e., applicable in different context. The tiers are meant as a guideline to a set of methods and data used and should be followed by an in-depth analysis of the suggested set of methods. Here, the method cards provide useful information about resource requirements and practical questions of application.

Currently, the tiered approach with the associated decision tree focuses on the purpose of the assessment. It is intended to further elaborate the decision tree and include aspects such as data characteristics, services and scale. It was mentioned that indicators would be a further useful category to be added to the decision tree. The option to enter the decision tree from different aspects is expected to make it more useful in different context.

A further interesting comment raised the issue of the quality and uncertainty related to approaches at different tier levels and the comparisons of mapping services at different tier levels. It would be interesting to look at the uncertainties related for the three tiers for the same service in the same case study area.

Interlinkages between methods

Outline: The aim here was to create a shared understanding of the interlinkages among different methods that belong to different dimensions (biophysical, economic and socio-cultural), which is a key objective to trigger the process of developing the flexible methodology. To this end, some evidence based results from the literature of potential interlinkages among methods were presented. Hence, participants discussed whether they could validate or complement this information based on their own experiences. Finally, the question on how to best include these potential methods interlinkages in the flexible methodology was debated.

Main Outcome of discussion on interlinkages between methods: The session is related to the deliverable in WP3 "how to link all the methods across domains", but is also of interest for the final deliverable in WP4, namely "Report on multifunctional assessment methods and the role of map analysis". The discussion made clear that in future analysis will have to differentiate linkages between:

a) Individual methods which are integrative in its own rights, e.g. CBA; and
b) A combination of individual methods, leading to an integrated result, e.g. a combination of a bio-physical and social method.

As an example, we could think of "Spreadsheet methods" (biophysical) to map provision of the recreation in certain area and PPGIS survey (socio-cultural) to map the demand of the recreation in the same area. Overlaying results will provide more comprehensive information of the provision and demand of the recreation than using only other method. Or we could use, for example, biophysical methods to provide material and data (input) for economic valuation (Figure 5.7).

Purpose of studies and policy questions are highly relevant. Also the role of stakeholders is highly important. What are the stakeholder needs, why ES needs to be identified? Stakeholder needs could be one way to link methods (e.g. social methods are used to map demand and biophysical to map supply

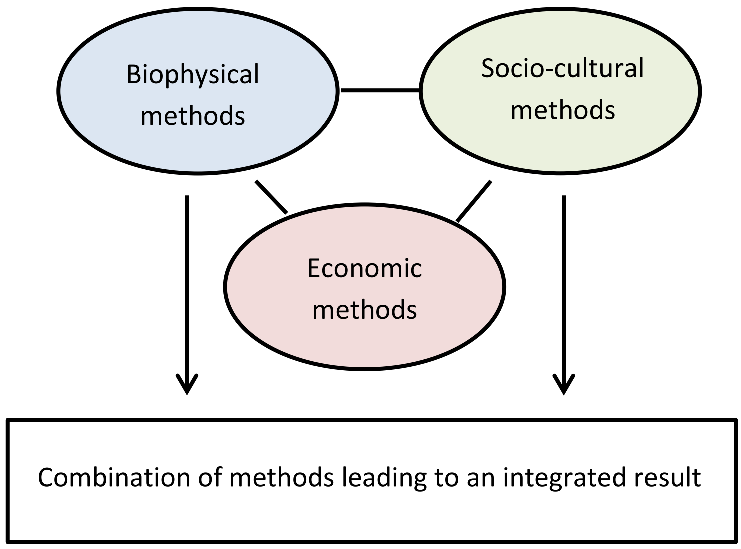


Figure 5.7. Methods can be linked in two different way: 1) Output of one method can be used as input data for other method or 2) outputs of individual methods can be compared together to create more comprehensive results.

For the three dimensions (biophysical, socio-cultural, and economic), following are examples of interlinkages identified by the participants based on their previous studies and experience.

Biophysical methods

- Spread sheet matrix methods were linked with market price, travel cost, preference assessment, photo elicitation and participatory mapping;
- Green and blue space models were linked with participatory mapping;
- ESTIMAP was linked with participatory mapping and hedonic pricing;
- Network analyst was linked with spread sheet method;
- Some of the biophysical methods were found to be integrated within themselves (e.g. BBN).

NB. During the discussion problem emerged with the list of biophysical method: it includes both tools and methods that are not on a same level (e.g. QuickScan includes multiple methods, BBN can include input created using network analyst tool).

Socio-cultural methods

- Preference assessment was linked to Fragmentation analysis, Habitat modelling and Integrated modelling framework;
- Stakeholder engagement was linked to BBN, Market Price and Value Transfer;
- MCA could be linked with all the economic methods: in fact, MCA needs biophysical input but includes also subjective view (scoring);
- Methods are not on a same level (e.g. network analysis and spread sheet methods);
- Method grouping would reduce the number of methods and could help to understand links better.

Economic methods

- Cost benefit analysis, Damage Cost Avoided and Travel cost were linked with Green Model, Invest and MIUU model;
- MCA was also mentioned to be truly integrated method. In fact, multi-criteria method is mentioned in every method group;
- Method list was seeing quite comprehensive.

Following are the main discussion points and some conclusions reached during the session:

- Especially the list of biophysical methods was seen problematic. The ESMERALDA database questionnaire indicated a large amount of methods that were not included in the Final method compendium". Hence it was decided that the list of biophysical methods still needs to be reviewed. However, we cannot make changes to the method names as people have already answered to the database questionnaire. Still we can try to make some classification to the methods into more general classes.
- In the group, it was felt that a 1:1 correlation of methods (the presented matrix) was not the best way forward to find typical interlinkages. It was discussed that "expert" knowledge might help in creating "narratives" of typical method combinations.
- Quality of the data is highly correlating to the output. For example, if a biophysical method is used to create input data to some economic method the scale of the biophysical data must be sufficient also for economic method.
- We need to create guidelines to the final tool produced in ESMERALDA.
- It is important to note what is meant with integrated methodology. Method integration can deal with practical issues related to putting together results based on biophysical, socio-cultural and economic methods. However, integrated methodology can be also interpreted as a wider concept related to assessment methods and policy targets of particular ecosystem assessment.

Policy questions

Background

Ecosystem assessments usually start with a set of policy questions. Also the MAES initiative organized 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 by another pair of participants. In case of contrasting conclusions, a discussion resulted in a final conclusion or in no conclusion.

Finally, a number of ideas emerged on how to group policy questions. Different proposals were made:

- Group 1: (Cost of actions; Benefits of actions; Planning – priorities and selection; How do you plan (future and current); Future trends)
- Group 2: (Which kind of sector would use…; Scale and time; Current or forecasting)
- Group 3: (Future trends; Users)

The list with questions as well as the conclusions are provided in Table 5.2.

Table 5.2. Policy questions (including source) and conclusions, i.e. A) ESMERALDA can provide an answer; B) ESMERALDA cannot provide an answer; C) No conclusion.

Policy question	A	B	C
How can the ecosystem service concept be made relevant and find its entry into the development of the next CAP? What are ecosystem services farmers could be paid for? (13th MAES meeting)	x		
How can we link different result and data sets at different scales (i.e. EU, National, and Local)? (13th MAES meeting)	x		
Which are the priority ES that need to be mapped & assessed? (13th MAES meeting)	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)	x		
Where to get an independent measurement of ES flows to validate our calculations/ models predicting ES delivery? (13th MAES meeting)	x		
Why different methods for mapping & valuing ES will provide different results(13th MAES meeting)			x
How can the data & knowledge gained through MAES/ MAES-type projects be used by local planners – e.g. where to put a new housing development or road? (13th MAES meeting)	x		
How might ecosystems & ES change under plausible future scenarios? (13th MAES meeting)	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)	x		
How mapping of degraded ecosystems could contribute for MAES process? (13th MAES meeting)		x	
How can member states contribute to development of pilot studies? Is it possible to provide technical support for them? (13th MAES meeting)	x		
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)	x		
Why should we invest in measuring carbon stocks if they do not have real-life economic value? (13th MAES meeting)	x		
How can the lack of knowledge on ESS production functions be addressed within the MAES process? (13th MAES meeting)		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)		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)	x		
What is necessary to bridge all that is known on ESD in the scientific community to the policy domain? (13th MAES meeting)		x	

Policy question	A	B	C
How can health benefits of ecosystem services be valued in such a way that decision making on spatial planning is influenced? (13th MAES meeting)	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)			x
What is the public's current understanding of ES? (13th MAES meeting)	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)		x	
What can we take back as a mission to our MS agency and administration concerning 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)		x	
The cost-benefit analysis is an appropriate tool to handling ES and valuing such bundles. Is this work to be taken up within MAES? (13th MAES meeting)	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)	x		
How can we use MAES/MAES-type work to determine optimization 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 the right (or an) answers? (13th MAES meeting)			x
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)		x	
How the "intrinsic value of nature" as is addressed in 7th EAP and BD strategy to 2020, captured with "elsewise" utilitarian approach of ecosystem services? (13th MAES meeting)			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 prioritizing their ESS?) (13th MAES meeting)		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 ES perception is surely another business opportunity to "Harvest from nature" without sustainable management? (13th MAES meeting)			x
What can we take back as MS representatives on ES accounting? What are the envisioned useful applications on MS level? What are the envisioned applications at EU level potentially impacting the MS? (13th MAES meeting)			x
How can MAES inform the spatial targeting of expenditure to conserve and enhance ecosystems? (13th MAES meeting)	x		
How, if at all, will ES approach be linked/aligned/matched with typology of Nature Based solutions that will be developed / with overarching conceptualization of nature's values within IPBES(13th MAES meeting)	x		
How to harmonize across the EU the prioritization of ecosystem services which are selected by national stakeholders(13th MAES meeting)		x	
What are the current state and trends of the EU's ecosystems and the services they provide to society? (1st MAES report)	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)	x		
What are the key drivers causing changes in the EU's ecosystems and their services? (1st MAES report)		x	
How does the EU depend on ecosystem services that are provided outside the EU? (1st MAES report)	x		

Policy question	A	B	C
How can we secure and improve the continued and sustainable delivery of ecosystem services? (1st MAES report)	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)	x		
What is the current public understanding of ecosystem services and the benefits they provide (some key questions could usefully be included in the 2013 Eurobarometer on Biodiversity)? (1st MAES report)	x		
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)	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)			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)			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 services on long-term human well-being and what are the knowledge constraints on more informed decision making (1st MAES report)			x
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)	x		x
How can MAES help to assess and review the design of prioritization 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)	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)	x		x
How to foster synergies between existing and planned initiatives at local, regional or national levels in Member States, as well as how to promote further investments, thereby providing added value to Member States action? (1st MAES report)			x
Do the measures generate social benefits? (ESMERALDA matrix)	x		
How high are costs of landscape degradation? How to protect landscape? (ESMERALDA matrix)	x		
What is the economic value of nature (bird watching) and what is its contribution to tourism management.	x		
“What do nature and water have to do with economics?” (ESMERALDA matrix)	x		
Are people have preferences for heathland restoration or river restoration? (ESMERALDA matrix)	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)	x		
How can we use ecosystem services for future vision building of a region? (ESMERALDA matrix)			x
How much to invest in forest management (ESMERALDA matrix)	x		
How to achieve economically viable grassland management while maintaining biodiversity? (ESMERALDA matrix)			x
How can the ES approach be integrated into planning and EIA processes? (ESMERALDA matrix)	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,	x		
how to map water quality-related ESs necessary for the implementation of specific measures in different planning levels (ESMERALDA matrix)			x
How to protect against flood risks resulting from tidal waves. (ESMERALDA matrix)			x

Policy question	A	B	C
In response to these figures, the I–O model developed below is used to answer the 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)		x	
Is there a positive preference for habitat restoration in coniferous forests (ESMERALDA matrix)	x		
Should the most valuable areas for ESs provision be taken into account as conservation priorities? (ESMERALDA matrix)			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)	x		
what are the most important actual and wanted ES (ESMERALDA matrix)			x
What are trade-offs between different landscapes scenarios? (ESMERALDA matrix)	x		
What environmental factors are most important for people who want to move out from the city? How to protect landscape? (ESMERALDA matrix)			x
What social benefits will the plan bring about? (ESMERALDA matrix)	x		
Where further improvement in land use should be targeted to strengthen the supply of analysed ES? (ESMERALDA matrix)	x		
Where are optional areas for specific land use that have not been realized so far? (ESMERALDA matrix)	x		
whether or not aquatic vegetation removal in the study area gives full cost recovery (ESMERALDA matrix)	x		
which are emphasized as particular priorities in current development policy and/or seen as major areas of opportunity for future economic growth (ESMERALDA matrix)			x
Which measures protect against flooding having the highest BC-ratio	x		

5.3.5. Integration of Results

This session represented a key step towards the activities under Task 1.5, which deals with the integration of the various project results from ESMERALDA Work Packages 1-6 into a flexible methodology for ES mapping and assessment. Specifically, the session showed how the case study approach has been used to test the identified methods, illustrated how the ES mapping and assessment contributes to integrated ecosystem assessment and how the EU Member States have progressed since the first inventory of MAES implementation during ESMERALDA's first phase. Finally, the session discussed the dissemination of the project outcomes, including opportunities for different types of publications. Following are the main outcomes of the session:

Links of methods to case studies

This consisted of updating the ESMERALDA consortium about the development of the case studies used for the first series of testing workshops (i.e. WS 3 Prague, WS 4 Amsterdam, and WS 5 Madrid). An overview of the methods applied for ES mapping and assessment was provided, highlighting those ES and methods that have been discussed with respect to specific issues (e.g. scale issues) during the workshops. As an outcome, the ESMERALDA partners were made aware of how the case studies provide evidence of the application of a set of (biophysical, socio-cultural, and economic) methods, covering a wide range of ES at different scales and tiers. At the end, all the ESMERALDA partners agreed that "somehow" their expertise was fairly covered in the final project outputs relating to case studies.

Integrated Ecosystem Assessment framework

This part explored how a number of different elements developed within the ESMERALDA come together to support an Integrated Ecosystem Assessment framework. A suggested draft framework (see Figure 5.8) was presented and members of the consortium had an opportunity to discuss and agree elements, as well as ways in which to develop supporting text.

Following are some key points that emerged from the discussion (see also Milestone Report 26):

- There is different understanding of integration: e.g. between ES and conditions, between biophysical, social and economic methods, between the wider policy question and the mapping part. In general, in the ESMERALDA project we ought to develop further the diagram above as much as possible. Thus, we provide the stakeholders/users with a wider understanding of integration so they can choose where to start and finish the assessment and the integration.
- A policy-oriented understanding of integration (and its evolution), including its relation with Action 5, 6 and 7 of the EU Biodiversity Strategy 2020 is essential for a follow up.
- In ESMERALDA there is need to catch up with the mapping of ecosystem conditions, e.g. Pilot study.
- The ESMERALDA consortium should not put more effort in conditions; it did not sign up for this. However, it is important that the framework above identify the areas where Member States and the Commission will work in the future (i.e. conditions, accounting) as well as areas that are important for IPBES. MAES and Member States were very enthusiastic; however, we should see where we as ESMERALDA could go with our limited resources and time.
- The ESMERALDA consortium’s position is that combining ecosystem conditions and ES is important but in the ESMERALDA, we focused on ES.

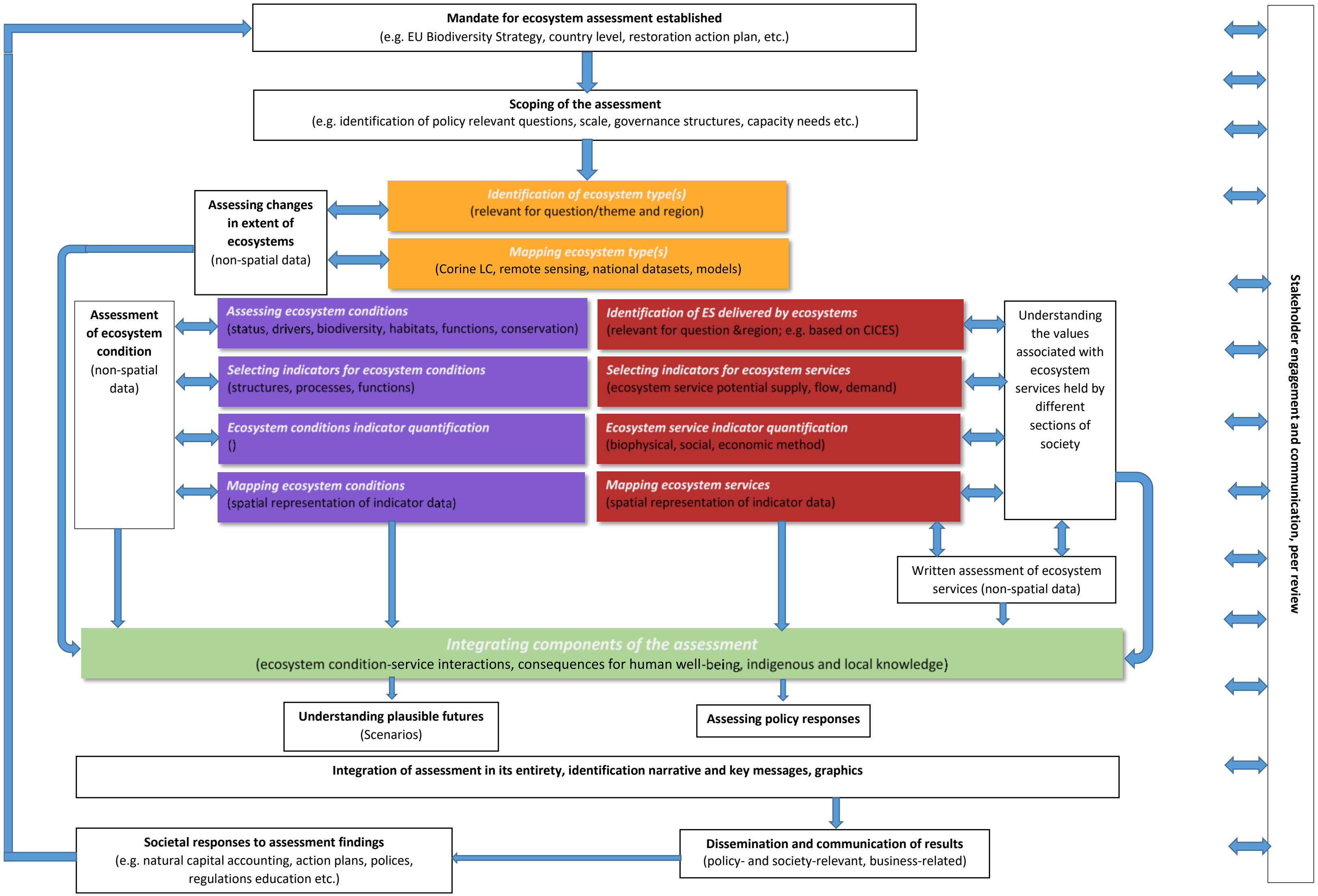


Figure 5.8. Towards an IEA framework in ESMERALDA drafted by Brown, C.; Potschin, M. and R. Haines-Young (2017) based on Burkard et al. (2016) and Maes, J. et al. (2014) 2nd Maes report

Ideas for publications of results

This part highlighted how publications are a key of project results' dissemination. After 2/3 of ESMERALDA project's duration has passed, it is time to think more concretely which results are there by now and how they can be published. One idea would be a journal Special Issue, starting with 1-2 group contributions introducing the ESMERALDA concept of methods' selection and case study testing, followed by several articles presenting the applications of selected methods in case studies. The participants discussed pros and cons of several candidate journals that could publish a Special Issue, and finally agreed that the ESMERALDA partner Pensoft will make a survey to collect a list of topics and to specify who could contribute what.

5.4. Stakeholder involvement and training

5.4.1. Progress of MS and way forward D2.3

This was an update to the participants and stakeholders about the progress of Member States and the identified gaps and solutions, based on the ESMERALDA deliverables 2.1 and 2.2. The talk also served as an introduction to the stakeholder interactive panel discussion held later on.

5.4.2. Stakeholder Interactive Panel Discussion. Needed support, suitable support mechanisms and relevant policy questions

This was an interactive panel where stakeholders were asked to answer questions concerning ESMERALDA from the stakeholders' perspective. Following are the questions, and the key points that emerged from the discussion. For more details, refer to the Milestone report 26.

❖ *What would be needed for mapping and assessment in your country?*

Most stakeholders saw that a lack of resources limits the mapping of ES. MAES' activity might not be in the highest priority in countries comparing, for example, to NATURA 2000 areas.

Implementations of the concept of ES more directly to real life cases highlighting the benefits to convince policy makers were seen a crucial element to enhance MAES work. However, ESMERALDA is not focusing on promoting the concept, whereas OpenNESS is more useful to this. More co-operation between larger projects is needed.

❖ *What are the relevant policy questions that MAES could answer?*

How we could prioritize MAES and make the ES concept more relevant to put it higher on the agenda? This is something that ESMERALDA could enhance with the flexible methodology and having all of the EU member states involved giving visibility to MAES.

How to integrate ES assessment and findings into the national assessment system and how to make this concept clear for policy makers? This relates to same discussion that ESMERALDA methods and findings should be simple to use and understand, but still have to have a scientific background to make sure that it can be used as a base for policies.

❖ *Impression on Esmeralda stakeholder workshops*

Message was that workshop organizers should pay more attention to the complexity of the methods and discussed subjects. The work done by ESMERALDA is important, but the concepts and methods were difficult to assimilate if you come outside of the research world. Suggestion was made that in the next workshop there could be parallel sessions running during the workshop for issues that are relevant for stakeholders. Also a lack of business sector was seeing problematic and discussion should be made how to engage this sector also into workshops and broader into MAES work.

❖ *How to improve communication with stakeholders?*

Key message in this question was better communication with simplified methods and concepts. It is important to invite stakeholders to these workshops, but we also, as researchers, should try to understand better stakeholder perspective and how they could use the information provided by ESMERALDA. And as stated before, mapping and assessment methods and outputs should be simple to use and understand, but still have to have a scientific background to make sure that it can be used as a base for policies.

Each MS have supporting groups that could be invited in each country to discuss with project partners about methods and other complex issues related to ES mapping and assessment that needs support.

5.5. Conclusions of WS 5

WS 5 was the last of the three testing workshops building on the experiences and feedback from the previous workshops. According to the feedback from previous workshops more emphasis was put on updating the participants on the progress of different work packages and building synergies between them. The stakeholders were given an opportunity to voice their concerns and give feedback in a more systematic way than in the previous workshops. In the case study break-out sessions the focus was on testing methods across specific biomes and regions. Entirely separate session was organized on Marine ecosystem services.

Some of the main outcomes were concerning tiers, method interlinkages and the ESMERALDA database. The tiers will be working as a guideline to a set of methods and data and it was decided to produce a short guidance document describing the tiered approach. Interlinkages among different methods (biophysical, economic and socio-cultural is a key objective to trigger the process of developing the flexible methodology. However, biophysical method group was still seen problematic as it includes both tools and methods that are not on a same level. This will require more work. ESMERALDA database questionnaire created using Webropol were seen suitable method for data gathering. Database provides a link also to policy questions. This will provide important knowledge of the methods used to tackle certain policy issues that can also serve as a guide for selecting relevant methods.

There was consensus that no new platform shall be created but to link the different, existing platforms to present the ESMERALDA outputs. BISE seems to be the most evident platform to share results of the project.

The results of the feedback survey conducted after the workshop showed that the workshop was rated very positively by the participants. According to the feedback the participants felt they got a good overview of the recent developments in the consortium, lot of new information and got a chance to discuss pressing topics with their peers. The participants were the most satisfied with the sessions focused on giving an overview of the project developments and synthesizing the results of the various different work packages. This time also some of the break-out sessions received high ratings. Especially the interactive facilitation methods (policy questions break-out) and active participation of stakeholders were (Spanish break-out group) were acknowledged by the participants. Similarly to the feedback of the previous workshops, however, the most valued part of the workshops in general, is a regular chance to get together, get to know each other and build networks across Europe.

The testing workshops (WS3, WS4 and WS5) have offered valuable stepping stones on the way to the development of the ESMERALDA flexible methodology. The various plenary and breakout sessions, presentations and discussions have brought together researchers and stakeholders giving an opportunity to receive feedback and integrate the results of the different work packages. Hence, the series of the testing workshops have formed a learning curve where the results and products of the project have been tested, revised and refined in a co-creative process.

6. Overview of the development and improvements of the ESMERALDA methods

Deliverable 5.2 reports the main results of three workshops conducted with the ESMERALDA consortium partners and stakeholders to test and refine the proposed flexible methodology in its different stages of development. Each workshop built on the efforts achieved in previous workshops and subsequent activities mainly in WP 3 and WP 4, where methods for biophysical, social and economic assessment of ES were being reviewed, discussed, and categorized to develop the first version of the ESMERALDA flexible methodology for mapping and assessment of ES. In each workshop, participants had the opportunity to first receive an update on the latest developments, and then discuss specific topics through a set of case studies. Finally, the three workshops contributed to stakeholders' involvement and training, adding to the more specific efforts of WP 2. In terms of content, each workshop generally consisted of three parts. A first part related to the case studies, a second part dealing with the actual development of the ESMERALDA flexible methodology itself, and a third part aimed at contributing to building capacity of stakeholder in understanding the variety of existing ES mapping and assessment methods, and the results that can be expected from their application.

6.1. ESMERALDA case studies related results

The two main outcomes here are the Case Study Booklets and Method Cards. The former illustrates the process of ES mapping and assessment in the nine ESMERALDA case studies, and thus providing a set of good working examples of ES mapping and assessment in real-life, covering different conditions across Europe, across themes, and for specific biomes and regions, as per the DoA (see Appendix: Case Study Booklets). The Method Cards synthesize, for a selected set of ES in the case studies, the main characteristic of the applied methods in terms of their data, and resources requirement, links and dependency on other methods, collaboration level needed, and spatial scale of application, among others. Both the Case Study Booklets and Methods Cards, which form the building blocks of the ESMERALDA flexible methodology, are integrated by the results of the specific discussion on specific aspects that took place during the workshops; for more on this see sections 3.2, 4.2 and 5.2.

6.2. ESMERALDA methods development

Concerning the ESMERALDA method development, a key feature was the collaborative, and iterative nature of the process, which involved the whole consortium under the guidance of the leaders of WP 3 and WP 4. Therefore, the work progressed tentatively under different streams: i) building of a database of methods for ES mapping and assessment, ii) classifying ES mapping and assessment methods, iii) reviewing policy questions, iv) tailoring a concept of tiers, and v) developing a framework for integrated ES mapping assessment, among others.

With respect to the first stream, initially two method databases were built based on 1) the entries of studies from the ESMERALDA consortium members, which started in WS 2 in Nottingham and continued overtime in the form of a "Google document", and 2) a comprehensive review of scientific literature carried out in WP 3 and 4. After the discussions held in WS 3 in Prague, decision was made to merge these two databases (using Webropol), and accordingly, a session in WS 4 in Amsterdam and another one in WS

5 in Madrid were dedicated to defining the final structure of the method database (for more on this see sections 4.3.2 and 5.3.2).

The second work stream, directly related to the first, ultimately resulted in the compilation of three method compendia (i.e. biophysical, social, and economic), based on the list of methods found in the just mentioned ESMERALDA merged database. In particular, in WS 4 in Amsterdam, the three method compendia were discussed with participants, as a result the list of economic and socio-cultural methods were confirmed as being exhaustive while the more wore was still needed to finalize the list biophysical methods. Generally, participants highlighted the need for further clustering, grouping and nesting of the methods; for more on this see in session 4.3.1.

The third stream focused on policy questions, seen as the starting point of any ecosystem assessments. Here the ESMERALDA consortium, under the guidance of Joachim Maes (JRC), built on various MAES initiatives (held in December 2012 and March 2017) in which a number of broad policy questions that justified the development of a knowledge base were formulated. This initial list from the MAES combined with input from the ESMERALDA consortium resulted in a final list of 82 policy question. In WS 5 in Madrid, the 82 policy questions were discussed with respect to the ESMERALDA flexible methodology, thus concluding whether the latter could provide answers to address the policy question. For more on this see 5.3.4.

The fourth work stream relates to the tailoring a tier concept to the ESMERALDA flexible methodology. First introduced in WS 3 in Prague (see 3.3.1), the tier approach was questioned regarding its added value during the ESMERALDA database structure definition in WS 4 in Amsterdam (see section 4.3.2). Finally, in WS 5 in Madrid, it emerged that the tiered approach has been used by several partners who found it to be a useful tool for communication, particularly in stakeholder processes, and to illustrate the quality of maps. Thus, it was agreed to adopt a tiered approach that is applicable to all types of ES combined with a decision tree providing guidance in the selection of tiers. For more of the challenges (e.g. whether to considers methods only or also data, and the suitability of the approach for cultural services), and ways forward (e.g. need to sharpen the definition together with the question of the intended users of the tiered approach) see section 5.3.4.

Finally, another stream mainly explored how a number of different elements developed within the ESMERALDA come together to support an Integrated Ecosystem Assessment framework. Thus, starting from the ES mapping framework proposed in the MAES a draft framework for integrated ES assessment as well as supporting text were developed. In the related discussion in WS 5 in Madrid, it emerged that there are different understanding of integration (e.g. between ES and conditions, between biophysical, social and economic methods, between the wider policy question and the mapping part), and the policy-oriented understanding of integration (and its evolution), including its relation with Action 5, 6 and 7 of the EU Biodiversity Strategy 2020 is essential for a follow up. For more on this see section 5.3.5

6.3. Stakeholder involvement and training

An additional objective of the ESMERALDA workshops is to contribute to build stakeholders' capacity in understanding the variety of existing methods for ES mapping and assessment, and the results that can be expected from their application. To this end, each workshop included sessions of oral and/or poster presentations of the ESMERALDA flexible methodology as well as some practical demonstration through field trips: the Třeboňsko UNESCO Biosphere Reserve and Protected Landscape (WS 3, Prague), the Biesbosch National Park, one of the last extensive freshwater tidal wetlands in Northwestern Europe (WS 4, Amsterdam), and the Guadarrama National Park, one of the largest national parks in Spain (WS 5, Madrid). Furthermore, besides providing specific input during the case study related sessions, the stakeholders actively participated to all the method development sessions as well. Finally, as reported in section 3.4.2 and 5.4.2, two additional sessions were entirely dedicated to collecting input from the case study stakeholders. One session focusing on the level of impacts of ES mapping and assessment (WS 3, Prague) and another on the “Needed support, suitable support mechanisms and relevant policy questions” (WS 5, Madrid).

6.4. Next steps

In the coming months, the here reported results of the testing will be used to develop the final version of the ESMERALDA ES mapping and assessment methods. The latter will be presented and discussed with project partners, stakeholders and members of the ESMERALDA Advisory Board during the Mid-term Project Meeting in Plovdiv (October 2017). Feedback will be collected during interactive sessions; hence, the feedback will be discussed and a roadmap for integration of the advices during the last project phase will be developed. This includes the last two ESMERALDA testing workshops, WS 7 in Trento (January 2018) and WS 8 in Budapest (March 2018), which will focus on testing the final methods in policy and decision-making (+ Businesses & Citizens). Accordingly, four policy & decision-making processes will be used to analyse how the methods can inform different stages of the processes, and promote outcomes that are more in line with the objectives of the EU Biodiversity Strategy.

7. Appendix: Case Study Booklets

Outline

In the ESMERALDA project, the objective of Work Package 5 is to identify case studies and test how the proposed methods for mapping and assessment of ES may be used to inform policy and decision-making processes. Testing enables the refinement of the methods developed within the ESMERALDA project, and the final drafting of guidelines to support users in the application of the methods to deliver under Action 5 of the EU Biodiversity Strategy. Testing activities are conducted through a series of workshops in different European contexts, each addressing a different set of themes and regions. Namely:

- **WORKSHOP 3 "Testing the methods across Europe", 26-29th September 2016, Prague (MS24)**
  - **Latvia Case study**: Mapping marine ES in Latvia.
  - **Czech Republic Case study**: Pilot National Assessment of ES.
  - **Germany Case study**: Mapping ES dynamics in an agricultural landscape in Germany.

- **WORKSHOP 4 "Testing the methods across themes", 9-12th January 2017, Amsterdam (M25)**
  - **Case study The Netherlands**: ES-based coastal defense.
  - **Case study Poland**: ES in Polish urban areas.
  - **Case study Malta**: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.

- **WORKSHOP 5 "Testing the methods for specific biomes & regions", 4-7th April 2017, Madrid (M26)**
  - **Case study Spain**: Spanish National Ecosystem Assessment.
  - **Case study Portugal**: BALA - Biodiversity of Arthropods from the Laurisilva of Azores.
  - **Case study Bulgaria**: Mapping and assessment of ES in Central Balkan area at multiple scales.

In each workshop, three case studies were considered to investigate specific issues relating to the applicability of methods across Europe, themes, and biomes and regions. This appendix includes the "Case Study Booklets", illustrating the process of mapping and assessment of ES in the nine selected case studies. Each booklets is structured in six parts as follows:

CASE STUDY BOOKLET

7) Case study factsheet and study area description

8) Main policy question and theme
   c) Objectives of ES mapping and assessment
   d) Role of stakeholders

9) Ecosystem Types and Conditions
   c) Identification and mapping of ecosystem type(s)
   d) Assessment of ecosystem conditions

10) Mapping and assessment of ES
   e) Identification of ES
   f) Applied biophysical methods
   g) Applied socio cultural methods
   h) Applied economic methods

11) Use & integration of ES mapping & assessment results
   c) Addressing the policy question
   d) Results communication and dissemination

12) References & Annexes


ESMERALDA

Case study booklet for:
WORKSHOP 3: "Testing the methods across Europe" held in Prague, Czechia
26-29 September 2016

(Picture by Ilze Strēle)

Mapping marine ecosystem services in Latvia

(Version 1, 09 September 2016)

ESMERALDA partner: Baltic Environmental Forum (BEF)
Case Study Coordinators: Anda Ruskule

ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

1

Case study booklet for:
WORKSHOP 3: "Testing the methods across Europe" held in Prague, Czechia
26-29 September 2016


(Picture by Ilze Strēle)

1. Mapping marine ES in Latvia

November 2016

ESMERALDA partner: Baltic Environmental Forum (BEF)

Case Study Coordinators: Anda Ruskule & Kristina Veidemane

ESMERALDA

Enhancing ES mapping for policy and decision making

1.1. Case study factsheet and study area description

Mapping marine ES in Latvia

WS3_cs1

NAME AND LOCATION OF STUDY AREA	Territorial waters and Exclusive Economic Zone of Latvia
COUNTRY	Latvia

STATUS OF MAES IMPLEMENTATION	Stage 1	Stage 2	Stage 3

BIOMES IN COUNTRY	1 Tropical & Subtropical Moist Broadleaf Forests	4 Temperate Broadleaf & Mixed Forests
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	

case study outline

SCALE	national	sub-national	local
AREAL EXTENSION	Ca. 28 000 km²		

THEMES	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
	health	ES mapping and assessment		

ECOSYSTEM TYPES	urban	cropland	grassland	woodland and forest
	heatland and shrub	sparsely vegetated land	wetlands	rivers and lakes
	marine inlets and transitional waters	coastal	shelf	open ocean

Study area description

The study area includes all marine waters under jurisdiction of the Republic of Latvia including the internal marine Waters, territorial waters and Exclusive Economic Zone (EEZ) (see Figure 1.1). The study area covers 28,517.5 km^2 out of which 10,861 km^2 belongs to the territorial sea. According to the Corine Land Cover classification all the area belongs to the category 5.2 marine waters (5.2.3. sea and ocean).

The borders of the study area correspond to the border of Latvian EEZ – the area that was covered by the national maritime spatial planning, carried out by the Baltic Environmental Forum (BEF) from January 2015 until April 2016 in frame of the contract with Ministry of Environmental Protection and Regional Development.

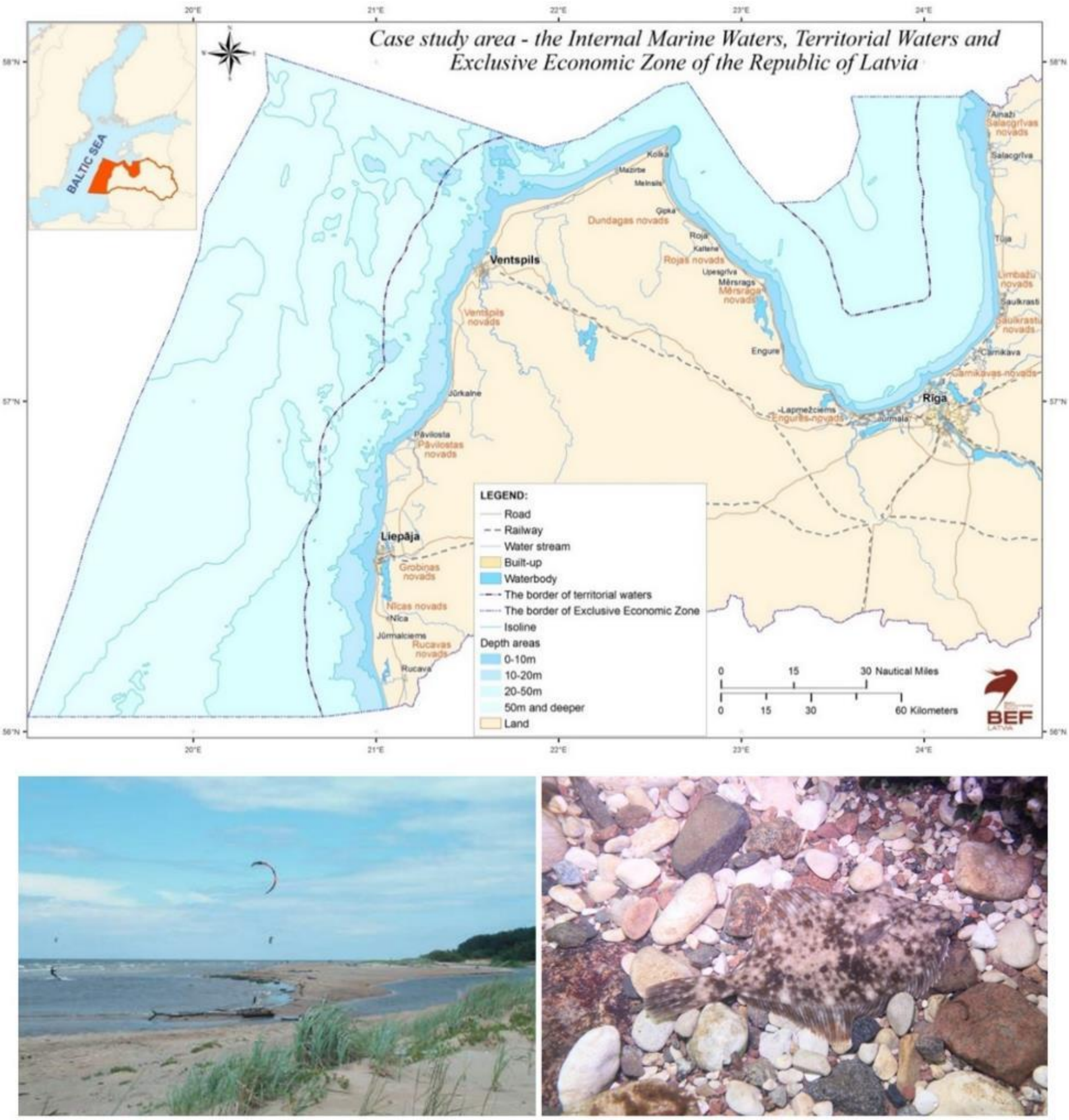


Figure 1.1. Case study area including the internal marine Waters, territorial waters and Exclusive Economic Zone of the Republic of Latvia. Data source: Latvian Maritime Administration and Latvian Geospatial Information Agency).

1.2. Main policy question and theme

1.2.1. Objectives of ES mapping and assessment

The mapping and assessment of marine ES was performed as one of the steps **for implementation of the ecosystem based approach within development of the national Maritime Spatial Plan (MSP)** for Latvian territorial waters and EEZ. The EU policy establishes ecosystem based approach (EBA) as interlink between implementation of the **Directive 2008/56/EC** establishing a framework for community action in the field of marine environmental policy (**Marine Strategy Framework Directive**) aiming at Good Environmental Status of marine waters and the **Directive 2014/89/EU** establishing a framework for maritime spatial planning, which aims at encouraging «Blue growth». EBA is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, with the aim to ensure that human use of ecosystems is kept within the limits of ecosystems' capacity to regenerate with regard to their structure, dynamics and functions. EBA shall help to understand interaction between ecosystem and human activities, thus supporting sound decision making on sea use.

According to the HELCOM-VASAB "Guidelines for the implementation of ecosystem-based approach in MSP", identification of ES is one of the key elements for operationalization of EBA. The guidelines refer to ES at various steps of the development of MSP, including the identification of current and potential resources, development of preliminary planning options or strategies, identification of existing and potential threats, communication of the planning goals with stakeholders and preparation of the planning proposal with respect of potential impacts on ecosystem goods and services. However, the guidelines do not provide any specific methodological indications on identification of ES.

The objective of the ES mapping in Latvian MSP was to provide spatial information on distribution of areas important for provision services related to direct sea uses (e.g. fisheries, coastal tourism) and regulation and maintenance services essential for existence of resilient marine ecosystem and related benefits to human well-being (e.g. water purification, maintenance of nursery areas, and climate regulation). The mapping results were used to assess the possible impacts of different sea use scenarios, and to identify the optimum sea use solution from ecological and socio-economic perspectives, including suitable areas for locations of new uses - offshore wind farms and marine aquaculture farms. Moreover, the results are included in the strategic environmental assessment (SEA) of the proposed MSP solutions.

1.2.2. Role of stakeholders

Mapping of ES was carried out in collaboration between experts from the BEF, researchers from the Latvian Institute of Aquatic Ecology (LIAE), Latvian Fisheries Research Institute (BIOR) and experts on tourism. The methods for ES mapping were discussed and agreed with spatial planning experts from the Ministry of Environmental Protection and Regional Development. They were also presented at international meetings with planning experts form the Baltic Sea Regional countries and Norway. So far, the process of ES mapping and assessment has been mostly expert and data driven, and the stakeholders were not directly involved in the exercise. The results and their application in SEA were presented in four public hearing events, involving in total more than 100 participants representing different sea use sectors and competent authorities. In the future, coastal communities could be involved in a more comprehensive assessment of cultural services provided by coastal ecosystems.

1.3. Ecosystem Types and Conditions

1.3.1. Identification and mapping of ecosystem type(s)

The mapping of marine ecosystem was performed within the whole area of the MSP, including the Internal Waters, Territorial Waters and EEZ of the Republic of Latvia. The marine waters of Latvia cover the following ecosystem types: **C1** Marine inlets and transitional waters, **C2** Coastal areas (depth between 50 and 70 m), and **C3** Shelf (up to ca. 200 m depth).

The marine ecosystem is three dimensional, consisting of the two main sub-systems – pelagic and benthic, which interact with each other. Its structure is formed by the abiotic environment (i.e. sea bottom substrate, depth, differences of the light intensity within the water column) as well as the biotic or living environment (i.e. populations of plankton, benthos, fish, birds and marine mammals). For the purpose of MSP and ES assessment, the structuring of the ecosystem of Latvian marine waters was performed using the HELCOM Underwater Biotope and habitat (HELCOM HUB) classification system (HELCOM, 2013). The HELCOM HUB 2013 classification describes habitats at 6 levels: level 1 defines the region; on level 2 habitats are divided in benthic habitats - associated with the bottom and pelagic habitats - associated with the water masses, and further split into vertical zones by the availability of light - photic or aphotic zone (see Figure 1.2); level 3 is defined according to substrate; level 4 – community structure; level 5 – typical communities and level 6 – dominant species groups.

All Latvian marine waters were classified as HUB benthic habitats based on coastal survey and monitoring data of the Latvian Institute of Aquatic Ecology as well as the sediment map of the sea bottom produced in the frame of the MSP. More specifically, the habitats were detected at levels 3-5 of the classification system, based on availability of field data and density of biological sampling stations within the different parts of marine waters (see Figure 1.3). The maximum depth where macro-vegetation can be found, i.e. 21 m at the coast of the open Baltic Sea and 10 m in the Gulf of Riga, was defined as the border between photic and aphotic zones (HELCOM HUB 2013).

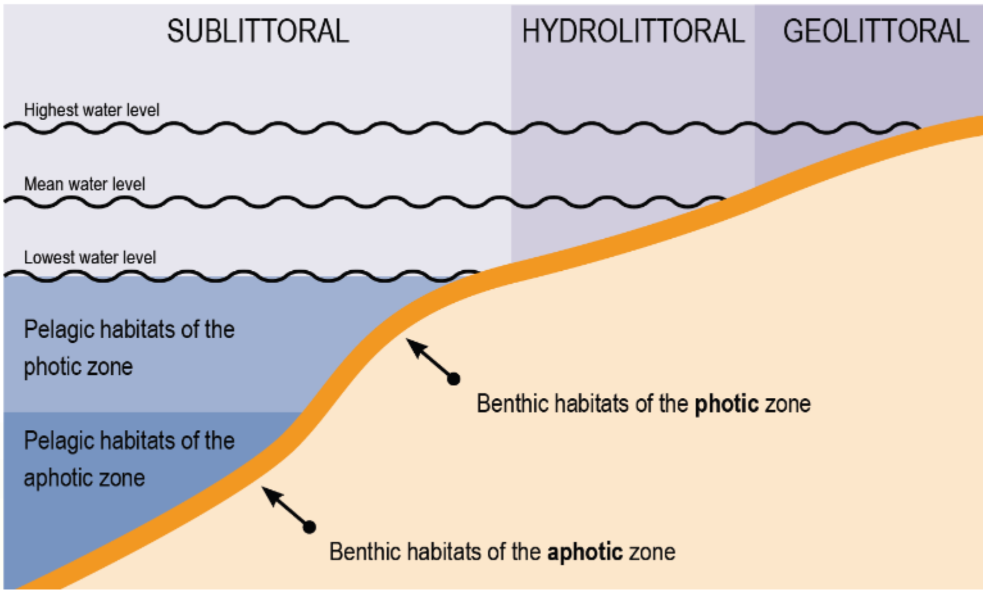


Figure 1.2. Zonation of marine habitats. Source: Baltic Environmental forum, 2009; adopted from D. Boedeker, Federal Agency of Nature Conservation, Germany, 1998.

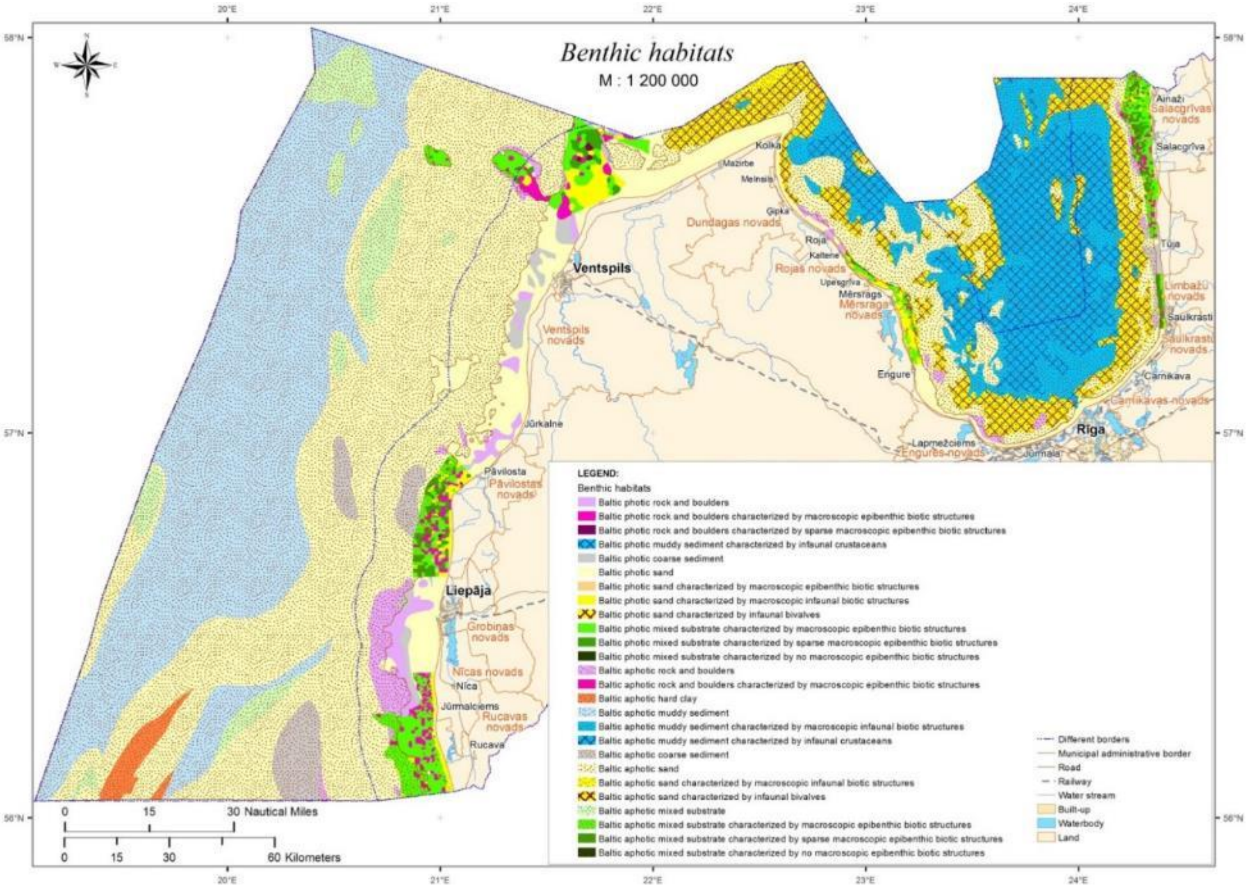


Figure 1.3. Benthic habitat map of the Latvian marine waters, developed by LIAE, 2015. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016

1.3.2. Assessment of ecosystem conditions

The ecosystem conditions were assessed for the whole territory of the Latvian marine waters or separately for its two major parts – the Gulf of Riga and the Baltic Proper, using the indicators for assessment of the condition and biodiversity of ecosystems as suggested in the 2nd - Final MAES report (2014). Assessment was based on reporting on conservation status of habitats and species (Art.17, Habitats Directive) as well as environmental status of the marine waters (MSFD Initial assessment). In particular, the following descriptors were included:

- D1 "Biodiversity" (indicator: Benthic Quality Index);
- D3 "Population of commercial fish and shellfish" (indicator: Spawning stock biomass);
- D4 "Elements of marine food webs" (indicator: Zooplankton mean size vs. total stock);
- D5 "Eutrophication" (indicators: Summer chlorophyll *a* concentration; Depth distribution of *Fucus vesiculosus* (in Gulf of Riga) and *Furcellaria lumbricalis* (Baltic Proper)).
- D6 "Sea floor integrity" (Indicator: Population structure of *Macoma balthica*; however, no data was available for assessment of the present value of this indicator).

At the time of the assessment, there were no spatially explicit data sets available for the above-described indicators, which meant the assessment could not be directly used for mapping of ES condition. Instead, the Latvian Institute of Aquatic Ecology has developed a map of ecological values, which combines available spatial data sets on distribution of benthic habitats, algae, birds and fish species (see Figure 1.4 - Left). The map is developed by summarizing the information according to the following selected criteria:

- biodiversity (number of species, coverage of biologically significant species);
- aggregation (areas important for birds and fish species);
- rarity (unique features) – no data was available at this stage;
- naturalness (presence of invasive species);
- proportional significance (coverage of benthic habitats).

However, the mapping results shall be interpreted with caution, because of the high level of uncertainty, due to limited coverage of field surveys. The level of certainty was estimated based on the number of ecological categories that were evaluated in the particular grid cell (see Figure 1.4- Right).

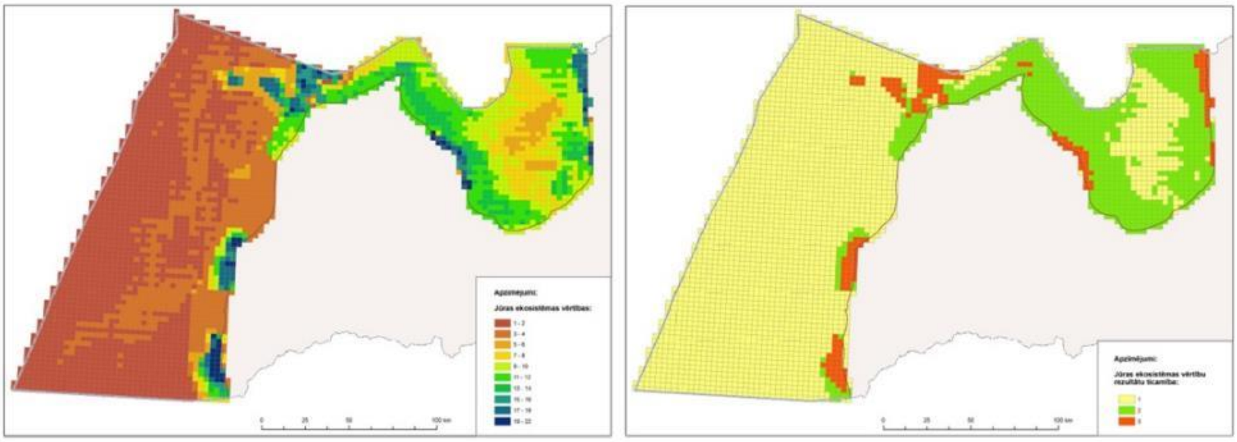


Figure 1.4. (LEFT) Sum of ecosystem values estimated by different criteria. Legend: ecosystem value from low (red) to very high (dark blue). Source: LIAE, 2015. (RIGHT) Estimation of certainty of the results. Legend: level of certainty - low (yellow); medium (green); high (red). Source: LIAE, 2015.

1.4. Mapping and assessment of ES

1.4.1. Identification of ES

The ES were selected based on expert knowledge and relevance to the MSP process. Particularly, mapping included those ES that provide basis of existing or potential sea use activities as well as have significant role in maintenance of the resilient marine ecosystem. The experts involved in MSP development identified the relevant services. Stakeholders were not involved in this process. To a certain extent, also data availability played an important role in the selection of ES.

As shown in, the ES were identified using the CICES v4.3 (2013) classification and relating that to the classification used for characterization of the ES within the Initial assessment of the current environmental status of the marine waters, prepared in 2012 for implementation of the Marine Strategy Framework Directive.

Table 1.1. Overview of the ES and related mapping and assessment methods in the Latvia case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.3 Wild plants, algae and their outputs*	X		
1.1.1.4 Wild animals and their outputs	X		
2.1.1.1 Bio-remediation by micro-organisms, algae, plants, and animals	X		
2.1.1.2 Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, & animals.	X		
2.2.1.1 Mass stabilization and control of erosion rates	X		
2.3.1.2 Maintaining nursery populations and habitats*	X		
2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations	X		
3.1.1. Experiential and physical use of plants, animals and landscapes /seascapes in different environmental settings *	X		

* ES selected for further discussion during ESMERALDA workshops 3 in Prague.
B = biophysical methods; S = socio-cultural methods; E = economic methods.

1.4.2. ES mapping and assessment: biophysical methods

Mapping of ES was performed using the available spatial data sets as well as based on expert knowledge. Since no national guidelines on methods for mapping of marine ES are available in Latvia the appropriate methods were selected and elaborated in consultation with involved experts on marine ecology, fishery and tourism. The assessment results were presented in the grid, where each cell forms 2.8 x 3 km.

Mapping of provisioning services

1.1.1.3: Wild plants, algae and their outputs

Indicator: *area covered by red algae Furcellaria lumbricalis*

The potential resource of red algae was mapped, using the expert knowledge to identify the benthic habitats that are related to distribution of the *Furcellaria lumbricalis* and combining this information with data from field surveys, which partly cover the possible species distribution area and provides information on coverage of algae beds within defined spatial units. The assessment results are presented in scale from 1 to 3, where 1 refers to habitats suitable for distribution of the species, but no occurrence so far has been detected; 2 – low occurrence detected; 3 – high occurrence detected (see Annex, Figure 1.5).

1.1.1.4: Wild animals and their outputs

Indicator: *total catch of commercially important fish species (sprat, herring, cod, and flounder) in 10 years period (2004-13).*

Mapping based on data from fishery logbooks. Data were processed with R Statistical Software estimating the total value of fish catch in the cell per species, year as well as number of fishing acts. Values of the cells are visualized in proportional scale from 1-5. (See Annex, Figure 1.6).

Mapping of regulating and maintenance services

It was performed using the spreadsheet method and benthic habitat map as proxy for potential of ES supply. The ES within each habitat type were assessed based on expert knowledge (binary assessment: does the particular habitat type provide the particular service – yes/no). Assessment in relative scale at this stage was not possible due to a lack of relevant research data from Latvian marine waters. The following services were assessed:

2.1.1.1: Bio-remediation by micro-organisms, algae, plants, and animals.
Indicators: *Distribution of benthic habitats providing service of 1) eutrophication control through denitrification; 2) eutrophication control through storage of nutrients; 3) storage of pollutants*.

2.1.1.2: Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals.
Indicator: *Distribution of benthic habitats providing service of filtration of nutrients by mussels.*

2.3.1.2: Maintaining nursery populations and habitats.
Indicator: *Distribution of benthic habitats providing service of nursery sites for fish species.*

2.3.5.1: Global climate regulation by reduction of greenhouse gas concentrations.
Indicator: *Distribution of benthic habitats providing service of carbon storage.*

Based on results of expert assessment six maps of single regulating services were prepared as well as a summary map, with number of identified services in each grid cell (see Annex, Figure 1.7).

Mapping of cultural services

3.1.1.1+3.1.1.2: Experiential and physical use of plants, animals and landscapes /seascapes in different environmental settings
Indicator: *marine tourism and leisure possibilities at the coast.*
It was based on field survey data in combination with expert knowledge (Tier 2). The assessment value of each grid cell was obtained by combination of several criteria: number of visitors; suitability of the area (or best place) for particular tourism or leisure activity/life style (e.g. angling, bird watching, kiteboard, etc.); accessibility – presence of parking lots and public access roads near the coast; and data on settlement pattern and population size. The assessment results were presented in a scale of 1 to 5, from very low to very high suitability for tourism and leisure activities (see Annex, Figure 1.8).

1.4.3. ES mapping and assessment: socio cultural methods

No socio-cultural mapping and assessment methods were applied

1.4.4. ES mapping and assessment: economic

No economic mapping and assessment methods were applied.

1.5. Use and integration of ES mapping and assessment results

1.5.1. Addressing the policy question

The objective of the mapping (and the initial policy question) was to characterize the ES, to gain an overview on spatial distribution of areas significant for provision of ES and to ensure that planning solutions do not have adverse impact on capacity of ecosystem to provide those services. This objective was achieved by using the mapping results in the SEA of the Marine Spatial Planning in Latvia.

So far, the biophysical mapping has not been integrated with other socio-cultural and economic methods for ES mapping and assessment. Moreover, the socio-economic system components, e.g. relating to the demand of services or estimation of benefits to society, have not been explicitly addressed as such.

The application of the results of the ES mapping in assessment of possible impacts of different sea uses scenarios was straightforward by overlaying the spatial data sets of the assessed ES with planned sea uses. This was providing easily interpretable additional justification for identification of optimum sea-use solutions. However, further the application ES mapping results in decision making on particular sea use projects might be difficult due to very superficial assessment of regulating services as well as due low awareness and understanding of the concept by competent authorities and other stakeholders.

1.5.2. Results communication and dissemination

The communication of the mapping results and their application in the SEA was mostly targeted to component authorities and decision makers in charge for allocation of the sea space for different uses. Results were also presented at the public hearing meetings of the MSP proposal and SEA report, involving representatives of local authorities as well as from sectors of environmental protection, fishery, shipping, tourism, national defense, etc. However, the ES mapping results were not discussed in detail, because it was rather challenging task to bring across the message - the concept of ES is mostly unknown to majority of the stakeholders and it would be too much time consuming to explain it in addition to already very complex information of MSP.

The characterization of ES as well as communication of the assessment results was already foreseen by the contract on development of MSP. Much more attention still has to be paid to awareness rising about the ES concept and its role and potential in the policy-making and spatial planning process.

1.6. References & Annexes

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Annexes

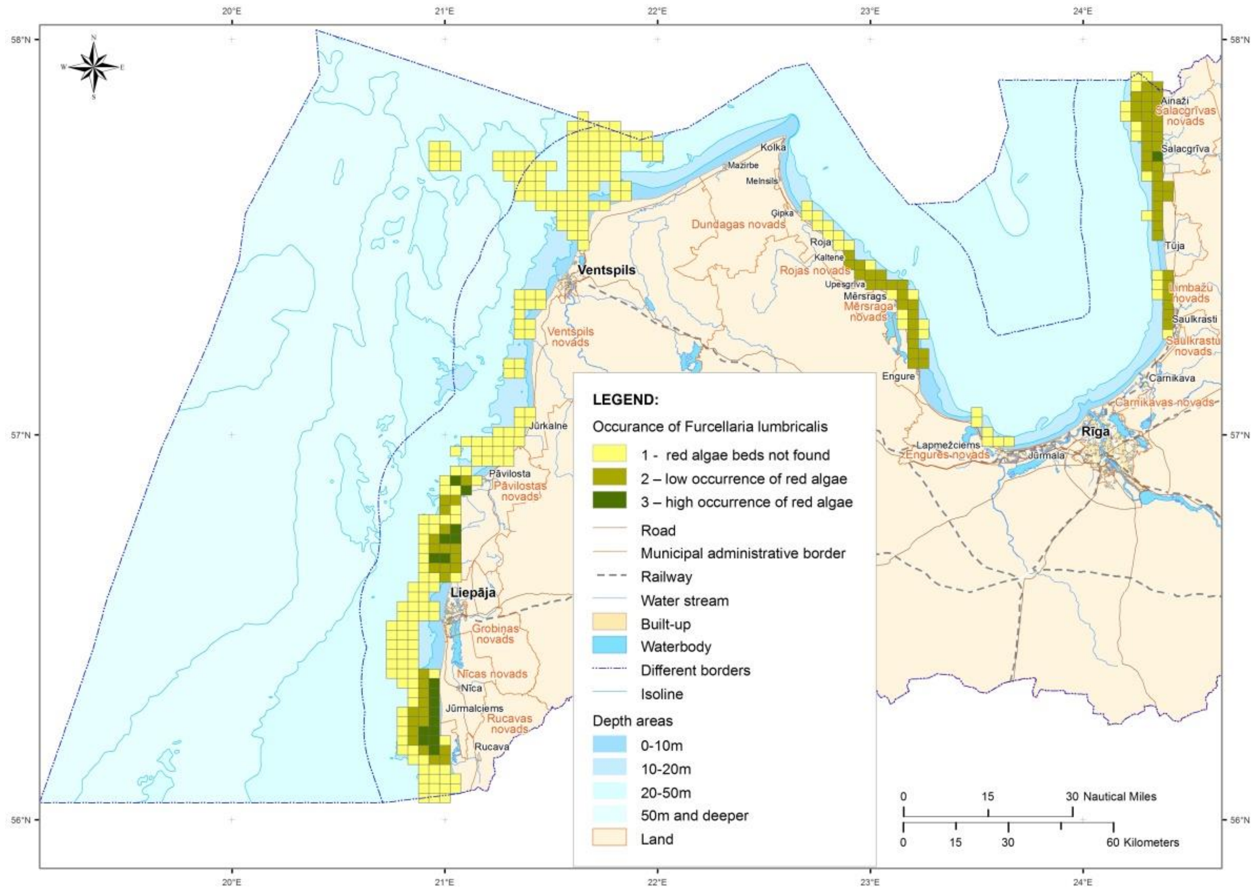


Figure 1.5. Provisioning service – algae and their outputs. Indicator: area covered by red algae Furcellaria lumbricalis. Map developed by LIAE & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

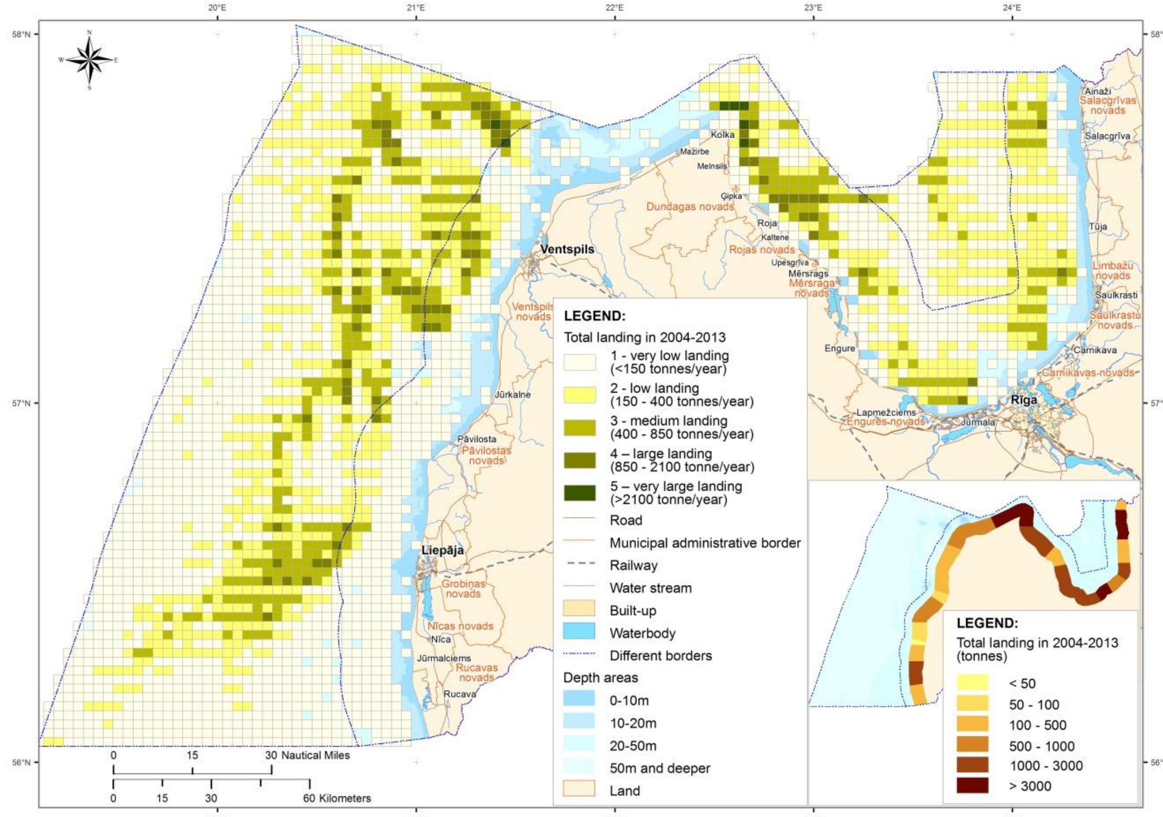


Figure 1.6. Provisioning service – fish for food. Indicator: total landing of commercially important fish species in the Open sea in the Gulf of Riga and Baltic proper (>20 m depth) and total landing from coastal fishery. Map developed by BIOR. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia.

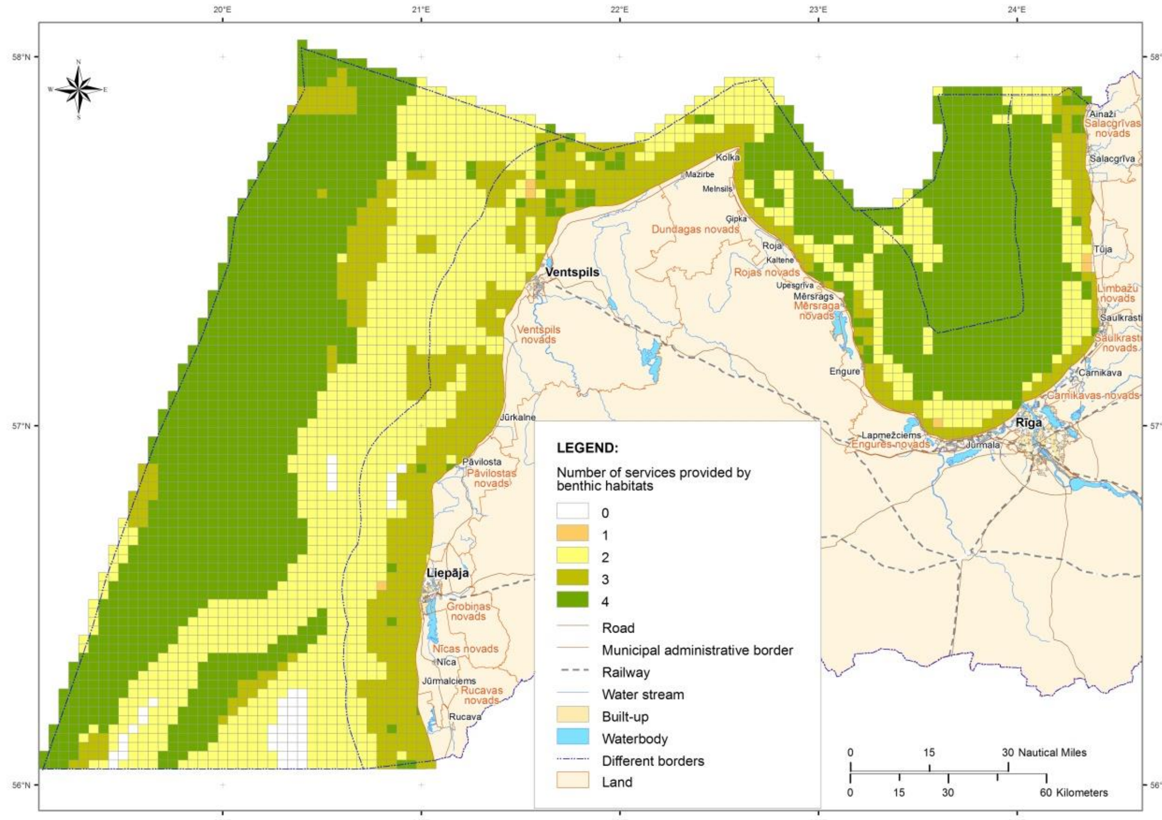


Figure 1.7. Number of regulating and maintenance services provided by benthic habitats. Map developed by LIAE & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

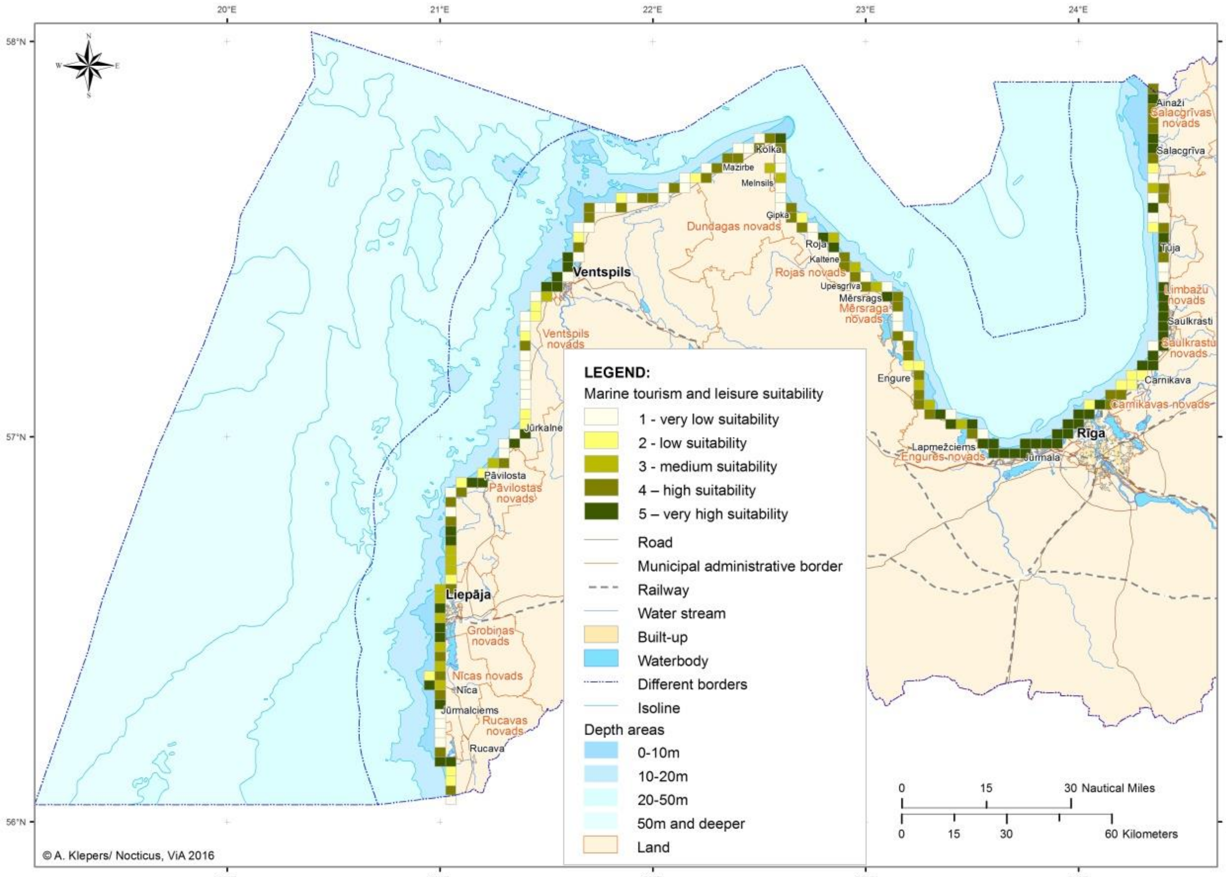


Figure 1.8. Cultural services – physical and experiential interaction. Indicator: marine tourism and leisure possibilities at the coast. Map developed by A. Klepers & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

Case study booklet for:
WORKSHOP 3: “Testing the methods across Europe” held in Prague, Czech Republic, 26-29 September 2016

(Picture by Miroslav Hátle)

2. Czech Republic Pilot National Assessment of ES

September 2016

ESMERALDA partner: Global Change Research Institute (CVGZ)

Case Study Coordinators: David Vačkář

ESMERALDA

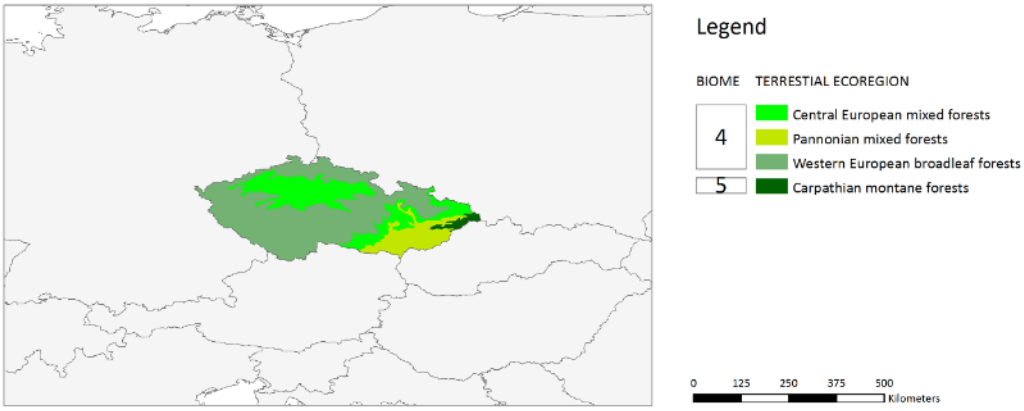
Enhancing ES mapping for policy and decision making

2.1. Case study factsheet and study area description

Pilot National Assessment of ES WS3_cs2

NAME AND LOCATION OF STUDY AREA	Czech Republic		
COUNTRY	Czech Republic		
STATUS OF MAES IMPLEMENTATION	Stage 1	**Stage 2**	Stage 3

BIOMES IN COUNTRY	1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	



case study outline

SCALE	**national**	sub-national	local	
AREAL EXTENSION	78 866 km^2			
THEMES	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
	health	**ES mapping and assessment**		
ECOSYSTEM TYPES	**urban**	**cropland**	**grassland**	**woodland and forest**
	heatland and shrub	sparsely vegetated land	**wetlands**	**rivers and lakes**
	marine inlets and transitional waters	coastal	shelf	open ocean

Study area description

The study area incorporates the whole of the Czech Republic, an inland state located in central Europe (between latitudes 481 and 511N, and longitudes 121 and 191E) with an area of roughly 78,866 km^2 and 10.6 million inhabitants. Despite its relatively small size (compared to other European countries), the country has an exceptionally variable landscape providing a diversity of habitat types. According to the WWF classification, the following ecoregions are present: Western European broadleaf forests (85%), Carpathian montane conifer forests (9%), Pannonian mixed forests (4%) and Central European mixed forests (2%).

The climate is temperate continental with relatively high seasonal dynamics as well as great variation of temperature and precipitation depending on altitude. The long-term average annual precipitation is 689 mm, and average annual temperature is 7.5 °C. The country overlaps with three main river basins: the Elbe River (western part), the Oder River (northeastern part) and the Danube River (southeastern part). As shown in Figure 2.1, agricultural land use represents more than 53% of the total area of Czech Republic, followed by forests covering about 33%, water bodies and built-up areas (both about 2%) and other areas (9%). Protected areas cover almost 16% of the country.

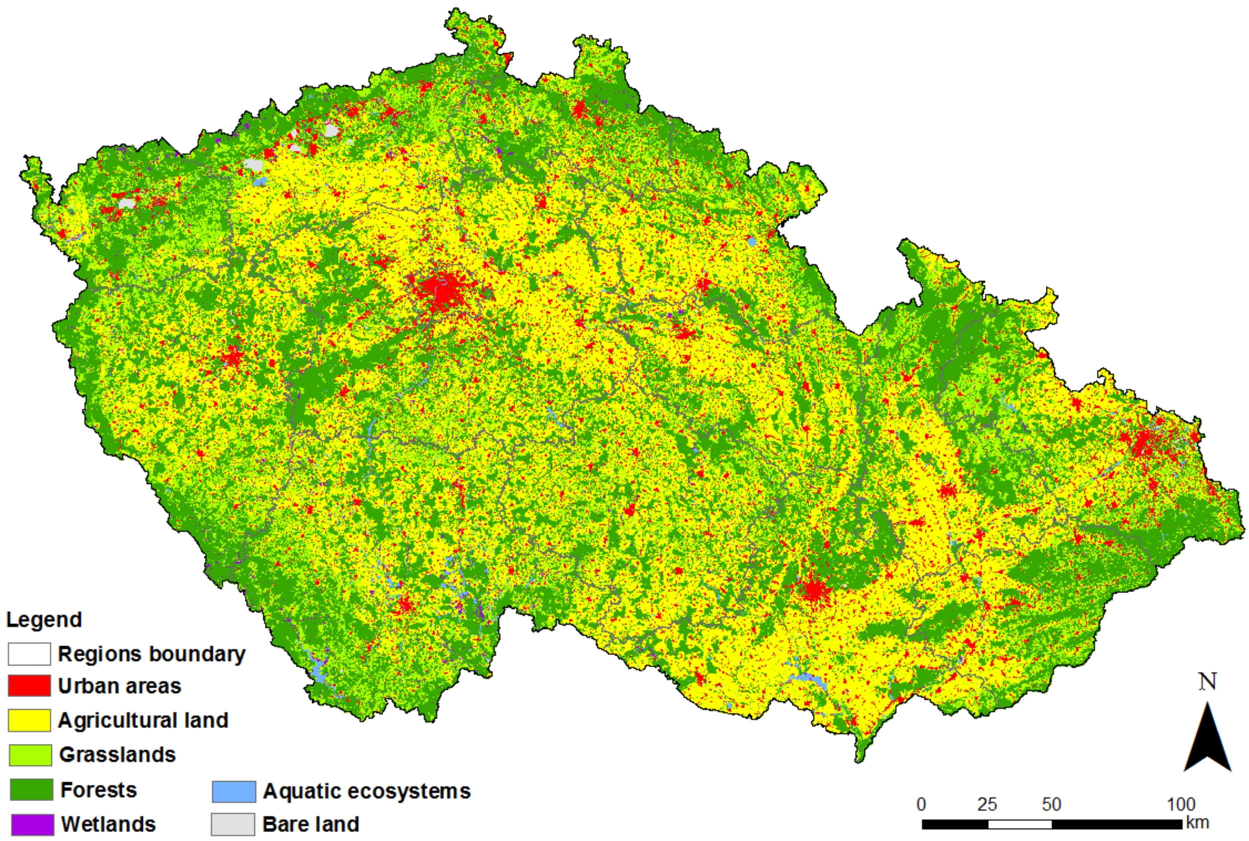


Figure 2.1. Land cover/use map of the Czech Republic (based on the Consolidated Layer of Ecosystems – see below for further source information)

2.2. Main policy question and theme

2.2.1. Objectives of ES mapping and assessment

This Czech pilot ES assessment and mapping followed the worldwide mainstreaming and establishment of global and sub-global assessments within the framework of the Millennium Ecosystem Assessment (MA) in order to substantially contribute to the knowledge on the state of the environment and the sustainable management of natural capital in the Czech Republic. Actual policy demand was driven mainly by the **Aichi Targets (Strategic Goal D) and the EU Biodiversity Strategy to 2020 (Action 5**), which focus on mapping and assessing the state of ecosystems and their services in the national territory, as well as streamlining ES into decision-making and national accounts. Therefore, meeting this goal required us to start with the completion of a national-scale mapping and assessment effort.

The objective of the pilot study was to map ecosystems within the territory of the country and assess the value of ES provided by nature in the Czech Republic. The economic valuation of ES was motivated by the objective to make the value of ES more visible and provide an initial estimate illustrating the importance of ES for society. This captured total value is also aimed to be included in national wealth and accounting, to further emphasize the benefits provided by ecosystems in the Czech Republic.

A preceding pilot study conducted for the government-based Nature Conservation Agency and the European Topic Centre on Biodiversity, focused on the benefits provided by grasslands in the Czech Republic. This is considered a complementary study where some of the methodological approaches were tested. The pilot assessment presented in this case study however, was the first inclusive assessment of ES provided by the diverse ecosystem types across the country.

Individual ES were identified and assessed. This was done with respect to local conditions, and applicable methodologies were prepared for both national and regional scales to further enable application into effective policy responses aimed at halting future ES degradation.

2.2.2. Role of stakeholders

Creating the main land cover GIS data layer (called the Consolidated Layer of Ecosystems of the Czech Republic, CLES) involved cooperation with the Nature Conservation Agency of the Czech Republic (AOPK ČR) (For more information see the link[23]). Overall, they provided insight and help in terms of habitat mapping, acquiring some of the national data and harmonization of different spatial land cover data in the initial phase of creating this GIS layer.

The Ministry of the Environment was also involved at a later stage. Their role was mainly in reviewing and certificating the final methodology for the wider and more detailed national assessment.

[23] http://www.ecosystemservices.cz/en/consolidated-layer-of-ecosystems-of-the-czech-republic

2.3. Ecosystem Types and Conditions

2.3.1. Identification and mapping of ecosystem type(s)

The Consolidated Layer of Ecosystems of the Czech Republic (CLES) was created, because existing spatial data sources were not suitable for national level assessment. As its main data source, the CLES used a Habitat Mapping Layer initially produced to provide Natura 2000 site identification. It was then further combined with Corine Land Cover 2006, Urban Atlas, the Czech ZABAGED data (Fundamental Base of Geographic Data) and other specific data on waters (DIBAVOD). The final polygon layer is therefore based on data from varying temporal resolutions. This approach enabled coverage of all different ecosystem/habitat types in the Czech Republic in order to have the complete picture for further value transfer (see Frélichová et al. 2014 for more information). The final layer consisted of 41 individual habitat categories at four hierarchical levels (See Table 2.2). The most general land cover categories consisted of agricultural land, grasslands, forests, urban areas, aquatic ecosystems and wetlands (e.g. Figure 2.2). Values for the evaluation were made first at the highest level and then for the lower land cover levels.

These ecosystems types were covered (according to ESMERALDA coding):

A.1. Urban ecosystems, **A.3.** Grasslands, **A.5.** Heathland, **A.7.**Inland wetlands,
A.2. Croplands, **A.4.** Woodlands, **A.6.** Sparsely vegetated land, **B.1.** Rivers and lakes

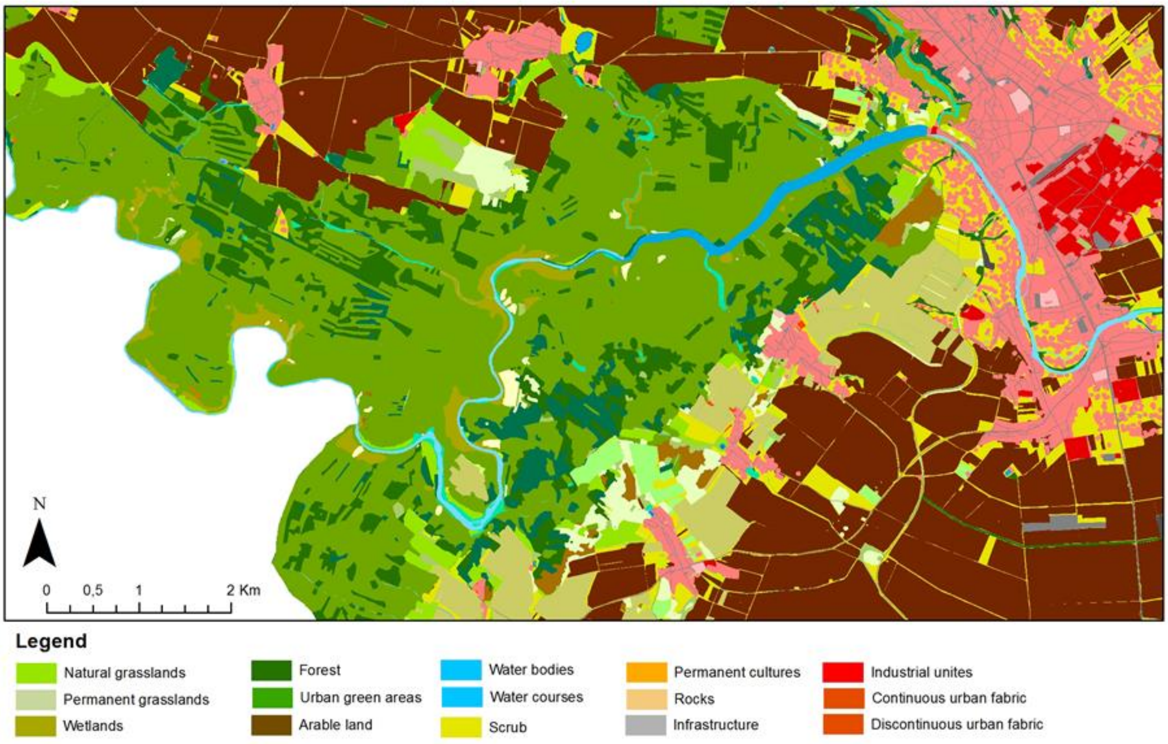


Figure 2.2. Example of consolidated layer of ecosystems for the national assessment and mapping of ES at the hierarchical level 4.

2.3.2. Assessment of ecosystem conditions

The ecosystem conditions were not assessed in this study.

2.4. Mapping and assessment of ES

2.4.1. Identification of ES

The ES were selected based on their relevance to the identified habitat categories, the significance of such services for people and a preliminary assumption that it is theoretically possible to acquire data for their quantification. More details are provided in Annex: Table 2.3. Supporting services were not included in the assessment, as they are assumed conditional for the availability of the other three types of services (de Groot et al., 2002; MA, 2005).

In relation to the aim of mapping all the services provided by ecosystems in the Czech Republic, the study and final assessment was limited by reliable data availability for the database and subsequent value transfer. For more details on the number of values in the database, see Annex: Table 2.4 and Table 2.5.

Table 2.1 shows the classification of ES according to the CICES, although the classification adopted within the MA (2005) was originally used in this case study.

Table 2.1. Overview of the ES and related mapping and assessment methods in the Czech Republic case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.1 Cultivated crops			X
1.1.1.3 Wild plants, algae and their outputs			X
1.1.1.4 Wild animals and their outputs			X
1.1.2.1 Surface water for drinking*			X
1.1.2.2 Ground water for drinking			X
2.1.1.2 Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants,			X
2.1.2.1 Filtration/sequestration/storage/accumulation by ecosystems	X		X
2.1.2.2 Dilution by atmosphere, freshwater and marine ecosystems			X
2.2.1.1 Mass stabilization and control of erosion rates	X		X
2.2.2.1 Hydrological cycle and water flow maintenance	X		X
2.2.2.2 Flood protection			X
2.3.1.1 Pollination and seed dispersal			X
2.3.4.1 Chemical condition of freshwaters			X
2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations*	X		X
2.3.5.2 Micro and regional climate regulation			X
3.1.2.4 Entertainment*	X		X
3.1.2.5 Aesthetic			X

* ES selected for further discussion during ESMERALDA workshops 3 in Prague
B = biophysical methods; S = socio-cultural methods; E = economic methods.

2.4.2. ES mapping and assessment: biophysical methods

Biophysical methods for mapping and assessment of ES were used in studies complementing the pilot national assessment, and represented Tier 2 and Tier 3 methods. For grassland ecosystems, the approach corresponded to the bookkeeping model developed for long-term carbon accounting for instance (e.g. see Hönigová et al., 2011). The final biophysical measure was a product of per unit intensity of the ES and the total area of the ecosystems category where the service is provided. Data were up-scaled from a review of studies, transferred from available estimates or based on original calculations.

ES assessed biophysically included livestock provision capacity, carbon sequestration, erosion control, invasion regulation, water flow regulation, waste treatment and recreation/aesthetic quality.

For example, water regulation was mapped based on combined indicators and values of soil water holding capacity, slope and land cover/use (Figure 2.3). This was done in GIS by combining the layer of soil water holding capacity with slope and land cover data layers, which were reclassified based on their ability to retain water (relative scale).

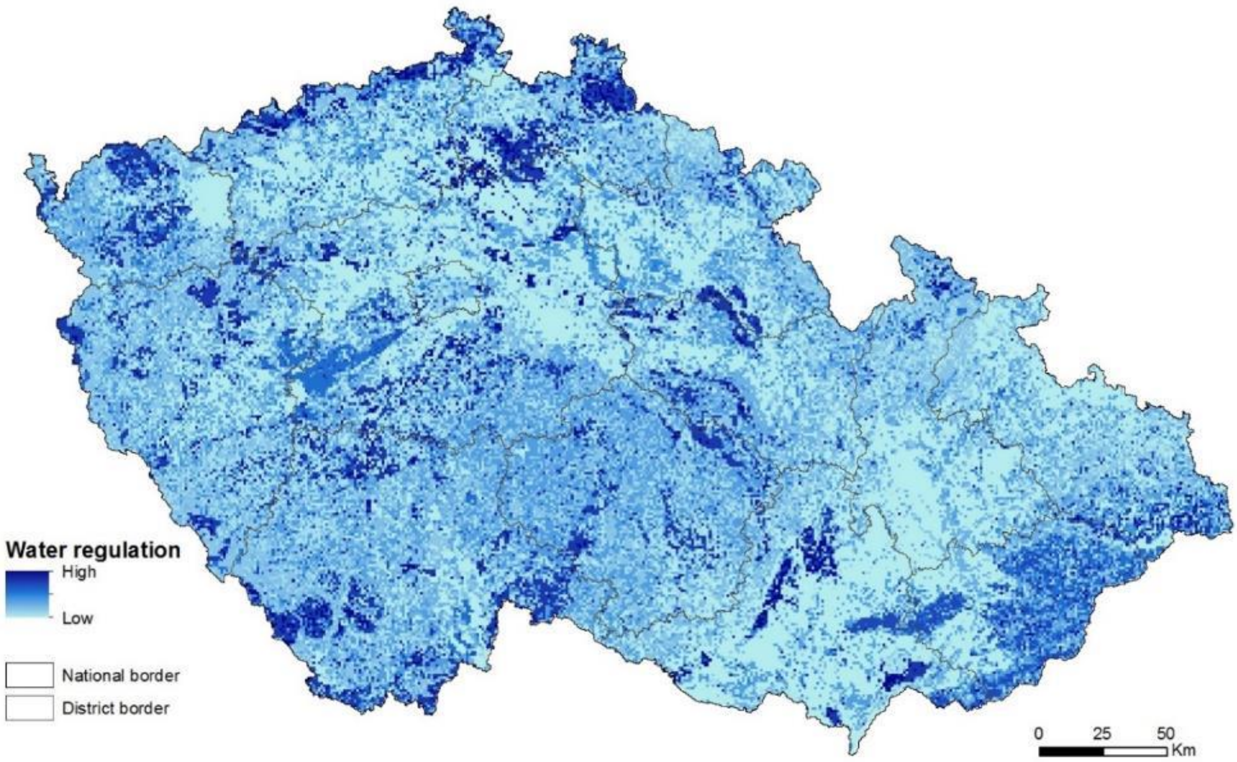


Figure 2.3. Map of water regulation potential based on biophysical mapping of soil water retention capacity.

The recreation was mapped using the ESTIMAP approach and the carbon sequestration by InVEST model based on the available data.

We also used the InVEST modelling suite to model some of the ES delivered across the Czech Republic, especially carbon storage. Other modules have been applied in regional case studies.

2.4.3. ES mapping and assessment: socio cultural methods

No socio-cultural mapping and assessment methods were applied in this case study

2.4.4. ES mapping and assessment: economic

The value transfer method was selected because of its time- and cost-effectiveness as well as the potential to substitute the primary data when specific data was not available. The methodological framework consisted of four individual steps: (1) systematic review of the literature, (2) database construction, (3) value transfer, (4) analysis and subsequent data interpretation (see Frélichová et al. 2014 for details).

The literature search was conducted in *Web of Science* and *Scopus* journal databases for a combination of keywords. Example for grassland land cover: "**Ecosystem service*** AND **valuation** AND **grassland***" and "**Ecosystem service*** AND **assessment** AND **grassland***". For other ecosystems the "grassland*" keyword was replaced by another topmost hierarchical land cover class. Documents published from 01/01/2000 to 31/12/2012 were considered. Google Scholar was checked as well, but with no additional results.

Criteria for data selection were defined similarly to those applied in the case of the ES Valuation Database (Van der Ploeg & de Groot, 2010). In order to ensure the applicability of the transferred data to Czech conditions, the intention was to ensure similarity in socio-economic factors by an application of these conditions. Because most of the studies selected for the transfer had been conducted in Europe (90%), we decided to narrow our initial geographical zone and focus on European studies only. As another criterion, studies needed to provide either original data or data properly referenced to the source. Another requirement was that studies needed to provide a biophysical or economic value of an ES with a reference to a particular ecosystem type/habitat.

Next, the basic value transfer was applied. Therefore, values were converted into common metrics and, in case of monetary values, were standardized to EUR per hectares per year using 2012 as the base year. Once the values were standardized, the average values of individual ES were estimated as well as a total value per hectare of selected ecosystems. In addition, a matrix of ES were assembled to see expected services in particular ecosystem types. A total value per hectare of ecosystem was counted as a sum of the means of available services values. Next, the values of all Czech ecosystems were generated by attributing total values to each individual land use. For more details, see Annex: Table 2.6.

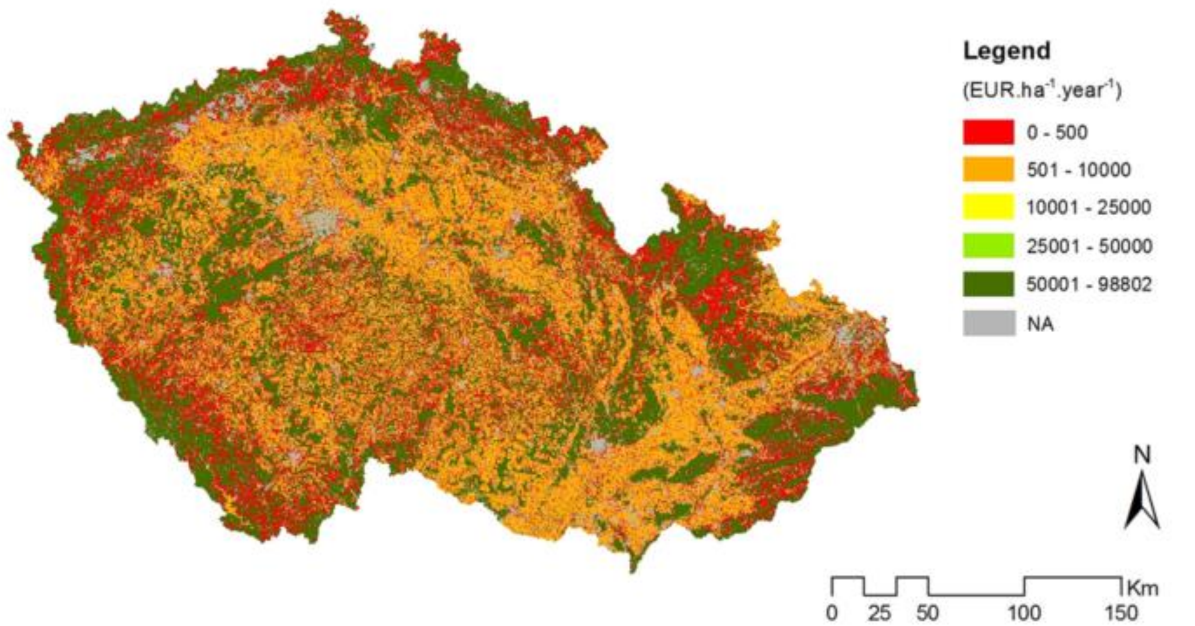


Figure 2.4. Final valuation map of ES in the Czech Republic.

2.5. Use and integration of ES mapping and assessment results

2.5.1. Addressing the policy question

The results of the assessment have not yet been integrated within socio-economic system components. However, there is an ongoing project on the development and testing of environmental accounting in the Czech Republic led by CzechGlobe, which aims to develop experimental pilot ecosystem accounts based on the results from this assessment. We envision this project will provide the opportunity to integrate the results of this assessment as a means of real-life application.

The pilot study also served as an initiation for the discussion on conducting National Ecosystem Assessment in the Czech Republic.

2.5.2. Results communication and dissemination

Communication and dissemination of results were made through regular meetings with the Nature Conservation Agency of the Czech Republic and the Ministry of Environment, from the start of project implementation until its completion. At the end of the process, a summarizing article was also published for a Czech scientific journal, Nature Protection, as well as another paper published in the international journal, ES. The resulting Consolidated Layer of Ecosystems with ecosystems services values and methodology are also available online through a web-based map application (http://envisec.cenia.cz) and website (www.ecosystemservices.cz). Results of the study, especially the Consolidated Layer of Ecosystems, have been distributed by the Nature Conservation Agency and are available for all interested partners.

In general, however, the ES concept is still not widely used and valued among the majority of policy-makers, beneficiaries and practitioners in the Czech Republic, so further dissemination and communication would be recommended.

2.6. References & Annexes

Reference

De Groot R.S, Wilson M.A, Boumans R.M.J. (2002) A typology for the classification, description and valuation of ES, goods and services. Ecol. Econ, ***41*** *(2002), pp. 393–408*

Frélichová J, Vackar D, Partl A, Louckova B, Harmackova Z, Lorencova E (2014) Integrated assessment of ES in the Czech Republic, ES ***8****:110-117*

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: A Framework for Assessment. Report of the Conceptual Framework WG of the Millennium Ecosystem Assessment. Island Press, Washington, DC.

Van der Ploeg, S. and R.S. de Groot (2010) The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ES. Foundation for Sustainable Development, Wageningen, The Netherlands.

Annexes

Additional information based on the article by Frelichova J. et al., (2014).

Table 2.2. Hierarchical classification of the Consolidated Layer of Ecosystems

Level 1	Level 2	Level 3	Level 4
Urban areas	Continuous urban fabric	Continuous urban fabric	Continuous urban fabric
	Discontinuous urban fabric	Discontinuous urban fabric	Discontinuous urban fabric
	Industrial and commercial	Industrial and commercial units	Industrial and commercial units
	Transport units	Transport units	Transport units
	Dump and construction units	Dump and construction units	Dump and construction units
	Green urban areas	Natural urban green areas	Urban nature
		Artificial urban green areas	Parks, gardens, cemeteries
			Recreation and sport areas
Agricultural land	Arable land	Arable land	Arable land
	Permanent cultures	Orchards and gardens	Orchards and gardens
		Hop fields	Hop fields
		Vineyards	Vineyards
	Permanent grasslands	Intensive grasslands	Intensive grasslands
Grasslands	Natural grasslands	Natural meadows	Alluvial meadows
			Dry grasslands
			Mesic meadows
			Alpine grasslands
			Heaths
Forests	Forested areas	Intensive forests	Intensive mixed forests
			Intensive broad-leaved forests
			Intensive coniferous forests
		Natural forests	Alluvial forests
			Oak and oak-hornbeam forests
			Ravine forests
			Beech forests
			Dry pine forests
			Spruce forests
			Bog forests
	Scrub	Areas with no forest cover naturally	Natural *Pinus mugo* scrub
		Areas with introduced no forest cover	Introduced *Pinus mugo* scrub
			Introduced shrub vegetation
Wetlands	Wetlands	Natural wetlands	Wetlands and litoral vegetation
		Natural peatbogs	Peatbogs and springs
		Anthropogenic swamps	Swamps
Aquatic ecosystems	Water bodies	Natural water bodies	Lakes
		Anthropogenic water bodies	Ponds
	Water courses	Natural water courses	Natural water courses
		Anthropogenically influenced water	Anthropogenically influenced water

Table 2.3. An overview of ES in the scope of the study

Service	Services	Ecosystem	Valuation methods	
			Biophysical	Economic
Provisioning	Crop	A		NP
	Biomass	A, F, G, W, WET	Modeling productivity	DMP, NVA
	Fish	W, WET	No. of professional fishermen	MA, DMP, NVA
	Game	F	Gross animal weight	DMP
	Non-timber	F	Non-timber production	DMP
	Timber	F	Timber production	DMP, LEV
	Water	W, WET	Extraction, infiltration	AC, CV, MA, NVA
Regulating	Air quality	F	Average dry deposition of PM_{10}	AC
	Climate	A, F, G, U, WET	Carbon sequestration	AC, BT, CV, ET, MAC, DMP, SCC
	Disturbance	W, WET	-	DC, CV
	Erosion	A, F, G, WET	Model of erosion risk control,	AC, BT, MA, RC
	Nutrient	A, G, W, WET	Review	BT
	Pest control	A, F, G, WET	-	BT, CV
	Pollination	A	-	BT, IPEV
	Water cycle	A, F, G, U, WET	Run-off, modelling	AC, BT, MA, RC
	Water quality	G, F, WET	Review	AC, BT, CV, MA, PES, RC
Cultural	Aesthetic	A, F, W, WET	-	BT, PV, CV, MA
	Recreation	A, F, G, U, W, WET	No. of visitors/visits	BT, CPS, DV, DMP, FI, MA, MAC, NVA, TCM

Acronyms for ecosystems: A – agricultural, F – forests, G – grasslands, U – urban, W – water, WET – wetlands.
Acronyms for the valuation methods: AC – avoided costs, BT – benefit transfer, CV – contingent valuation, ET – emission trading scheme, IPEV – insect pollination economic value, LEV – land expectation value, MA – meta-analysis, MAC – marginal abatement costs, DMP – direst market pricing, NP – net production, NVA – net value added, SCC – social costs of carbon, DC – damage costs, RC – replacement costs, PES – payment for ES, PV – property value, CPS – consumer and producer surplus, TCM – travel cost.

Table 2.4. An overview of data used within the database

	Total no. of records	No. of standardized values (per hectare)	Character of values
Biophysical values	55	51	-
Economic values	142	121	Strong values: 102 Weak values: 19 ESVD values: 40

Table 2.5. Frequency of valuation records according to ecosystem types and ES categories in the final database for value transfer

Ecosystem type	Biophysical values	Economic values
Agricultural	16	30
Forests	19	45
Grasslands	4	9
Urban	2	4
Aquatic	6	9
Wetlands	8	45
Ecosystem Services		
Provisioning	9	24
Regulating	42	72
Cultural	4	46

Table 2.6. Final ES values employed

Ecosystem Service category	Service	Average value (in EUR per ha)
Provisioning	Biomass provision	421.39
	Fish provision	107.54
	Game provision	9.91
	Non-timber provision	57.23
	Timber provision	6912.09
	Water provision	32.43
Regulating	Air quality regulation	266.33
	Climate regulation	4015.78
	Disturbance regulation	8456.19
	Erosion regulation	5766.57
	Nutrient regulation	200.10
	Pest control	7.31
	Pollination	1378.76
	Water cycle regulation	1373.14
	Water quality regulation	1210.67
Cultural	Aesthetic value	5971.94
	Recreation	2190.52

Case study booklet for:
WORKSHOP 3: "Testing the methods across Europe" held in Prague, Czechia, 26-29 September 2016

(Picture taken ca. 1990)

3. Mapping ES dynamics in an agricultural landscape in Germany

September 2016

ESMERALDA partner: Christian Albrechts University Kiel (CAU)

Case Study Coordinators: Benjamin Burkhard, Marion Kruse, Felix Müller

ESMERALDA

Enhancing ES mapping for policy and decision making

3.1. Case study factsheet and study area description

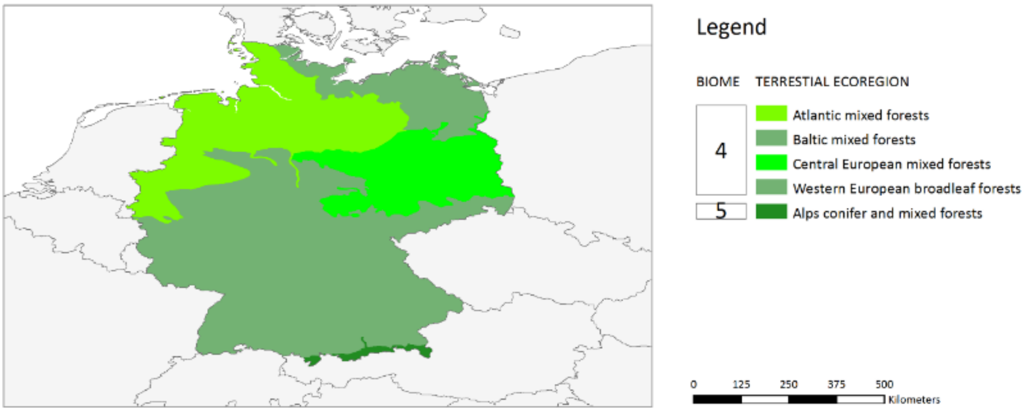
Mapping ES dynamics in agricultural landscapes

WS3_cs3

NAME AND LOCATION OF STUDY AREA	Bornhöved lakes district, Schleswig-Holstein
COUNTRY	Germany

STATUS OF MAES IMPLEMENTATION	Stage 1	Stage 2	**Stage 3**

BIOMES IN COUNTRY	1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	



case study outline

SCALE	national	sub-national	**Local**	
AREAL EXTENSION	Ca. 60 km²			
THEMES	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
	health	**ES mapping and assessment**		
ECOSYSTEM TYPES	urban	**cropland**	**Grassland**	**woodland and forest**
	heathland and shrub	sparsely vegetated land	Wetlands	**rivers and lakes**
	marine inlets and transitional waters	coastal	Shelf	open ocean

Study area description

[*Copied & modified from Kandziora et al. 2014*[24]] The Bornhöved Lakes District (German Bornhöveder Seenkette) is located 30 km south of the federal state capital Kiel. The study area was delimited to a size of 60 km² and lies partly within ten municipalities in the two districts of Plön and Segeberg. Located on the outskirts of the Weichselian glaciation, the northern part of the Bornhöved Lakes Districts belongs to the moraine area of the "Ostholsteinisches Hügelland" with its diversified relief. The southern part, the so-called "Trappenkamper Sander" contains mostly fluvioglacial deposits. Six glacially formed lakes (between 0.27-1.4 km²) are predominate features, which are surrounded by forest areas. The lakes have been landscape protection areas since 1962 and partly conservation areas since 1983. Predominant soils are luvisols, cambic arenosols, and histosols. The Bornhöved Lakes District was the focus of an interdisciplinary ecosystem research project, which has been conducted from 1988 to 2001.

The area is an important supplier of multiple ES due to the large extent of agroecosystems (see land use map Figure 3.1 and Figure 3.3), forests and lakes and it is considered a representative landscape for Northern Germany. Furthermore, it is a good example for development of agricultural land use and related ES supply and demand over the past decades.

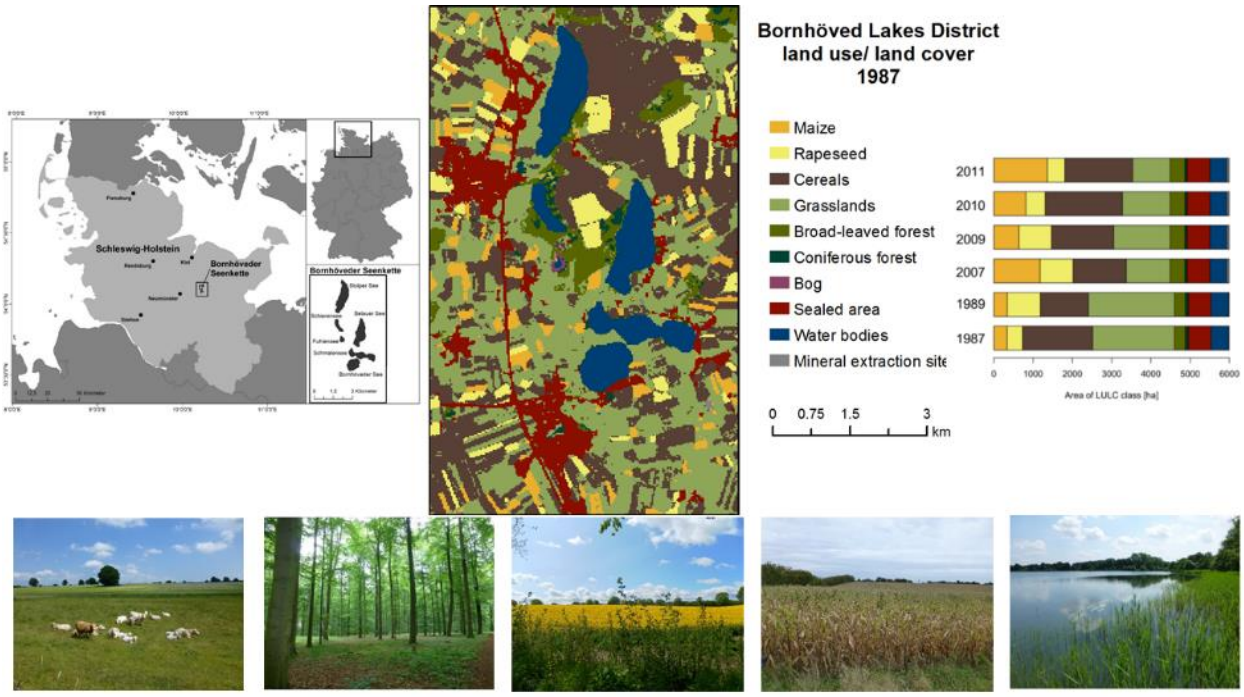


Figure 3.1. Location of the study area (top left; example land use/land cover map and their dynamics (top right); impressions from the area (bottom: All photos taken by Marion Kandziora Kruse).

[24] http://www.landscapeonline.de/wp-content/uploads/DOI103097-LO201435.pdf [Open Access]

3.2. Main policy question and theme

3.2.1. Objectives of ES mapping and assessment

ES mapping and assessment in the case study have been so far mainly scientifically driven. This means that the ES assessment framework (including indicators, quantification methods, etc.) was applied and tested in the area. The case study is partially part of the LTER (Long Term Ecological Research) program. Several ecological data sets are available from previous projects (e.g. Long-Term Research in the Bornhöved Lake District; see Fränzle et al. 2008[25]). This information is used to detect changes in ecosystem conditions, biodiversity, ecosystem functions, land use and other human activities in the area.

The land cover pattern in the area has been rather constant in the last decades. However, significant changes in agricultural land use regarding crop rotation are obvious. This is mostly due to policy changes in Germany that have been heavily promoting and supporting the use of renewable energy since the past years[26]. Resulting impacts were analyzed by land use change detection and statistical analyses of resulting changes in ES supply and demand. The increasing cultivation of energy plants (such as maize or rapeseed) for biomass generation has caused changes especially within provisioning ES (e.g. Figure 3.2). Their supply shows a shift from fodder (and partly food) production towards biomass for energy. The increasing cultivation of maize has further effects on biodiversity, regulating and cultural ES. Thus, the real-life policy question to be addressed would be:

"*How does the national German renewable energy strategy impact on the regional land use / land cover and related ES supply in a northern German agricultural landscape*?"

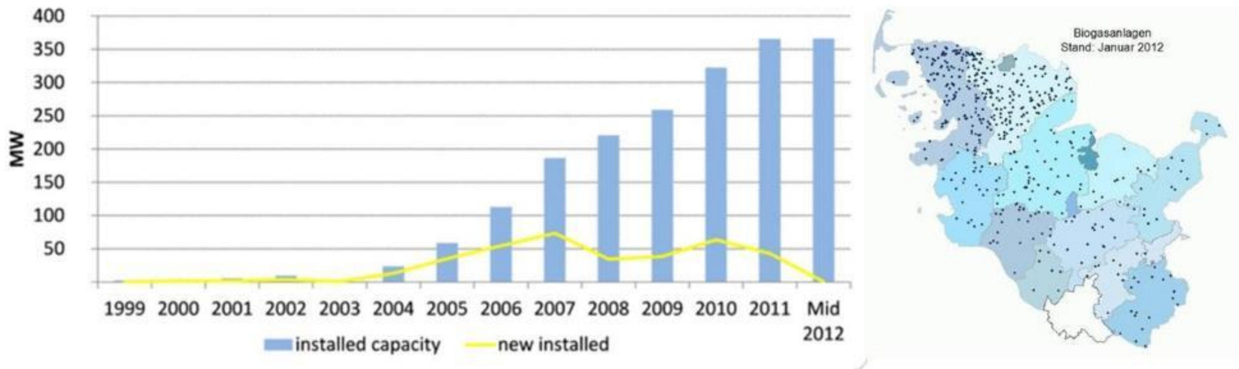


Figure 3.2. Development of electricity generation based on biomass (left) and map of biogas power plants (right) in the federal state of Schleswig-Holstein (Source[27]).

3.2.2. Role of stakeholders

Landowners/farmers were involved in the preceding project "Long-Term Research in the Bornhöved Lake District" (see Fränzle et al. 2008[28]) in order to carry out research on their property or to acquire

[25] http://www.springer.com/de/book/9783540758105
[26] http://www.bmwi.de/EN/Topics/Energy/renewable-energy.html
[27] http://info.furgy.eu/en/energiethemen/bioenergie/bioenergy-in-schleswig-holstein
[28] http://www.springer.com/de/book/9783540758105

information about their land use activities. However, in the actual ES mapping and assessment, stakeholders were mainly involved as experts for selected ES quantifications or for data requests (e.g., governmental departments).

Landowners/farmers should be included further in order to analyses and to quantify in detail changes in agricultural activities and how policy is changing their behavior (e.g. due to increasing cultivation of biomass for energy). Furthermore, local people and other land users should be included to quantify for example recreational activities and other cultural ES, besides the (supraregional) tourists (mainly day trips). The existing data and experience from prior ecosystem condition (ecological integrity) assessments could be used to identify linkages between ecosystem conditions and ES supply.

One key federal state-level stakeholder is the State Agency for Agriculture, the Environment and Rural Areas[29] of Schleswig-Holstein. Their tasks include state-level fishery, emission protection, water management, nature conservation, waste management and soils, all relevant for biodiversity and ES.

3.3. Ecosystem Types and Conditions

3.3.1. Identification and mapping of ecosystem type(s)

Corine land cover data (from 1990, 2000 and 2006) were the initial data source for a preliminary study. The maps were compared and changes detected. The main land cover type is agricultural areas and there were only little changes in the different land cover classes. One larger land cover change was the increase of open cast mining areas (sand and gravel extraction).

As the case study area is very relevant for supply of provisioning ES, the focus was brought to a more detailed analysis of crop cultivation and rotation changes. Other available official data sets such as ATKIS[30] (Authorative Topographic-Cartographic Information System) were applied as well. However, they also did not sufficiently reveal temporal (i.e. annual) land use changes in the agricultural classes. Therefore an own LANDSAT image-based land use / land cover classification was conducted. The resulting time series was the base for a change analysis with statistical data and gave the possibility to have more detailed spatially explicit data for mapping ES. The spatial resolution of LANDSAT data is 30 m x 30 m, the temporal resolution was based on yearly data sets from 2007 and 2009-2011 and the years 1987 and 1989 for comparison. Currently, the attempt is made to continue the analysis until 2015. The developed approach was aimed at being easy to reproduce and to upscale, for example for the whole federal state of Schleswig-Holstein, to be able to compare changes and impacts and to formulate guidelines for sustainable landscape management and policy-making.

[29] http://www.schleswig-holstein.de/DE/Landesregierung/LLUR/llur_node.html
[30] http://www.adv-online.de/Geotopography/ATKIS/

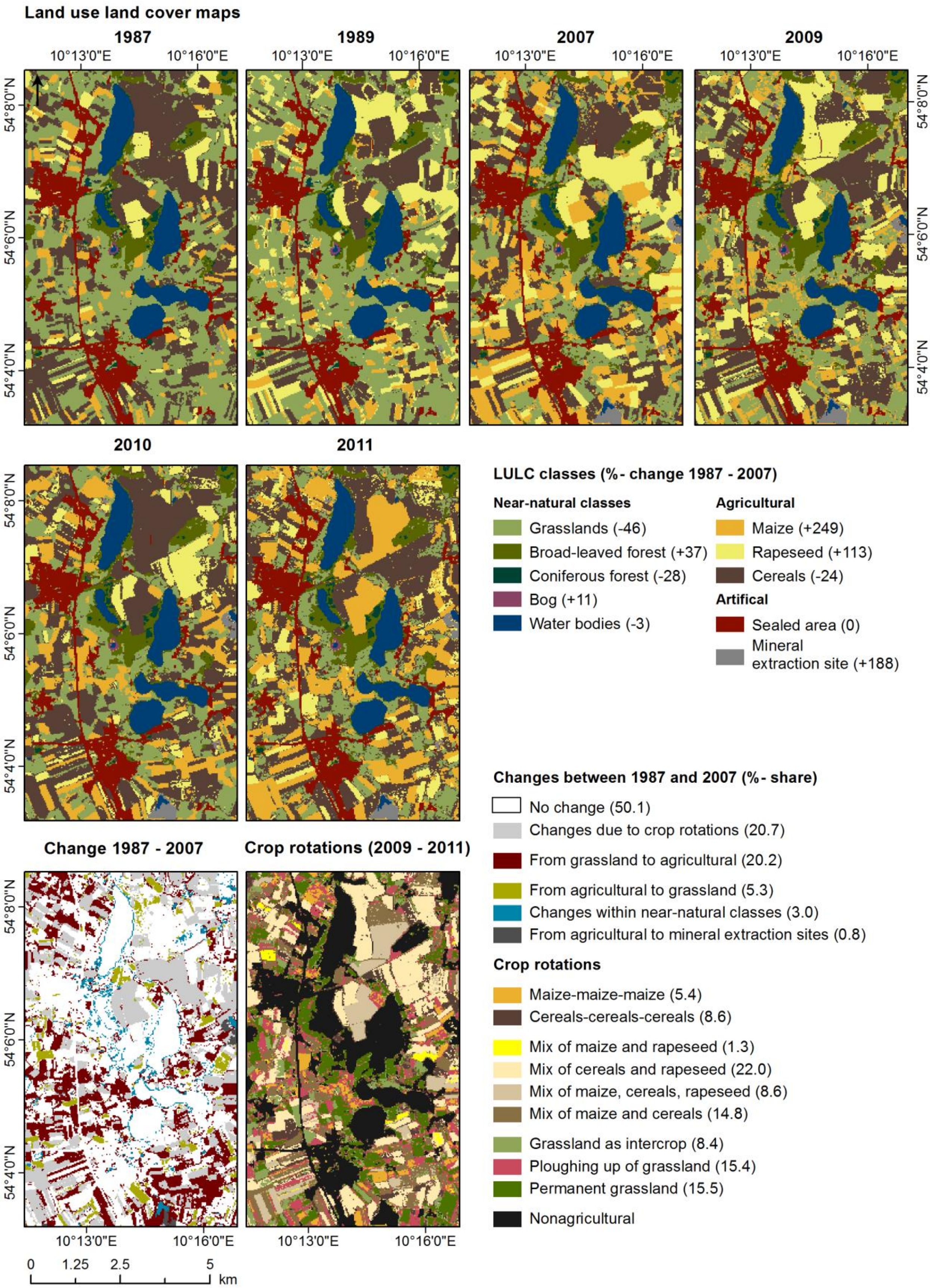


Figure 3.3. Land use / land cover maps for the Bornhöved Lakes District. Changes [%] in area between 1987 and 2007 are listed in parentheses (see legend) and illustrated spatially in the third row. The third row presents retrieved crop rotations from 2009 – 2011. Share [%] is shown in parentheses (see legend) [Kandziora et al. 2014].

3.3.2. Assessment of ecosystem conditions

Ecosystem conditions have been assessed based on the concept of ecological integrity during the long-term ecosystem research project ''Bornhöved Lakes'', which has been conducted between 1988 and 2001. An ecological integrity indicator set has been applied within several case studies on different scales. The indicators related to landscape organization and energy, water and matter budgets that were quantified based on direct measurements, model outputs and other data sources. Within the main research area ''Altekoppel'', comparative empirical ecosystem studies were carried out in agroecosystems and forests with specific focus on a 100 years old beech forest and a directly neighboring arable land ecosystem (see Figure 3.4). Both ecosystems had a similar agricultural use before the forest was planted.

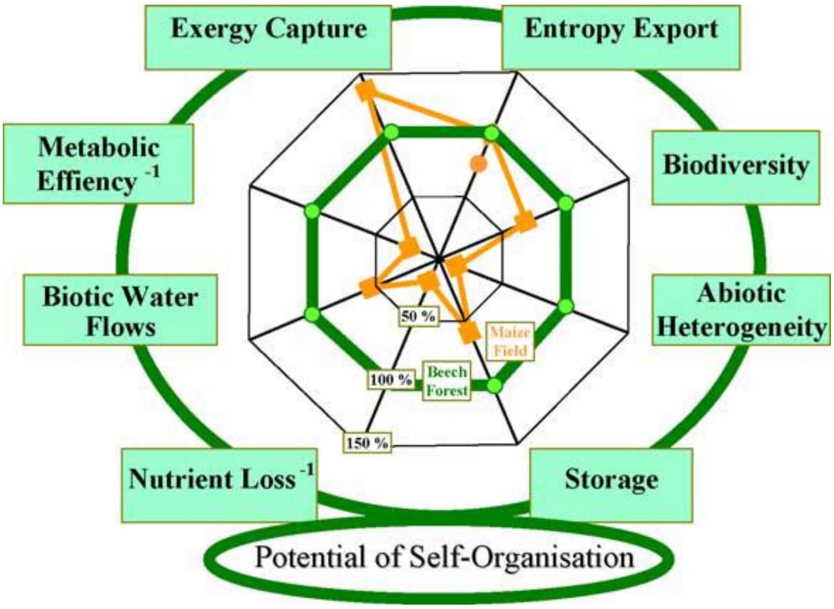


Figure 3.4. Synopsis of the ecological integrity indicator values for the two compared ecosystems (Source: Müller 2005[31]).

In a next step, the ecological integrity indicators were (hypothetically) related to the main categories of ES (see Table 3.1). These hypotheses and individual relations should be tested in further studies.

Table 3.1. Ecological integrity (ecosystem conditions) as basis for ES provision (Source: Müller & Burkhard 2007[32]).

		Ecosystem service			
		Supporting	**Provisioning**	**Regulating**	**Cultural**
Components of ecological integrity	Exergy capture	X	X	X	
	Exergy dissipation	X		X	
	Biotic water flows	X	X	X	
	Metabolic efficiency	X		X	
	Nutrient loss	X	X	X	
	Storage capacity	X	X	X	
	Biotic diversity	X	X	X	X
	Organization	X	X	X	X

[31] http://www.sciencedirect.com/science/article/pii/S1470160X05000257
[32] http://www.springer.com/us/book/9783540367628

3.4. Mapping and assessment of ES

3.4.1. Identification of ES

Relevant ES were identified based on: (a) identified land use / land cover changes and their effects of ES, and (b) data and respective quantification methods availability (also driven by the precedent long-term ecosystem research project). ES that were identified based on a) are especially suitable to address the policy question described in the first section, whereas the ecosystem research data (b) provide information about long-term dynamics of ecosystem conditions.

The identification and quantification of ES has been based on an own ("Kiel") classification system (published in the "ES matrix" in Burkhard et al. 2009 and updated by Kandziora et al. 2013). Table 3.2 shows the ES considered in the study according to the CICES classification. Besides the ES mentioned in Table 3.2, expert-based spreadsheet (method A1) ES supply (potential and flow) and demand scorings were carried out for 11 regulating, 14 provisioning and 5 cultural ES (Burkhard et al. 2014).

Table 3.2. Overview of the ES and related mapping and assessment methods in the German case study

ES selected for mapping and assessment	B	S	E
1.1.1.1 Cultivated crops	X		
1.1.1.2 Reared animals and their outputs	X		
1.2.1.2 Materials from plants, algae and animals for agricultural use	X		
1.3.1.1 Plant-based [energy] resources*	X		
2.2.1.1 Mass stabilization and control of erosion rates	X		
2.2.1.2 Buffering and attenuation of mass flows*	X		
2.3.1.1 Pollination and seed dispersal	X		
2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations	X		
3.1.2.2 Educational*		X	
3.1.2.5 Aesthetic		X	

* ES selected for further discussion during ESMERALDA workshops 3 in Prague
B = biophysical methods; S = socio-cultural methods; E = economic methods.

3.4.2. ES mapping and assessment: biophysical methods

A broad range of biophysical data are available from the long-term ecological research that was carried out in the study area. They can be used to assess ecosystem condition; less for mapping due to their (for most indicators) lacking spatial extension. Newer studies focused on deriving data sets on land use/land cover changes (LULCC) based on satellite image interpretation, harnessing statistical data to quantify and map selected provisioning ES (Tier 2) and apply direct measurement and expert-based methods (Tier 1) and model outcomes (Tier 3) to quantify and map selected regulating ES.

Mapping of provisioning services

1.1.1.1 Cultivated crops

Indicator: *harvested crops (e.g. wheat yield* (dt/ha/a))

LULC was classified based on a Landsat TM 5 remote sensing data series covering the years 1987, 1989, 2007 and 2009-11. In combination with data from regional statistics (Tier 2) on crop supply and demand (consumption), ES budgets for selected crops (cereals) were calculated and mapped for selected years (Resnikov 2016)[33]. Additional information can also be found in Kandziora et al. (2014)[34].

1.1.1.2 Reared animals and their outputs

Indicator: *number of livestock (only cattle) (n/a)*

Data from regional statistics (Tier 2) on the numbers of cattle in the case study area were used to quantify this ES in the years 1988, 2007 and 2010 (Kandziora at al. 2014)[7]. Changes of livestock numbers can be related to respective changes in grassland areas as supplier of fodder for livestock.

1.2.1.2 Materials from plants, algae and animals for agricultural use

Indicator: *harvested crops (e.g. wheat yield* (dt/ha/a))

LULCC was classified based on a Landsat TM 5 remote sensing data series covering the time period from 1987 to 2014. In combination with statistical data (Tier 2) on crop supply and demand, ES budgets for selected plants (maize, grass) for agricultural use (fodder for dairy cows) were calculated and mapped for selected years (Resnikov 2016)[6]. Additional information can also be found in Kandziora et al. (2014).

1.3.1.1 Plant-based [energy] resources

Indicator: *harvested crops (e.g. maize* (dt/ha/a))

LULCC was classified based on a Landsat TM 5 remote sensing data series covering the years 1987, 1989, 2007 and 2009-11. In combination with statistical data on crop supply and demand, ES budgets for selected plants (cereals, maize, and grass) for electricity generation in biogas plants were calculated and mapped for selected years (Resnikov 2016)[6]. Additional information in Kandziora et al. (2014)[7].

Mapping of regulating and maintenance services

2.2.1.1 Mass stabilization and control of erosion rates and

2.2.1.2 Buffering and attenuation of mass flows

Indicator: *Universal Soil Loss Equation*

This ES was quantified and mapped with the add-on water erosion tool in GISCAME. The aim was to analyze the effects of the change in crop rotation and share of grassland between 1987 and 2011 (loss of 50% grassland area).

2.3.1.1 Pollination and seed dispersal

Indicator: *Number of pollinators found in the traps*

Insect pollination of oilseed rape was quantified in the year 2015 based on direct measurement (Tier 1) of pollinator activities with pan traps and exclusion experiments along a gradient of landscape complexity

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[33] Land Use Change Effects on Provisioning Ecosystem Services Supply and Demand - Case study Bornhöved Lakes District, Germany. MSc Thesis Sustainability, Society and the Environment. Kiel University.

[34] http://www.landscapeonline.de/wp-content/uploads/DOI103097-LO201435.pdf [Open Access]

in parts of the study area (Jähne 2016)[35]. In parallel, pollination has been modelled for the same area using InVest (Jähne 2016)[8].

2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations

Indicator: *carbon in different carbon pools (e.g. above-ground biomass, soils etc.)*

Global climate regulation was quantified and mapped based on the InVEST carbon model for the years 1987 and 2011 with primary and secondary data.

3.4.3. ES mapping and assessment: socio cultural methods

A broad set of ES supply and demand (11 regulating, 14 provisioning and 5 cultural ES) has been assessed based on the "ES matrix approach" using expert knowledge; see Burkhard et al. (2014)[36]. Two cultural ES have been assessed in another study (Mocior and Kruse 2016[37]) based on questionnaires.

3.1.2.2 Educational

Indicator: *survey data on qualitative scale*

In the frame of an exploratory survey with young experts (n = 37) from two universities, photographs from various landscapes (global distribution, with two examples from the Bornhöved case study) were evaluated on a relative scale for their educational value and criteria for the evaluation of the educational values were stated by the participants.

3.1.2.5 Aesthetic

Indicator: *survey data on qualitative scale*

A similar approach was conducted to analyze and discuss the aesthetic values of landscapes and the criteria involved since 6 years in one master's course at Kiel University.

3.4.4. ES mapping and assessment: economic

No economic mapping and assessment methods were applied.

[35] Modelling and quantifying insect pollination of oilseed rape along a gradient of landscape complexity. MSc Thesis Sustainability, Society and the Environment. Kiel University 2016.

[36] http://www.landscapeonline.de/103097lo201434 [Open Access]

[37] http://www.sciencedirect.com/science/article/pii/S1470160X15003647

3.5. Use and integration of ES mapping and assessment results

3.5.1. Addressing the policy question

So far, the "ES matrix" was used to link geo-biophysical landscape units (e.g. land use types) to various ES by indicating supply capacities of/demands for various ES. The capacities have been assessed based on selected indicators and quantified using different approaches as previously described.

Future research will aim at integrating further quantification and mapping methods and data sources. Feedback from state-level authorities about the applicability of the mapping and assessment results will be used in order to figure out what kind of information, at which scale and accuracy level is actually needed for decision making on the one hand and what, on the other hand, science can provide considering available resources and justifiable efforts.

3.5.2. Results communication and dissemination

So far, the outcomes have been published in scientific publications and one comprehensive book resulting from the long-term research project in the area. Future activities should work on the science-policy-society interface in order to make the results useful for decision making and (at least) to raise awareness about the importance of ecosystem conditions and services. Moreover, the methods that were developed and applied in the case study area are all transferable as they all are based on freely available data (such as Corine and LANDSAT) and methods.

3.6. References & Annexes

Reference

Burkhard, B., Kandziora, M., Hou, Y., Müller, F. (2014) Ecosystem Service Potentials, Flows and Demand – Concepts for Spatial Localisation, Indication and Quantification. Landscape Online 34: 1-32.

Fränzle, O., Kappen, L., Blume, H.-P., Dierßen, K. (Eds.) (2008) Ecosystem Organization of a Complex Landscape Long-Term Research in the Bornhöved Lake District, Germany. Ecological Studies. Springer.

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Kandziora, M., Burkhard, B., Müller, F. (2013) Mapping provisioning ES at the local scale using data of varying spatial and temporal resolution. ES 4: 47-59.

Kandziora, M., Dörnhöfer, K., Oppelt, N., Müller, F. (2014) Detecting Land Use And Land Cover Changes in Northern German Agricultural Landscapes To Assess Ecosystem Service Dynamics. Landscape Online 35:1-24.

Mocior, E., Kruse, M. (2016) Educational values and services of ecosystems and landscapes – An overview. Ecological Indicators 60: 137–151.

Müller, F., Burkhard, B. (2007). An ecosystem based framework to link landscape structures, functions and services. In: Mander, Ü., Wiggering, H., Helming, K. (Eds.): Multifunctional Land Use – Meeting Future Demands for Landscape Goods and Services. Springer: 37-64.

Rensikov, N. (2016) Land Use Change Effects on Provisioning ES Supply and Demand - Case study Bornhöved Lakes District, Germany. MSc Thesis Sustainability, Society and the Environment. Kiel University.

Annexes

Case study booklet for:
WORKSHOP 4: "Testing the methods across themes" held in Amsterdam, Netherlands, 09-11 January 2017

4. ES-based coastal defense in the Netherlands

December 2016

ESMERALDA partner: VU University, Amsterdam (VU)

Case Study Coordinators: Pieter van Beukering

ESMERALDA

Enhancing ES mapping for policy and decision making

4.1. Case study factsheet and study area description

ES-based coastal defense

WS4_cs1

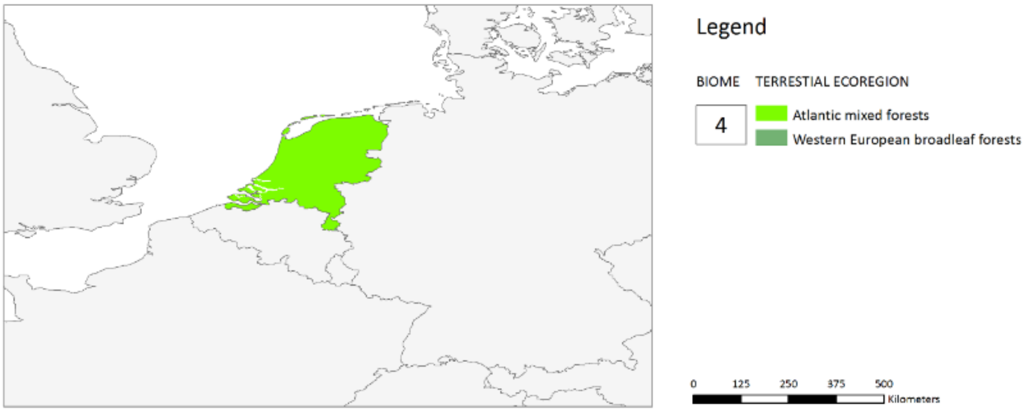
NAME AND LOCATION OF STUDY AREA	Haringvliet
COUNTRY	Netherlands

STATUS OF MAES IMPLEMENTATION

Stage 1	Stage 2	**Stage 3**

BIOMES IN COUNTRY

1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
5 Temperate Conifer Forests	6 Boreal Forests/Taiga
8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
14 Mangrove	



SCALE

national	sub-national	**local**

AREAL EXTENSION: **81,000 HA**

THEMES

nature conservation	**climate, water and energy**	marine policy	**natural risk**
urban and spatial planning	**green infrastructures**	**agriculture and forestry**	**business, industry and tourism**
health	**ES mapping and assessment**		

ECOSYSTEM TYPES

urban	**cropland**	grassland	woodland and forest
heatland and shrub	sparsely vegetated land	**wetlands**	**rivers and lakes**
marine inlets and transitional waters	**coastal**	shelf	open ocean

Study area description

The Haringvliet used to be the most important river mouth of the rivers Meuse and Rhine. When in 1971 the rivers were closed from the sea by the Haringvliet dam, the rich estuarine ecosystem heavily deteriorated. In 2018, the Haringvliet dam will be opened (a little) by the Dutch government. Six large Dutch nature organizations have joint forces to optimally use this development and think beyond 2018. They aim to bring back dynamics for real estuarine nature, migratory fish and birds.

4.2. Main policy question and theme

4.2.1. Objectives of ES mapping and assessment

In 2010, Anne Böhnke-Henrichs and Dolf de Groot conducted a total economic valuation study of the current and the future "restored" situation of the Haringvliet. This study is based on secondary valuation, using benefit transfer techniques. The results of this study are used in this document to explain the past valuation efforts.

A new primary valuation study is about to start in 2017, building upon the above benefit transfer study of the Haringvliet. This new study focusses on the potential future state of the Haringvliet and aims at measuring the changes in economic, social and environmental terms (in line with the triple bottom-line approach of People, Planet and Profit – see Figure 4.1). The study will use various methods (e.g. surveys) and will generate a range of outcomes (e.g. CBA, value maps). Where relevant, the elements of this new study will be elaborated upon. The study is highly policy relevant by addressing the following questions:

- *What are the trade-offs involved in allowing more natural flooding in the Haringvliet (i.e. ecological benefits versus changes in flood perception of local citizens)?*
- *What are the costs & benefits of different measures for ecosystem restoration of the Haringvliet?*
- *Who are the winners and losers of different scenarios in the Haringvliet and are there ways in which the losers could be accommodated?*

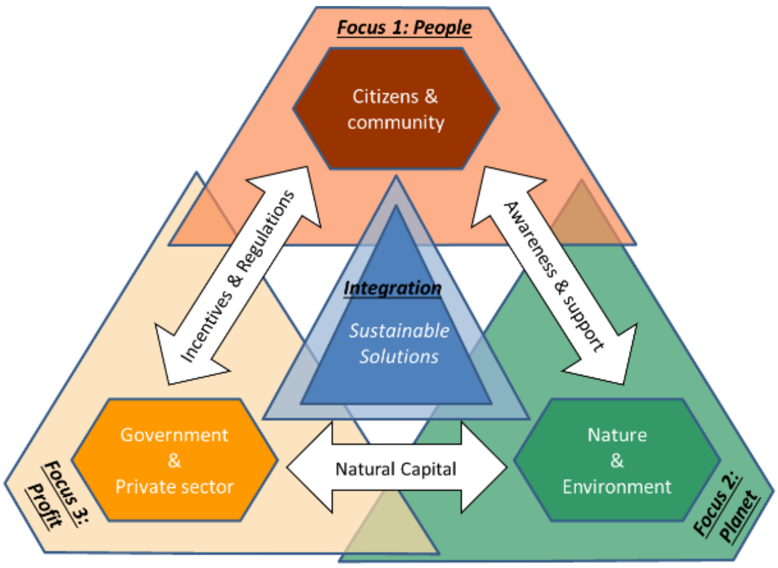


Figure 4.1. Conceptual framework of the "new" study assessing and mapping ES of the Haringvliet.

4.2.2. Stakeholders and their role

The main stakeholders involved in the study range from science to policy, and from citizens/business to NGOs. The best way to categorize them is by scale:

At the local scale, business, farmers and citizens are of specific interest in the process because of their direct stakes in the future of the Haringvliet. (1) Business can benefit from the increased recreational benefits of the area; (2) Farmers are the big landowners that may have to adapt to new ecological conditions; and (3) Citizens benefit from the recreational amenities but may also experience a change in the flood probability. They take part in the study by being a subject of multiple surveys implemented in the area and by participating in the stakeholder meetings that are organized by the Droomfonds Coalition.

At the regional scale, policy makers and NGOs are highly relevant. For the provincial government, this is a really prestigious and influential project and may be considered as an example for other estuaries in the region. For the NGOs, it is a unique form of collaboration which can only work well at the regional level given the effect that stretch beyond the local domain. NGOs and governments participate by contracting out the study, designing the development plan for Haringvliet and leading stakeholder sessions.

At the (inter)national level, the national government is involved since the Haringvliet has a symbolic function on how the Netherlands deals with flood risks and in that way is of interest to the whole country. In addition, the restoration project of the rivers may lead to more fish migration to upstream EU countries.

4.3. Ecosystem Types and Conditions

4.3.1. Identification and mapping of ecosystem type(s)

As a first step, the landscape types (or ecosystems) of the South-West Delta were identified. In total, 30 different types were considered. They cover natural types as estuarine open water, river with tidal influence, intertidal wetlands and alluvial willow forests on the one hand and cultivated types like fields (arable land) and artificial or anthropogenic altered types such as artificially closed coastal lagoon, conventional dikes and 'Klimaatdijken' (i.e. climate dikes are dikes that provide sufficient protection against future climate change and also allow for multiple functions besides flood protection).

The calculation of surface area per landscape type was done by using topographic maps (see Figure 4.2). For the scenario situation it was assumed that structures of the historically open Haringvliet will reestablish. Furthermore, for estimating the location and extent of the future landscape types the expected water level and tidal influence were estimated by expert judgement. The influence of salt water is expected to reach the western bank of the island Tiengemeten.

The landscape type 'closed coastal lagoon' only exists in the current situation and refers to the closed Haringvliet/Hollandsch Diep open waters. Under the Open Haringvliet scenario this will be replaced by a mix of four main ecosystem-types: estuarine water, coastal lagoon, river (tidal), and freshwater lagoon. The intertidal areas of the coastal wetlands are currently also not existing but will (re-)develop under tidal influence in the Open Haringvliet scenario. Due to dike relocation, about 27,500 ha of cropland in the current situation will be converted to wetlands or used to build Klimaatdijken. In the current situation only conventional dikes can be found in the area, most of them will be relocated and replaced by Klimaatdijken.

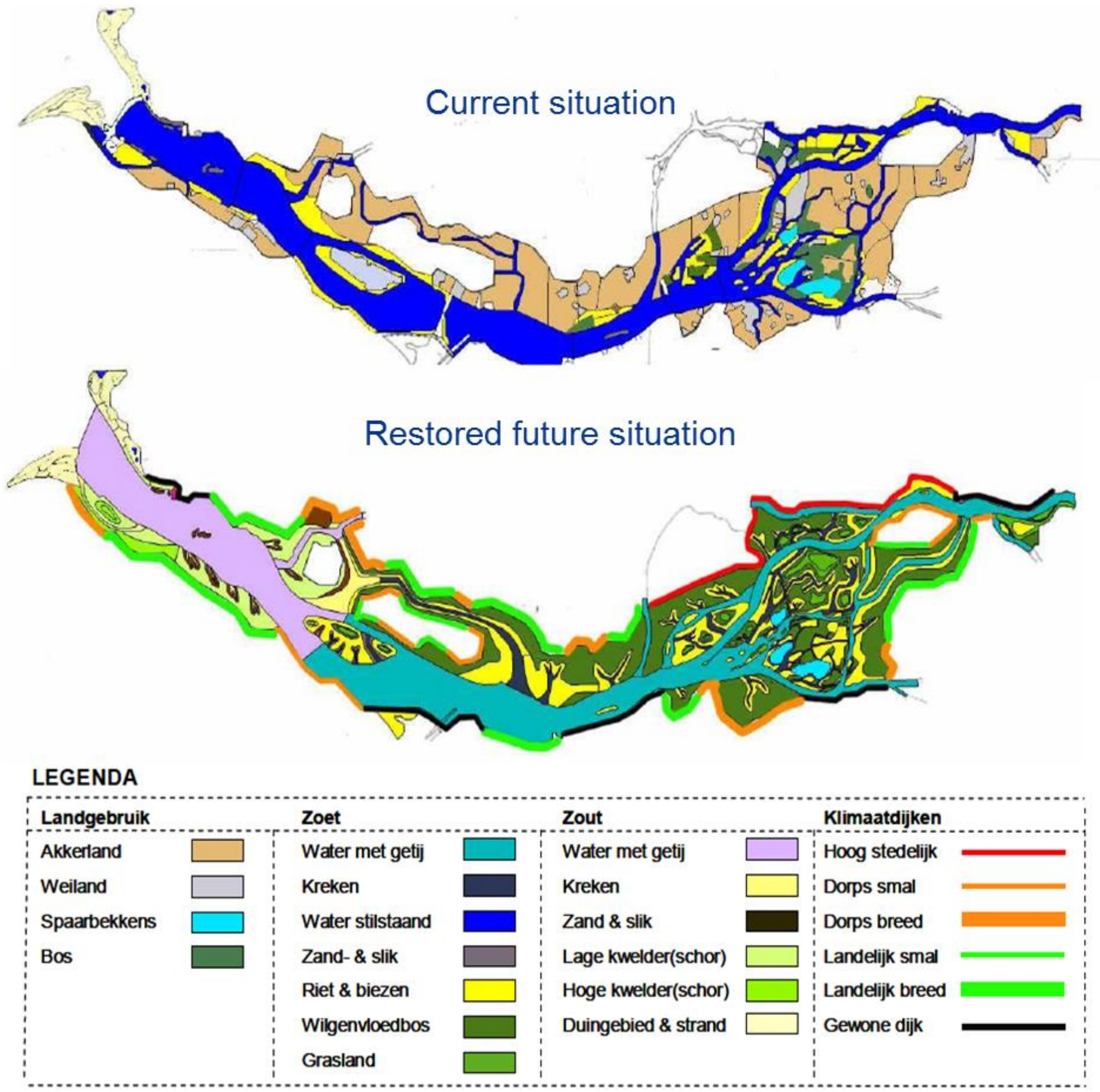


Figure 4.2. Ecosystem maps of the Haringvliet for current and potential "restored" future situation

4.3.2. Assessing ecosystem conditions

The Haringvliet was closed in 1971 by the Haringvliet dam. The Haringvliet used to be the most important river mouth of the rivers Meuse and Rhine. This estuary, with a gradual transition between fresh and salt water, sediment transport and strong tidal dynamics, used to be a highly productive ecosystem, with unique species. It was the entrance and exit for migratory fish. When in 1971 the rivers were closed from the sea by the Haringvliet dam, the rich estuarine ecosystem heavily deteriorated. The area became a stagnant freshwater lake, with algae seasonal blooming problems and ample migration possibilities for migratory fish, like salmon and eel.

Partly opening it will partly reintroduce tide. From the west salt water will enter a part of the area, while freshwater from the rivers will flow through the arm to the sea. The freshwater-saltwater gradient is restored. The location of this gradient zone will depend on the amount of fresh water that will flow in, but will occur mostly in the west area of the Haringvliet. Triggered by tide erosion and sedimentation, processes will form channels and islands again. The shallow zones along the dikes will rise because of sedimentation and wetlands will develop here.

The above-mentioned Figure 4.2 the current and a potential future scenario of how the Haringvliet could be developed with restored estuarine dynamics. Current dikes have insufficient height and can be replaced by “Klimaatdijken” (climate dikes) which are dikes that are unusually broad and because of their large area and slope provide opportunity for functions like recreation, residence and agriculture. The area outside the dikes is enlarged by placing the Klimaatdijken more inland to create a strip of land subject to tide and sedimentation. Here wetlands will (re-)establish, providing the opportunity of recreation, contributing to the storm buffering capacity and also support plant and animal populations. Opening the Haringvlietdam will also influence the Voordelta (i.e. parts of Haringvliet delta beyond the dam and adjacent coastal area), which is why this area was also included in the investigation.

The Droomfonds project consist of six large activities (taken from www.haringvliet.nu):

Nature restoration: The project focuses on improving the natural quality in and around the Haringvliet. Step by step the banks of the river will be restored. This includes tidal nature and brackish water zones. It requires purchase of land that is currently used as agricultural land.

Shellfish banks: A natural estuary contains shellfish banks, hotspots of aquatic life. With the opening of the Haringvlietdam there are good opportunities to restore these shellfish banks on the marine side of the dam. This will not happen spontaneously though and requires artificial interventions.

European sturgeon: The European Atlantic Sturgeon used to be an important habitant of the Rhine system. It spawned in the mainstream and grew up in the Dutch estuary. After more than a decade at sea, it returned to the Rhine again. This cycle stopped in the 1950’s because of loss of habitat, pollution and overfishing. We are currently working on the research to return this threatened species, which only lives in the Gironde delta, to the Rhine. Monitored reintroductions will tell us the chances of success of full scale reintroduction. Also we will work on a breeding center for the Rhine.

Fishery: When in 2018 the migratory fish can return to the Rhine and Meuse through the Haringvliet, it should be avoided that these species are caught as bycatch of the fishery sector. In close coordination with the fishery sector, we will work on a protection and management plan for the Haringvliet and the Voordelta.

Recreation: The newly developed nature will be enjoyed/enjoyable by a large audience. The nature deprived environment of Rotterdam is in dear need of areas where people can relax and appreciate the estuarine nature. The project will facilitate this through the development of infrastructure (electronic boats departing from Rotterdam, board walks etc.) and innovative structures like an underground glass viewing spot for birdwatching.

Monitoring: In close cooperation with the nature lovers, there will be an intense monitoring program, mainly focused on migratory birds and fish. This will set the baseline and show the impact of our activities and other developments in the area.

4.4. Mapping and assessment of ES

4.4.1. Identification of ES

Relevant ES and their subservices were identified using the "Atlas van de Zuidwestelijke Delta" (Hocks, Hoekstra et al. 2009) and literature on different usages of the area. The typology of the ES was taken from the TEEB project (de Groot, Fisher et al. 2009). Because the 22 ES identified in TEEB were defined in too general terms for this study, they were specified by identifying appropriate sub-services. In order to give a detailed picture of the consequences of the investigated scenarios for the delta, 50 ecosystem subservices were considered (see Annex: Table 4.1).

The next step in the analysis was to determine which landscape types are most relevant for providing a given ES. That was done based on a literature review (notably: Hocks 2009; Rijkswaterstaat 2008; Ens 2004; European-Commission 2009; Ruijgrok 2006; Rijkswaterstaat 2010; van der Hiele 2008; de Jong 2009) and complemented by expert opinions. For instance, the service "fish" is related to the large open water landscape types of the area, such as Coastal Waters, Estuarine open waters, Closed coastal lagoon and River. While for the recreational service it is assumed that the interaction of all natural landscape types is relevant for providing the recreational effect. Thus, these are all regarded as relevant for the service "recreation/day-tripping". Table 4.1 in the Annex shows the ES considered in the case study.

4.4.2. ES mapping and assessment: biophysical methods

In the original study in 2010, no biophysical methods for mapping and assessing ES have been applied. In the new study, a systematic review will be conducted on a range of biophysical indicators which are available in the literature as well as with a number of nature-conservation organizations that are active in the Haringvliet. Moreover, the team will do an analysis on the ecological effects of various ecosystem restoration measures in the Haringvliet. Finally, ES will be made spatially explicit by creating ES maps of the Haringvliet area. Figure 4.3 illustrates how the biophysical methods will be integrated in an overall assessment of future scenarios of the Haringvliet.

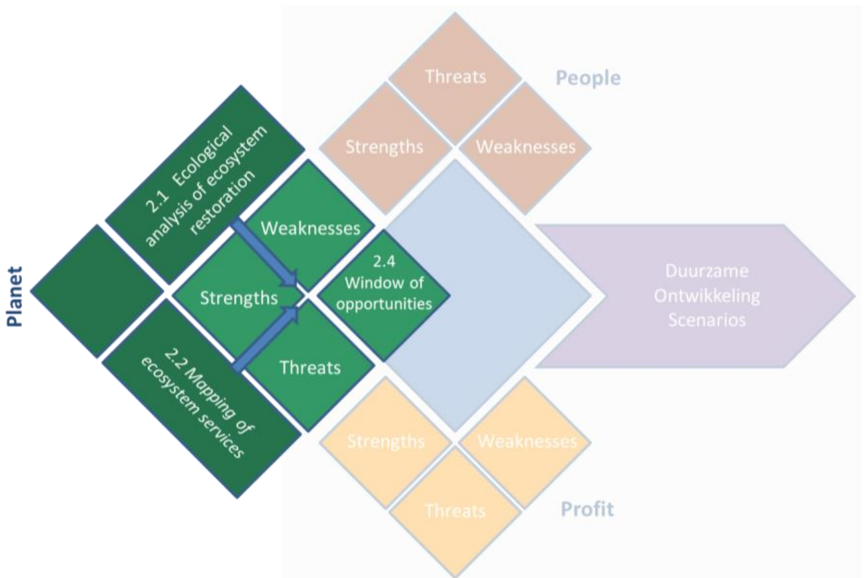


Figure 4.3. Biophysical methods for mapping and assessment of ES in the new Haringvliet study.

4.4.3. ES mapping and assessment: socio-cultural methods

In the original study in 2010, no social methods for mapping ES have been applied. In the new study, these social methods will be implemented aimed at tourists and residents. Extensive surveys will be conducted each including choice experiments in which respondents will be asked to make trade-offs between the main ES (e.g. tourism versus perceived flood risks). Figure 4.4 illustrates how the social methods will be integrated in an overall assessment of future scenarios of the Haringvliet. The values generated can be characterized as Tier 2 or Tier 3.

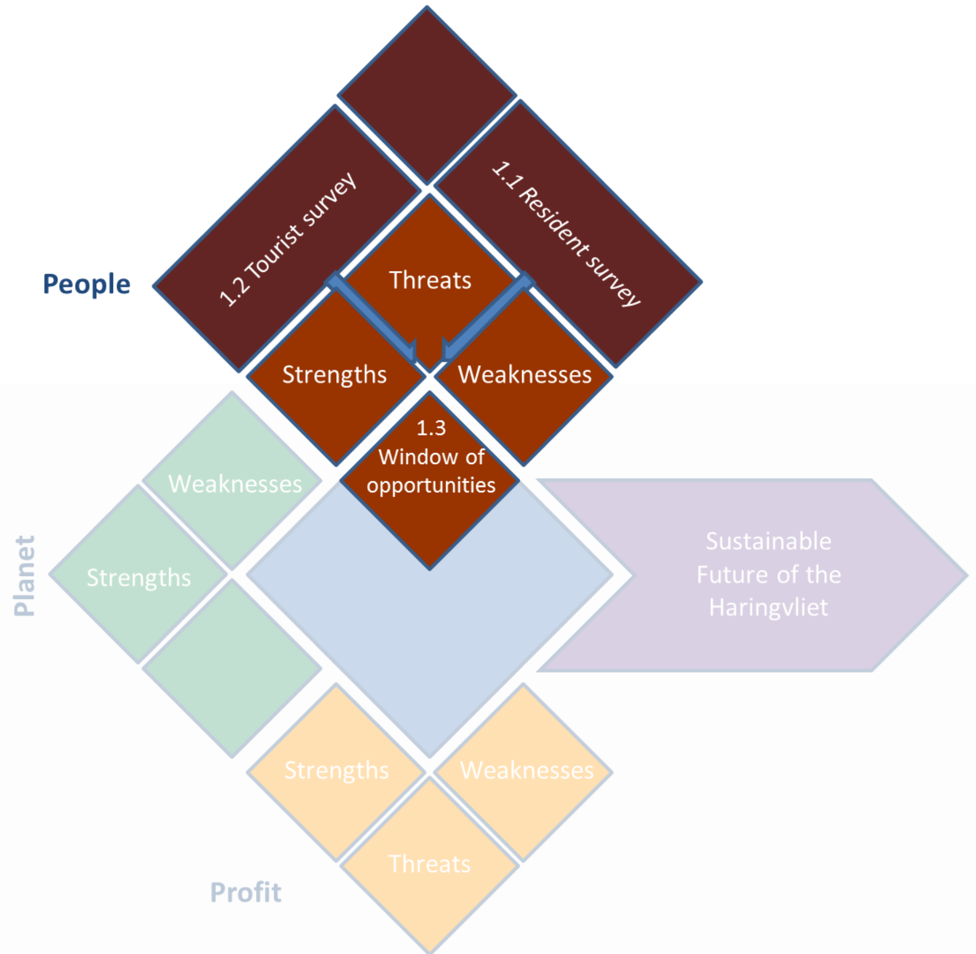


Figure 4.4. Socio-cultural methods for mapping and assessment of ES in the new Haringvliet study.

4.4.4. ES mapping and assessment: economic methods

To determine the monetary value of the ES provided by the Haringvliet, more than 40 reports, several data bases with statistics (from CBS, LEI and other organizations) and many websites were consulted, focusing on the South-West Delta. The remaining gaps were then filled in as much as possible by using the report on “Kentallen Waardering Natuur, Water, Bodem en Landschap” (Ruijgrok 2006). Because the values are mainly based on literature and expert judgements, we consider the economic valuation process mainly Tier 1.

Based on the available data, a monetary value per hectare was calculated for each service using the following methods:

- **Market values**:
  a) ***Market value*** was used for the provisioning services (i.e. harvesting of fish, shellfish, algae, wood, crops, livestock and water) and for recreational use;
  b) ***Factor Income method*** was used for grazing (fodder), the nursery service and inspirational value of the delta for paintings;
- **Indirect market valuation methods**:
  a) ***Avoided cost method*** (expenditures that would occur in the absence of the ES) was used for water regulation, flood prevention, air-quality regulation and carbon sequestration;
  b) ***Replacement cost method*** was used for water-treatment and storm protection services;
  c) ***Travel cost method*** was used to calculate additional expenses by visitors travelling to the area;
  d) ***Hedonic pricing*** (appreciation of ES reflected in higher house prices of houses);
- **Non-market valuation**: calculate the expenditures on purchase and management of protected areas
- **Benefit transfer**: using data from other publications on comparable ecosystems was used for the monetary value of the provision of fish and meat and of the service storm flood protection (in case of coastal wetlands).

Part of the results of the original study by Anne Böhnke-Henrichs and Dolf de Groot (2010) are shown in Figure 4.5. The rough estimate reveals that 'Klimaatdijken' in combination with natural wetlands in the Open Haringvliet scenario, provide cost-savings for a given safety-level of about **€0,25-€0,5 billion/year** compared to the current Haringvliet dam. Of all sub-services investigated the total value of only four sub-services is expected to decrease, namely: provisioning of meat (livestock), crops and timber and the value of the Haringvliet area as a study site for water engineering. The provision of drinking and irrigation water remains more or less the same in the scenario situation (change of less than 1%). The service expected to increase most is transportation/shipping (see also Annex: Table 4.2).

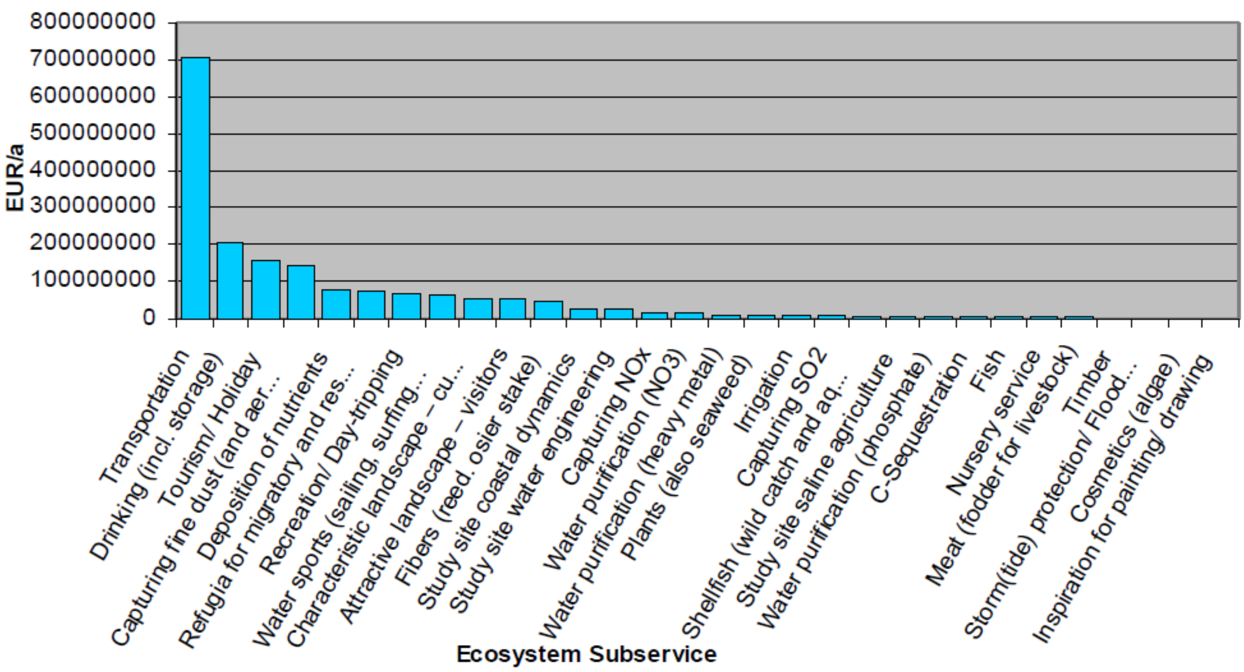


Figure 4.5. ES value of the Haringvliet for potential "restored" future situation (€/year).

In the new Haringvliet valuation study, several new economic (valuation) methods will be applied to measure specific values. For the economic benefits for the recreational industry an input-output model will be developed in which macro-economic effects, including changes in employment, will be estimated. The impact of land- and seascape changes on the real estate value will be estimated using hedonic pricing techniques.

4.5. Use and integration of ES mapping and assessment results

4.5.1. Addressing the policy question

This study aimed to provide a first estimate of the change in Total Economic Value (TEV) of the Haringvliet area in case the area would get an open connection to the sea based on an analysis of the changes in ES provided by the main landscape types affected by the opening of the Haringvliet area. This pilot study showed an increase in TEV of about 500 million EUR/year (from 1.26 billion currently to 1.74 billion under the open Haringvliet scenario) based on 30 ecosystem (sub) services included in the analysis.

More specifically, the TEV of the whole Haringvliet area was calculated by using the surface area of the landscape types today and of the Open Haringvliet Scenario. Hence, to compare the TEV of the current situation with the potential TEV of an Open Haringvliet scenario only the change in surface area was considered, while the "quality" of the service-provision, and thus the service-value per ha, is assumed to remain unchanged. For example, the amount of fish caught per ha, or the number of recreational visitors per ha is assumed to remain constant. Therefore, the value per hectare calculated here is considered to be irrespective of a specific scenario. This is of course a significant simplification.

4.5.2. Dissemination and communication of results

This information is not known to the team. What we do know is that the original study by Anne Böhnke-Henrichs and Dolf de Groot in 2010, despite of the clear results pointing at the net-benefits of opening up the Haringvliet, did not generate the public and policy support that was hoped for. This is probably the result of the fact that, because of the very limited budget, the study was conducted mostly in isolation of the main stakeholders and was therefore lacking the sense of stakeholder ownership that the study needed. This is one of the reasons that the Droomfonds coalition is now seeking for much more intensive and primary study in which stakeholder participation is key.

4.6. References & Annexes

References

Annexes

Table 4.1. Summary of the 50 ecosystem subservices considered

	Main provisioning service(s)	Main regulating service(s)	Main habitat service(s)	Main cultural service(s)
Intertidal areas (intertidal wetland – low)	• Meat (fodder for livestock) • plants	• storm tide protection/flood prevention • water purification (NO3, heavy metal)	• refugia for migratory and resident species, biodiversity protection	• attractive landscape – visitors • recreation/day-tripping • tourism/holiday • study site for coastal dynamics and saline agriculture
Willow forest	• fiber (osier stake)	• capturing fine dust, NOx, SO2 • storm tide protection/flood prevention	• refugia for migratory and resident species, biodiversity protection	• attractive landscape – visitors • recreation/day-tripping • tourism/holiday
Estuarine open water	• transportation • drinking water • irrigation	• C-sequestration	• refugia for migratory and resident species, biodiversity protection	• attractive landscape – visitors • recreation/day-tripping • tourism/holiday • water sports • study site for coastal dynamics and water engineering
River (tidal)	• transportation • drinking water • irrigation	• C-sequestration	• refugia for migratory and resident species, biodiversity protection	• attractive landscape – visitors • recreation/day-tripping • tourism/holiday • water sports
Closed coastal lagoon	• transportation • drinking water • irrigation		• refugia for migratory and resident species, biodiversity protection	• attractive landscape – visitors • recreation/day-tripping • tourism/holiday • water sports • study site for water engineering
Field (arable land)	• plants			
Conventional dike	• Meat (fodder for livestock=	• storm tide protection/flood prevention	•	• study site for water engineering
Klimaatdijk	• Meat (fodder for livestock=	• storm tide protection/flood prevention		• Characteristic landscape – cultural identity • Study site for water engineering and saline agriculture

The plans for measuring the values of the current situation and of different scenarios for the Haringvliet are depicted in Figure 4.6. The study by Anne Böhnke-Henrichs and Dolf de Groot in 2010 in principle provides an excellent starting point for a more elaborate analysis for future scenarios. For the justification of the measures implemented by the Droomfonds, baseline measures of key indicators is crucial.

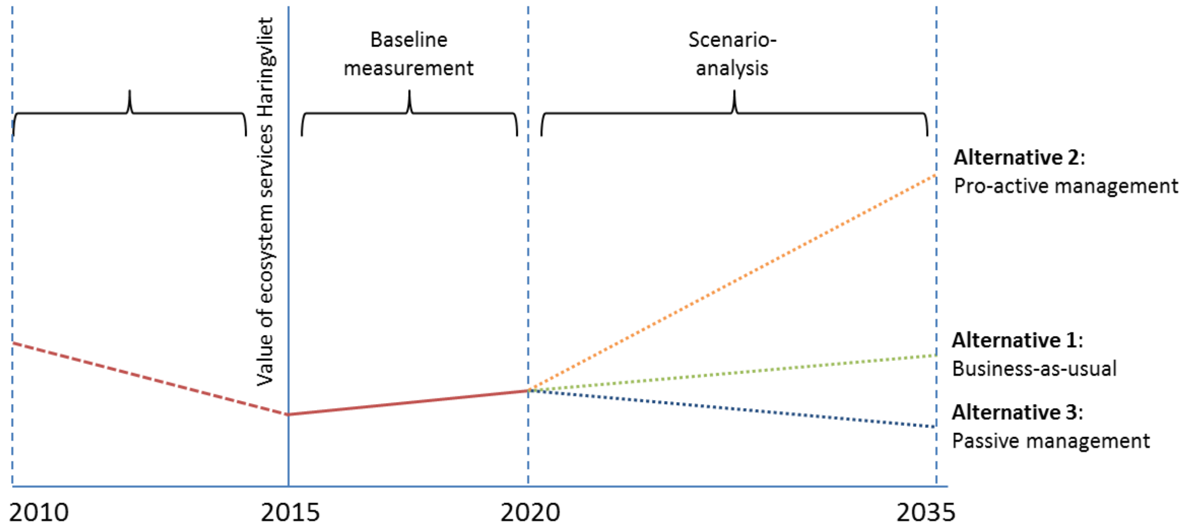


Figure 4.6. Time frames for measuring the values of the current situation and different scenarios for the Haringvliet.

Table 4.2. Change of value by main value-category between current and Open Haringvilet scenario

	Related Services (# correspond with Annex IV)	Current situation [€/year]	Open Haringvilet [€/year]	Change [€/year]
1. (Gross) market value				**+51.428.993**
Fish & shellfish (natural harvest)	1, 2, 3, 5, 6, 10	2.505.609	12.176.408	+9.670.799
Algae, saline vegetation	11, 12, 13	23.974	10.709.933	+10.685.959
Reed, willow-toes, timber	21, 22, 23	9.857.117	49.912.491	40.055.374
Crops, livestock - cultivated	9, 14	92.174.977	0	-92.174.977
Drinking water-extraction	15, 16, 37	207.281.737	207.281.610	-127
Recreation & tourism	55, 56, 57, 60	208.474.468	291.666.432	+83.191.964
2. Factor Income				**+3.833.364**
Fodder	7, 8	540.058	2.827.362	+2.287.305
Nursery	47, 48	1.858.941	3.403.430	+1.544.489
Paintings inspired by delta	62	3.139	4.709	+1.570
3. Revealed Willingness to pay				**+107.547.503**
Higher house value (Hedonic Pricing)	53 + 54	18.015.041	54.873.428	+36.858.388
Donations for conservation	50, 51	42.696.248	74.645.207	+31.952.959
Travel cost day visitors/tourists	52	36.538.535	54.818.979	+18.280.444
Knowledge network	58	37.042.594	57.498.306	+20.455.713
4. Avoided Damage Costs				**+139.803.650**
Avoided drought-damage	17	9.965.963	9.930.007	-35.956
Avoided Flood/Storm Damage*	32	0	1.470.871	+1.470.871
Avoided health damage	25, 26, 27, 28, 29	35.131.311	172.402.451	+137.271.140
Avoided climate change/C-seq**	30	3.348.563	4.446.157	+1.097.594
5 Replacement cost (avoided)				**+182.970.191**
(avoided) water treatment costs	34, 35, 36, 38, 39, 40, 41	7.818.131	32.254.050	+24.445.929
(avoided) transportation costs	18	545.156.57	703.680.419	+158.524.262

* Based only on additional damage protection capacity of Klimaatdjken compared to conventional dikes;
** Based on current stock exchange value of 14,26€/t CO_2

Case study booklet for:
WORKSHOP 4: "Testing the methods across themes" held in Amsterdam, Netherlands, 09-11 January 2017

5. ES in Polish urban areas

December 2016

ESMERALDA partner: Adam Mickiewicz University in Poznan (UPOZ)

Case Study Coordinators: Andrzej Mizgajski, Damian Łowicki

ESMERALDA

Enhancing ES mapping for policy and decision making

5.1. Case study factsheet and study area description

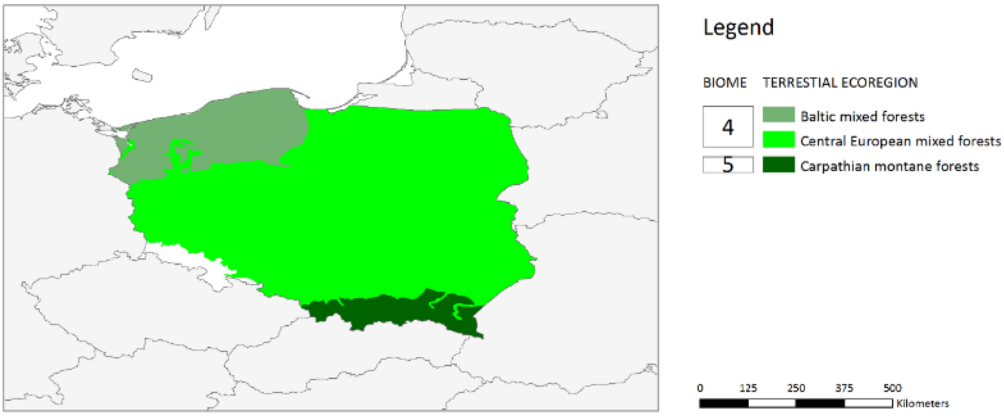
ES in Polish urban areas

WS4_cs2

NAME AND LOCATION OF STUDY AREA	10 polish Large Urban Zones with more than 100.000 inhabitants (see European Urban Atlas)
COUNTRY	Poland

STATUS OF MAES IMPLEMENTATION	Stage 1	Stage 2	Stage 3

BIOMES IN COUNTRY	1 Tropical & Subtropical Moist Broadleaf Forests	4 Temperate Broadleaf & Mixed Forests
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	



case study outline

SCALE	national	sub-national	local
AREAL EXTENSION	10 Large Urban Zones (area from 2.636 to 6.000 km^2)		

THEMES	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
	health	ES mapping and assessment		

ECOSYSTEM TYPES	urban	cropland	grassland	woodland and forest
	heatland and shrub	sparsely vegetated land	wetlands	rivers and lakes
	marine inlets and transitional waters	coastal	shelf	open ocean

Study area description

The Republic of Poland is a country in Central Europe, situated between the Baltic Sea in the north and two mountain ranges (the Sudetes and Carpathian Mountains) in the south. With a total area of 312,679 Km^2 and population of 38.5 million, it is the ninth largest and sixth most populous member of the EU. The study area includes the Larger Urban Zones in Poland, according to Urban Atlas (Figure 5.1 and Table 5.1).

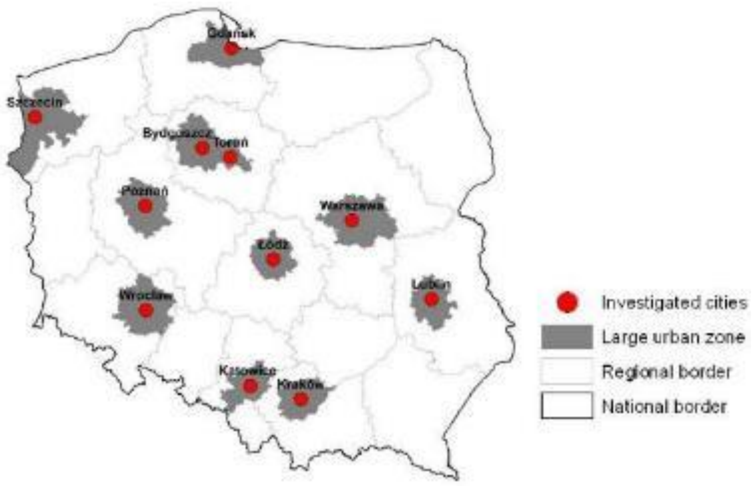


Figure 5.1. Polish agglomerations covered by analysis.

Table 5.1. Main characteristics of the analysed Larger Urban Zones

Larger Urban Zones	Total area [Km^2]	Population in 2015 [Inhabitants]
Wrocław	4.600	1.100.000
Szczecin	6,000	800,000
Gdańsk-Sopot-Gdynia	3.300	1.200.000
Poznań	3,700	1,100,000
Bydgoszcz-Toruń	4,800	900,000
Łódź	2,900	1,100,000
Warszawa	5,200	2,900,000
Katowice	2,600	2,600,0000
Kraków	3,000	1,300,0000
Lublin	2,900	600,000
Sum	*39.000*	*13.500.000*
Poland	*312,700*	*38,400,000*
% of Poland	*12,5*	*35,2*

5.2. Main policy question and theme

5.2.1. Objectives of ES mapping and assessment

The study under title “ES in Urban Areas” was commissioned by the Ministry of the Environment and conducted in year 2015. The study has been conducted in accordance with the MAES process the European Commission, and in particular is part of the implementation of Urban MAES pilot project.

The main purpose of the study was to identify the spatial structures of ecosystems in the 10 largest urbanized areas in Poland and compare them in terms of their potential for providing services (Table 5.1 and Figure 5.1). The second purpose was to suggest procedures for identifying and evaluating selected services, demonstrating their spatial distribution in the urban areas. Finally, based on the results of the study, propose recommendations for spatial planning on local and sub-regional levels.

5.2.2. Stakeholders and their role

The Ministry of Environment was the only stakeholder involved in the project. The procedures were discussed or negotiated with above mentioned institution on every step of the research. The potential stakeholders include the national authorities responsible for national urban policy, regional authorities responsible for plans for functional areas (e.g. for agglomerations) and local authorities dealing with urban governance. Very important are also the institutions which deal with nature protection on different levels.

5.3. Ecosystem Types and Conditions

5.3.1. Identification and mapping of ecosystem type(s)

The starting point for the analysis was to distinguish the parts of biologically active surface in urban areas that could be considered as the elements constituting a green infrastructure. Here, green infrastructure is understood as a network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ES. In urbanized area, a green infrastructure includes forests, surface waters, sport and recreational areas and urban greenery. Thus, the main source of data was the Urban Atlas, supplemented with grasslands (i.e. meadows, pastures and natural swards) and inland waterlogged areas based on the Corine Land Cover 2012 (see Figure 5.2)

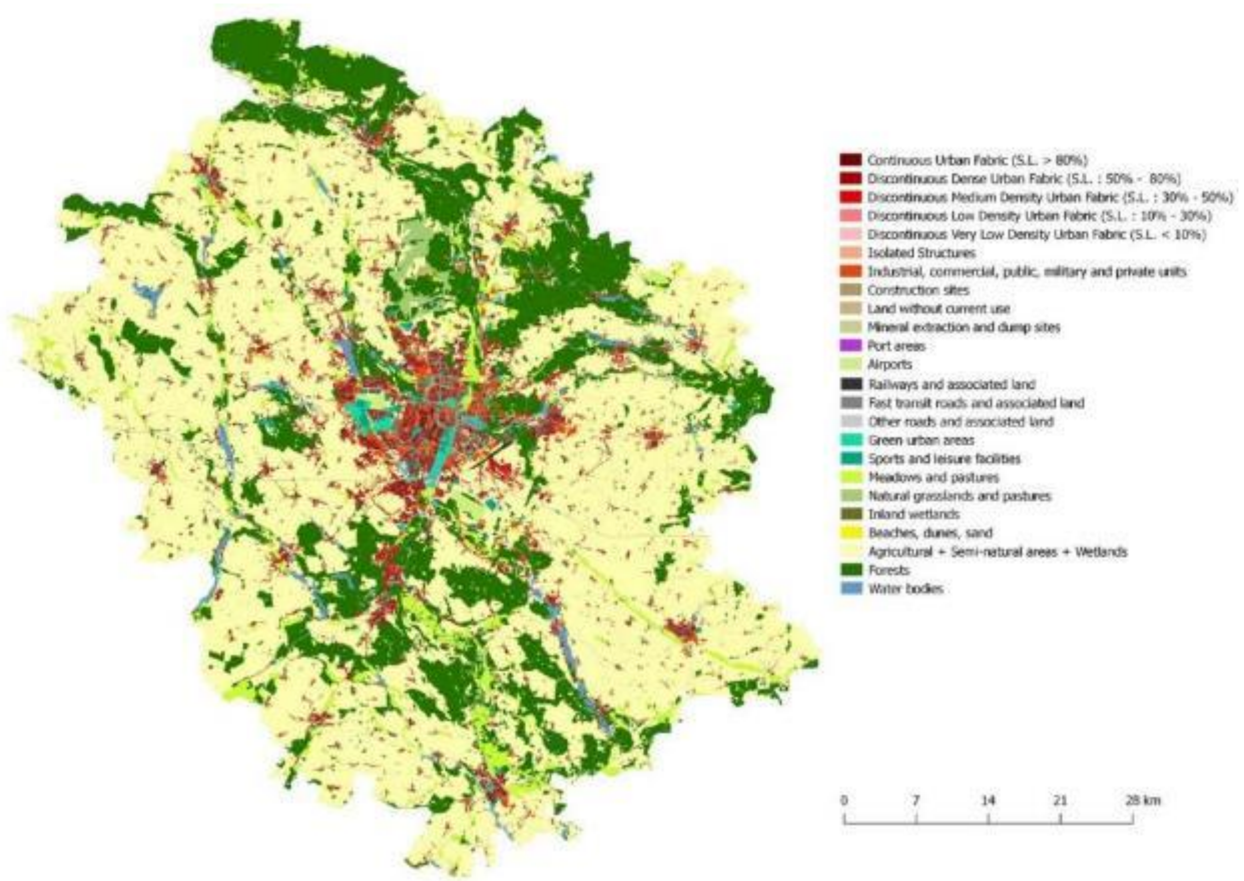


Figure 5.2. An example of ecosystem mapping for Poznan agglomeration

5.3.2. Assessing ecosystem conditions

There was no direct research conducted on ecosystem conditions. Some considerations were made with respect to, for example, air quality and contribution of green infrastructure for flood control, but only in the context of ES demand.

5.4. Mapping and assessment of ES

5.4.1. Identification of ES

The methodology of the synthetic gradation of the ES was developed using the categories of land cover allocated in Urban Atlas. Based on common classification of CICES v.4.3. The most important services for citizens of polish urbanized areas, suitable for the grading assessment based of land cover data was chosen (Table 5.2). In addition, several other ES and their spatial composition was described in preliminary research on Poznań urbanized area.

Table 5.2. Overview of the ES and related mapping and assessment methods in the Poland case study.

ES selected for mapping and assessment	B	S	E
2.1.2.1. Filtration/sequestration/storage/accumulation by ecosystems	x		
2.2.2.1 Hydrological cycle and water flow maintenance	x		
2.2.2.2. Flood protection	x		
2.3.5.2. Micro and regional climate regulation	x		
3.1.1.2 Physical use of land-/seascapes in different environmental settings	X		

* ES selected for further discussion during ESMERALDA workshops 4 in Amsterdam;
B = biophysical methods; S = socio-cultural methods; E = economics.

5.4.2. ES mapping and assessment: biophysical methods

Two methods: spatial proxy models and phenomenological models were applied. A matrix was created where the combinations of the individual land cover types and types of services were allocated with the level of ES: P – priority, I – significant, N – insignificant, B – lack. These levels were set based on expert opinion and indicators derived from literature. The analysis was conducted on Tier 2. Part of the input data was obtained from different institutions, e.g. valley retention from the National Water Management Authority, others was created by authors using GIS tools.

As shown in Figure 5.3 and , the survey was supplemented by landscape metrics for patches of green infrastructure. Three composition and configuration measures were chosen: fragmentation (Mean Patch Area and Patch Density), isolation (Euclidean Nearest Neighbor Distance) and contrast of usage intensity between neighboring patches (Mean Edge Contrast Index).

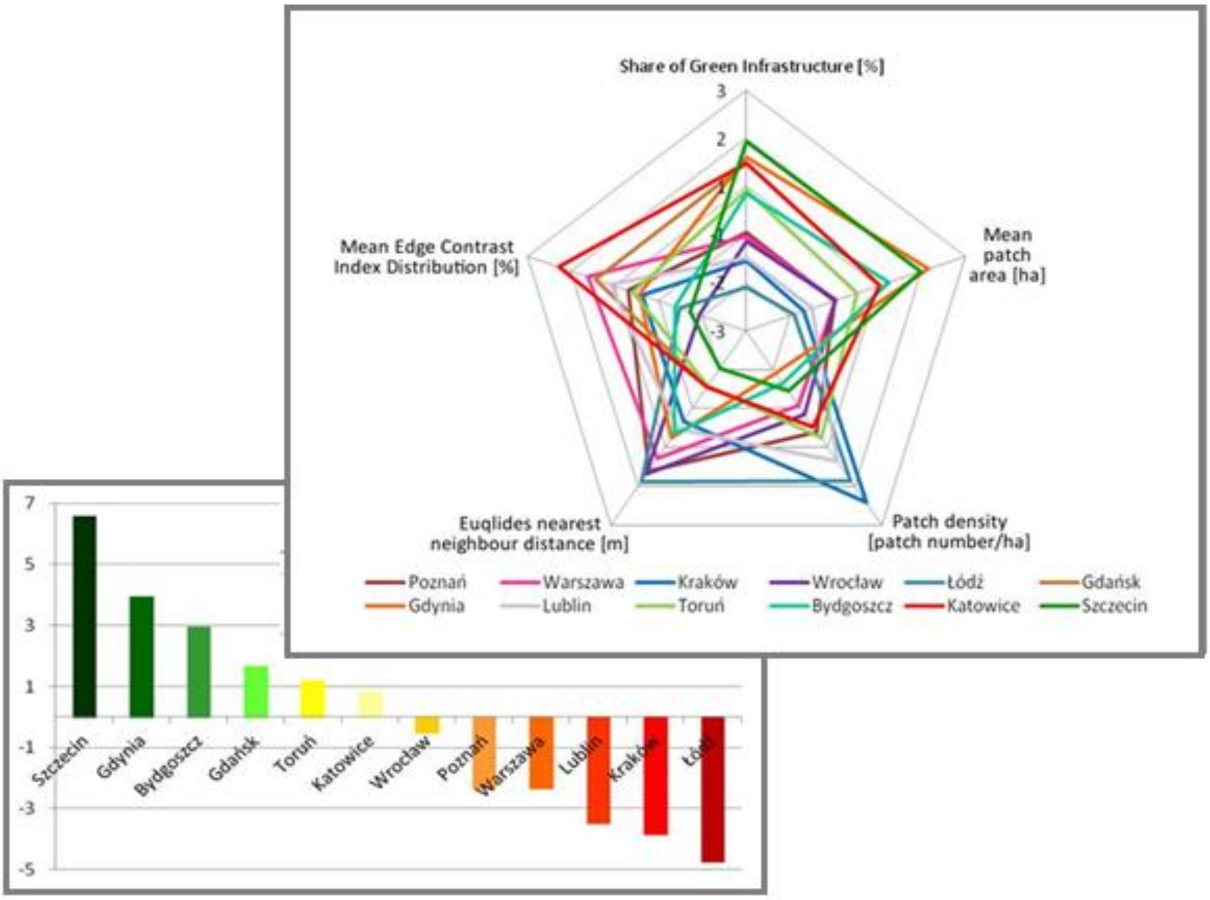


Figure 5.3. Spatial parameters of green infrastructure in the core cities according to standardized landscape metrics

Table 5.3. Main characteristics of green infrastructure in the analyzed larger urban zones.

Agglomerations	Share of green infrastructure [%]	Mean patch area [ha]	Patch density [amount/ha]	Euclidean nearest neighbor distance [m]	Edge contrast index
Warszawa	40,81	69,19	0,59	177,02	48,39
Poznań	29,51	62,65	0,47	256,49	49,30
Kraków	25,75	29,97	0,86	192,10	43,51
Wrocław	28,55	55,13	0,52	259,19	37,00
Łódź	28,42	39,33	0,72	191,92	41,87
Gdańsk-Gdynia-Sopot	36,25	40,94	0,89	166,11	36,92
Lublin	19,42	42,92	0,45	42,92	38,48
Toruń	41,43	106,5	0,39	243,98	44,93
Bydgoszcz	42,08	111,29	0,38	237,42	36,60
Katowice Conurbation	41,82	45,03	0,93	166,92	65,77
Szczecin	50,33	135,42	0,37	209,45	35,21

2.1.2.1. Filtration/sequestration/storage/accumulation by ecosystems

Indicator: *Share of some types of land cover based on their location in relation to the water bodies [%]*

Green infrastructure has a significant impact not only on the retention capacity of the catchment area, but also affects the capture of pollution coming especially from agriculture. Forests, woodlands, meadows, permanent grassland stimulate and maintain the processes of self-purification of the environment. Based on the literature review, different levels of filtration service to particular types of land use were assigned depending on the location. The main data sources were Urban Atlas and literature.

2.2.2.1 Hydrological cycle and water flow maintenance

Indicator: *Share of sealed surface [%]*

The data concerning the level of surface sealing was the basis for an introduction of a manner of connecting the land use with the assessment of the regulatory service regarding the precipitation water storage. The main data sources were Urban Atlas and literature.

2.2.2.2. Flood protection

Indicator: *Share of green infrastructure in zones in danger of floods [%]*

Preventing flood mitigation can be considered as a form of ecosystem services associated with the formation of the flow of matter, consisting of: capturing rainwater and reduce runoff, increasing capacity for water retention in the catchment area, reducing the economic losses due to floods by the use of floodplains, e.g. buffer parks. The absence of green areas in the valley create a flood risk for the settlements areas in the city. The main data sources were Urban Atlas and data gained from National Water Management Authority.

2.3.5.2. Micro and regional climate regulation

Indicator: *Radiation temperature [°C]*

The analysis of the radiation temperature for the different forms of land use in Poznań allowed to introduce the methodology of ecosystem classification according to their regulating influence on the local climate. The main data sources were LANDSAT TM images and literature.

3.1.1.2 Physical use of land-/seascapes in different environmental settings

Indicator: *Part of dense built-up (housing) areas adjacent to green infrastructure [m]*

To assess ES potential for physical use of landscapes for recreational purposes, a formalized procedure was proposed that consists of selecting the green infrastructure patches and recognizing what part of the intensive development is situated within comfortable distance from it. The distance is one of the main criteria deciding about physical use for recreation. The main data sources were Urban Atlas and literature.

5.4.3. ES mapping and assessment: socio-cultural methods

Social methods for mapping and assessment of ES were not used in this study.

5.4.4. ES mapping and assessment: economic-cultural methods

Economic methods for mapping and assessment of ES were not used in this study.

5.5. Use and integration of ES mapping and assessment results

5.5.1. Addressing the policy question

The biggest success of this study is that fact that it's been taken into account in the National Urban Strategy (NUS) for Poland. Although the NUS does not present the results of Urban MAES study directly, it contains recommendations for local authority to consider them in spatial planning. NUS determines the planned activities of the government on urban policy and objectives, and directions set out in the medium-term national development strategy and a national strategy for regional development. NUS shows how the various policies implemented by various ministries and government institutions should be adjusted and directions to the diverse needs of Polish cities - from the largest to the smallest. These recommendations may be useful for the comprehensive integration of the environment conditions in the planning of urban space.

5.5.2. Dissemination and communication of results

Assumptions and results of the research were presented at several conferences, both during the preparation of the document and after its completion. The most important are:

1. Mapping and Assessment of Ecosystems and their Services, EEA Grants/European Conference, Trondheim/Norway, 27-28 May 2015.
2. ECOSERV 2016, 4th Polish National Symposium on ES in transdisciplinary approach, Poznań/Poland, 5-6 September 2016.
3. European ES Conference, Antwerp/Belgium, 19-23 September 2016.

Very important for the project was a workshop on the valuation of ES with representatives of General and Regional Directorates for Environmental Protection, dealing with nature conservation at national and regional levels (Warsaw/Poland 3-5 November 2015). The project results were also presented in 4th Report MAES; Urban ecosystems (May 2016). Information about the project is available on specialized web portals dealing with biodiversity and ES: BISE, OPPLA, and ESP.

A major challenge is the lack of access to the document on the website of Ministry of Environment, as well as poor dissemination of the document among the authorities of individual cities.

5.6. References & Annexes

References

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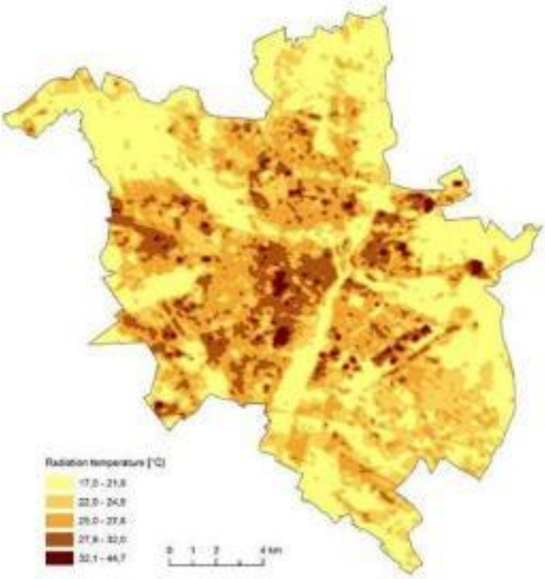
Mapping and assessment of ecosystems and their services in Poland (synthesis) - http://es-partnership.org/wp-content/uploads/2016/06/MAES-for-Poland-synthesis_Poland-introduction_objectives.pdf

National Urban Strategy 2015 (in Polish) - https://www.mr.gov.pl/media/10252/Krajowa_Polityka_Miejska_20-10-2015.pdf

Urban Atlas - http://land.copernicus.eu/local/urban-atlas/urban-atlas-2012/view

Urban MAES - ES in Urban Areas (summary) - http://es-partnership.org/wp-content/uploads/2016/06/Urban-MAES-for-Poland-abstract_Poland-introduction_objectives.pdf

Annexes



ITEM	Min_T	Max_T	Ave_T	SD_T
Agricultural + Semi-natural areas + Wetlands	17,4	37,5	23,0	2,3
Airports	23,2	32,8	28,2	2,1
Construction sites	20,5	32,0	25,5	2,2
Continuous Urban Fabric (S.L. > 80%)	19,2	35,5	27,3	2,1
Discontinuous Dense Urban Fabric (S.L. : 50% - 80%)	18,3	33,2	25,6	1,9
Discontinuous Low Density Urban Fabric (S.L. : 10% - 30%)	18,3	27,8	23,2	1,7
Discontinuous Medium Density Urban Fabric (S.L. : 30% - 50%)	18,3	30,7	23,9	1,9
Discontinuous Very Low Density Urban Fabric (S.L. < 10%)	20,1	21,0	20,5	0,4
Fast transit roads and associated land	20,5	31,1	25,5	1,8
Forests	17,0	37,5	20,8	2,0
Green urban areas	17,4	34,0	23,8	2,6
Industrial, commercial, public, military and private units	17,9	44,7	27,5	3,4
Isolated Structures	18,3	31,1	22,4	1,9
Land without current use	19,2	33,2	25,4	2,3
Mineral extraction and dump sites	19,7	31,5	24,6	3,1
Other roads and associated land	17,4	41,7	25,7	3,0
Railways and associated land	18,3	35,9	25,6	3,0
Sports and leisure facilities	18,3	32,8	24,6	2,3
Water bodies	17,0	32,0	20,8	2,2

Figure 5.4. Local climate regulation.

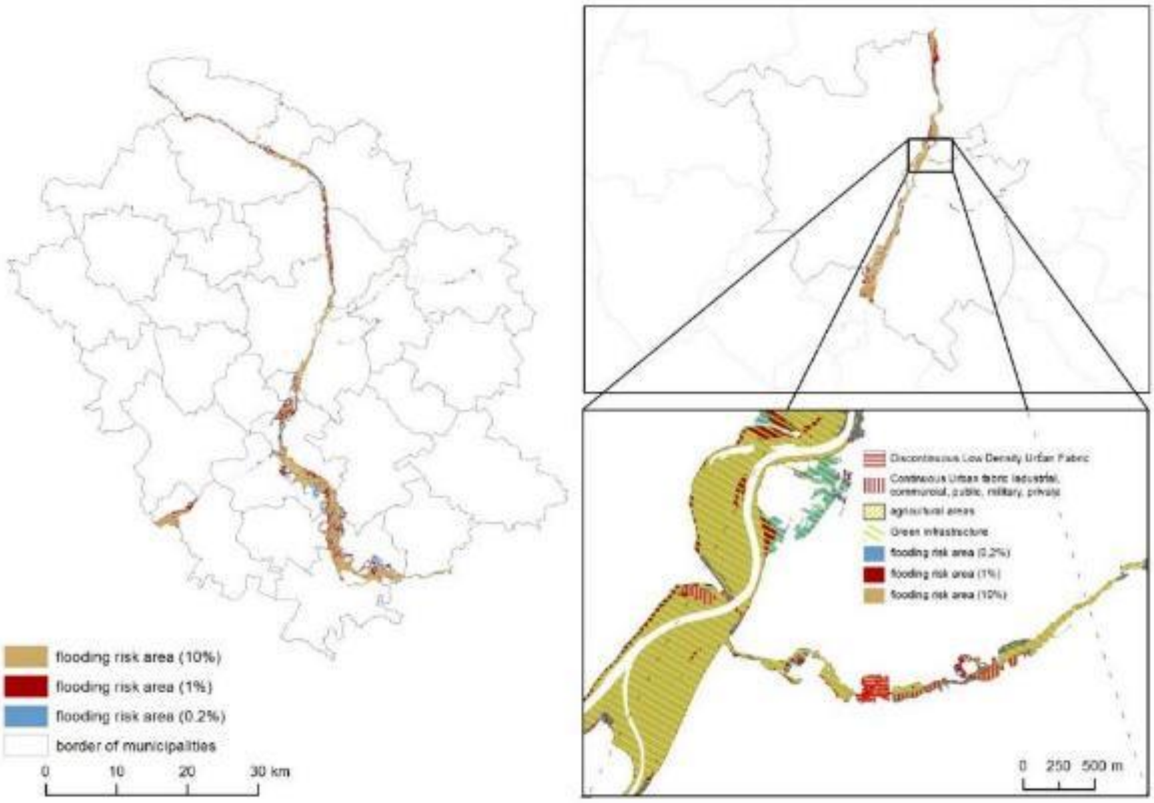


Figure 5.5. Mitigating the flow of matter on the example of mitigation of flood wave.

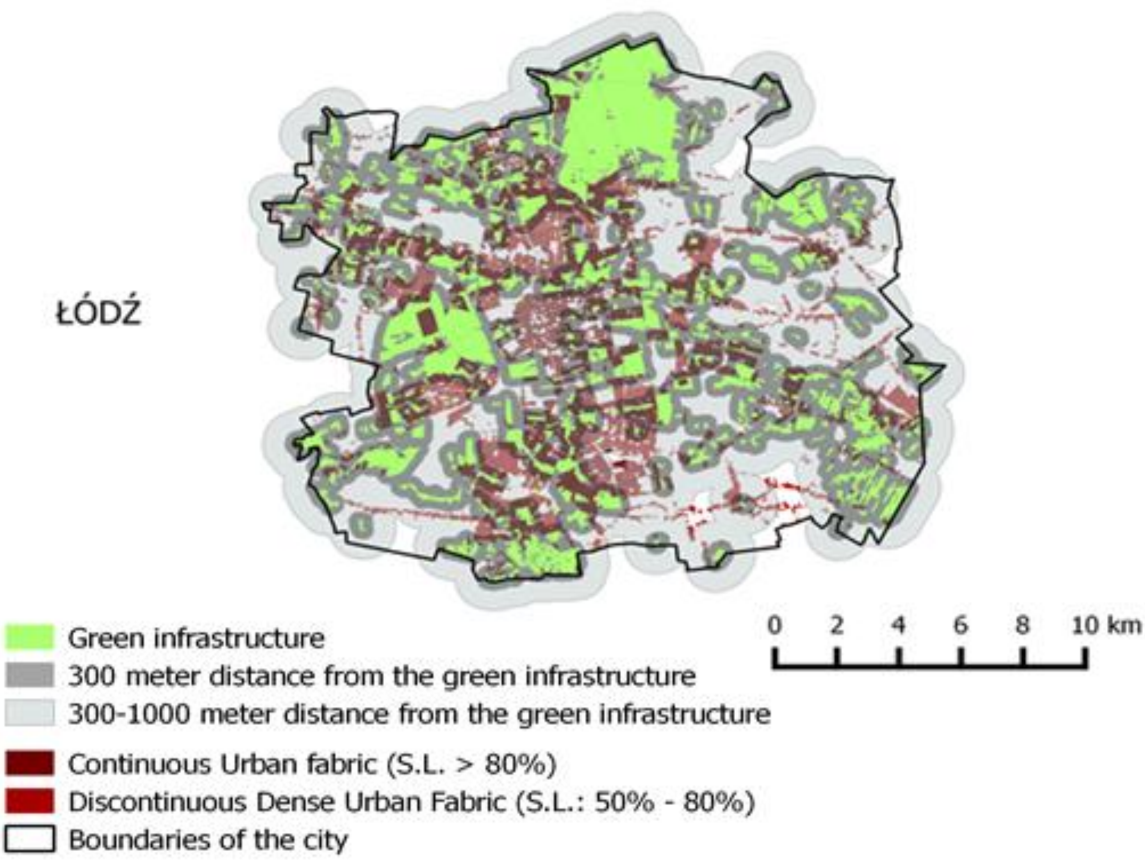


Figure 5.6. Availability of ES in the city of Lodz.

ESMERALDA

Case study booklet for:
WORKSHOP 4: “Testing the methods across themes” held in Amsterdam, Netherlands, 09-11 January 2017

6. Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

December 2016

ESMERALDA partner: Institute of Applied Sciences, MCAST

Case Study Coordinators: Mario Balzan

ESMERALDA

Enhancing ES mapping for policy and decision making

6.1. Case study factsheet and study area description

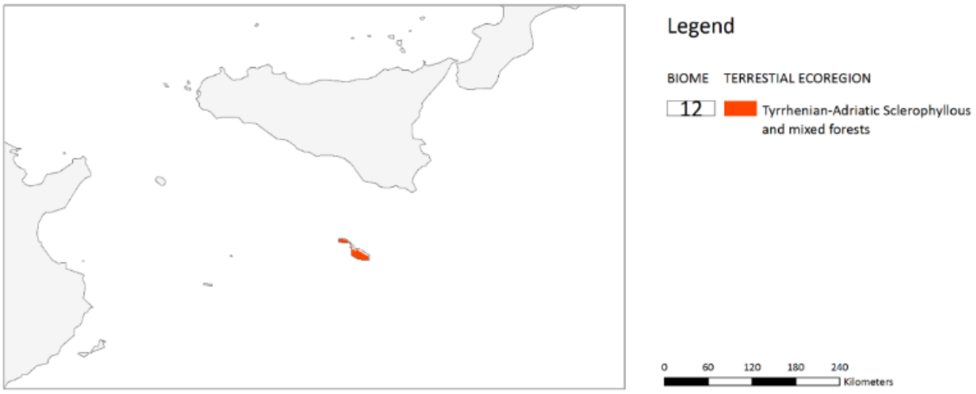
Mapping ES in Malta

WS4_cs3

NAME AND LOCATION OF STUDY AREA	Maltese Islands
COUNTRY	Malta

STATUS OF MAES IMPLEMENTATION			
	Stage 1	**Stage 2**	Stage 3

BIOMES IN COUNTRY		
	1 Tropical & Subtropical Moist Broadleaf Forests	4 Temperate Broadleaf & Mixed Forests
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	



SCALE	**national**	**sub-national**	local
AREAL EXTENSION	**316 km²**		

THEMES				
	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	**green infrastructures**	**agriculture and forestry**	business, industry and tourism
	health	**ES mapping and assessment**		

ECOSYSTEM TYPES				
	urban	**cropland**	**grassland**	**woodland and forest**
	heatland and shrub	**sparsely vegetated land**	**wetlands**	rivers and lakes
	marine inlets and transitional waters	**coastal**	shelf	open ocean

Study area description

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 316 km^2. The landscapes of the Maltese Islands have been shaped over several millennia by the geo-climatic conditions, and human exploitation, but nonetheless harbor considerable biodiversity; a consequence of the interesting biogeography of the Archipelago.

The Maltese Islands also have a long cultural history and the earliest evidence of settlement dates back to around 7200 BC. 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. Today agricultural land cover occupies around 51% of the territory, whilst built-up, industrial and urban areas occupy more than 30% of the Maltese Islands. With a population density of 1,346 persons per km^2, the highest in the European Union, and a booming tourism industry, the Maltese Islands' biodiversity would be expected to be subject to substantial pressure. Within this context, the Maltese Islands make for an interesting model for analysis of the role of mosaic and multi-functional landscapes in the delivery of ecosystem services (ES).

6.2. Main policy question and theme

6.2.1. Objectives of ES mapping and assessment

The present ES assessment and mapping has been mainly scientifically-driven, with the objective of this study being that of carrying out a first assessment of the capacity and flow of ES in the Maltese Islands (Central Mediterranean). ES capacity is defined as the potential of ecosystems to provide services appreciated by humans, while ES flow refers to the actual use of the ES and occurs at the location where an ES enters within a utility or production function.

Given the insular and urbanized environment, and the dependence on local ecosystems for the delivery of key ES, a policy objective could be that of analyzing the spatial variation of ES in Malta. This would permit for the identification of spatially overlapping bundles of ES, and for analyses of the impact of policies and developments on the ecosystems’ capacity to deliver key ES, and on their actual flow.

This work is particularly relevant to policy objectives of Malta’s National Biodiversity Strategy and Action Plan, 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 ES.

6.2.2. Stakeholders and their role

Within the ES mapping and assessment process, stakeholders were involved as experts for selected ES or for data requests. In the latter case, governmental departments and authorities provided baseline environmental data. Within this study, two groups of stakeholders were consulted in the ES assessments, and data collected from stakeholder participation was used to generate maps of these services. In order to assess the aesthetic value (CICES 4.3 - Aesthetic) of landscapes of the Maltese Islands, a questionnaire was conducted with members of the public. Whilst in the assessment of the capacity of ecosystems in the provisioning of honey (CICES 4.3 - Reared animals and their outputs), data was collected from questionnaires and focus groups with beekeepers.

The study was presented to scientific officers and biodiversity experts at the Environment and Resources Authority (ERA). In its mission to safeguard the environment for a sustainable quality of life, the ERA plays a pivotal, lead role on a number of dossiers. These include air quality, biodiversity and protected areas, environmental noise, radiation, environmental permitting services, soil, waste management and water.

6.3. Ecosystem Types and Conditions

6.3.1. Identification and mapping of ecosystem type(s)

The assessment of ES in Malta, presents a number of 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 categorization of agricultural areas that makes up almost half of Malta's land area, this was not used as a baseline map. For this purpose a land use land cover (LULC) map was developed. In addition, within this case-study, a tiered mapping approach, which makes use of different land-use datasets and ES assessment methods, was implemented. A LULC map was created based on Sentinel 2 satellite images provided by Copernicus. These were converted to reflectance. Images were then processed and mapped by applying a supervised multispectral classification with the maximum likelihood method. Ground truth areas were used during spectral signature creation, and for the evaluation of accuracy. The final classification consisted of a LULC map with 13 classes (see Figure 6.1).

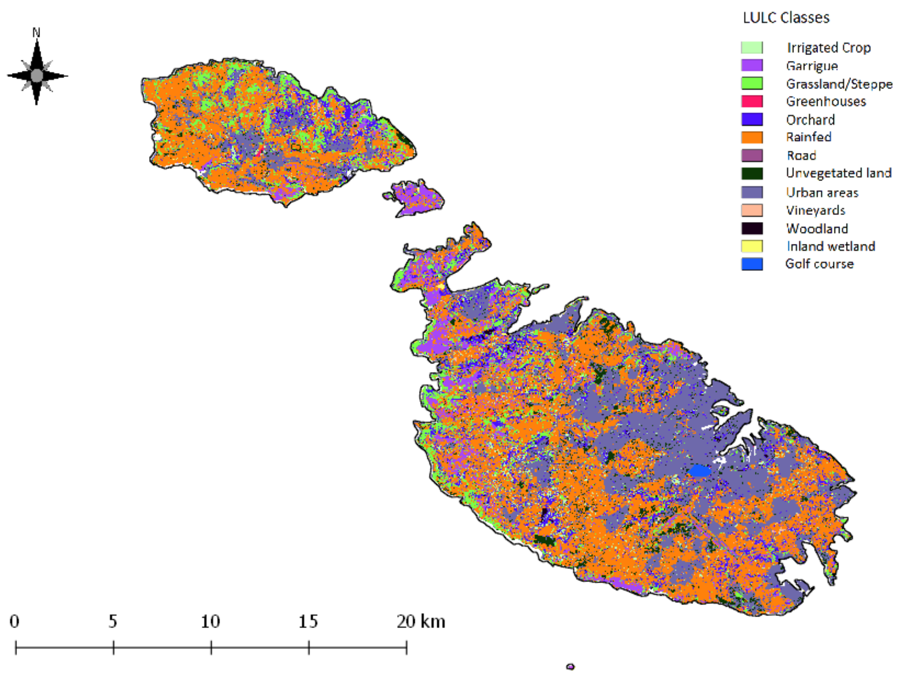


Figure 6.1. A land use land cover map of Malta was developed using Sentinel 2 satellite images.

6.3.2. Assessing ecosystem conditions

Ecosystem condition, defined as the effective capacity of an ecosystem to provide services relative to its potential capacity (MA, 2005), was not directly assessed within this case-study. However, the characterization of the habitats and landscapes through the use of satellite images within this study may be considered as a starting point for the assessment of ecosystem conditions. The produced land use land cover map characterizes 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.

In addition, the following spatially projected data was used to provide an indication of the ecosystem condition, and to assess the relative ability of ecosystems to deliver the selected ES, within this case-study:

- status of species and habitats (Art.17, Habitats Directive – see Figure 6.2)
- pollinator diversity in key habitats
- area of irrigated agricultural land

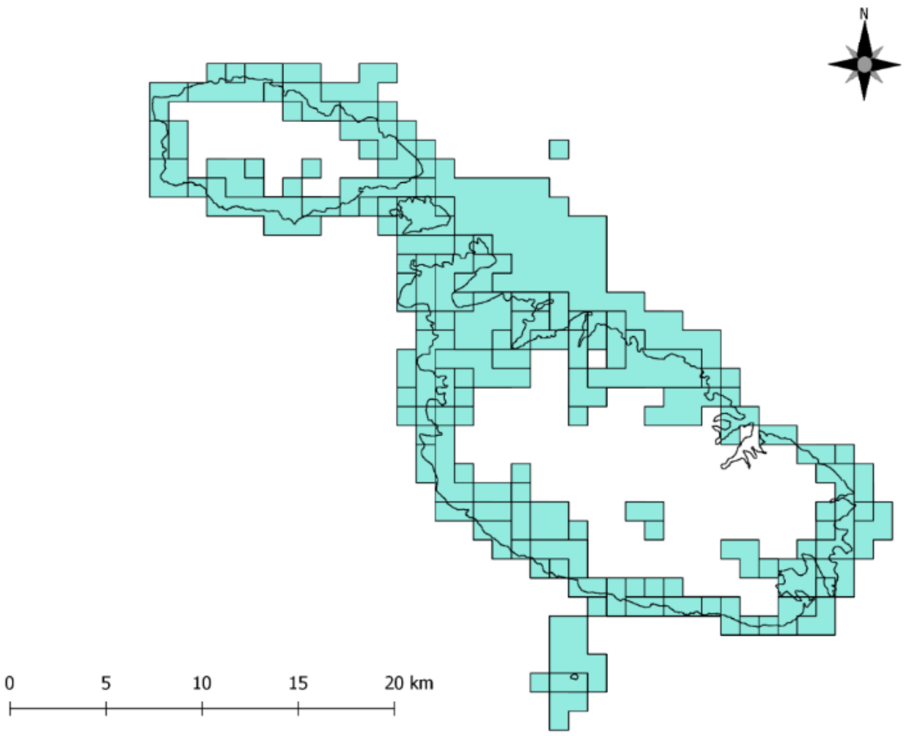


Figure 6.2. Shaded areas representing Annex I habitats' range in 1 km^2 cells (Art. 17, Habitats Directive).

6.4. Mapping and assessment of ES

6.4.1. Identification of ES

The selection of ES was based on expert knowledge and the availability of data and quantification methods, most of which have been used during or obtained from past and on-going research relating to the delivery of ES in the landscapes of the Maltese archipelago. Selected indicators were used to assess the ES capacity and flow in the landscapes of the Maltese Islands. Given the focus on the capacity and flow of ES in landscapes, only the ES delivered by terrestrial ecosystems were investigated in this study. For the purpose of this case-study a tiered mapping approach, which makes use of different land-use dataset and ES assessment methods, was implemented. Table 6.1 lists the selected ES in the case study, classified using the CICES v4.3 (2013) classification, and the related assessment method categories.

Table 6.1. Overview of the ES and related mapping and assessment methods in the Malta case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.1 Cultivated crops	X		
1.1.1.2 Reared animals and their outputs		X	
1.2.1.2 Materials from plants, algae and animals for agricultural use	X		
2.1.2.2 Dilution by atmosphere, freshwater and marine ecosystems	X		
2.3.1.1 Pollination and seed dispersal	X		
2.3.1.2 Maintaining nursery populations and habitats	X		
3.1.1.2 Physical use of land-/seascapes in different environmental settings		X	

* ES selected for further discussion during ESMERALDA workshops 4 in Amsterdam;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

6.4.2. ES mapping and assessment: biophysical methods

The assessment and mapping of ES was performed using the developed land use land cover map for the study area and available data sets. The biophysical methods included the delineation of areas for crop and fodder cultivation and the downscaling of national statistics (Tier 2), and the modelling of the relationship between biophysical structure of ecosystems and ES delivery using available data sets (Tier 3).

Mapping of provisioning services

1.1.1.1 Cultivated crops
Indicator: *Irrigated agricultural land (Capacity/Flow)*
Downscaling crop cultivation national data for irrigated agricultural land.

1.2.1.2 Materials from plants, algae and animals for agricultural use
Indicator: *Rain-fed agricultural land (Capacity/Flow)*
Downscaling fodder cultivation national data for rainfed agricultural land

Mapping of regulating and maintenance services

2.3.1.1 Pollination and seed dispersal
Indicator: *Pollinator Diversity (Capacity)*
A spatial proxy model that relates pollination ES to the land cover was developed during this study. The objective, in this case, was to analyze the contribution of different land cover categories to the diversity of pollinators in a number of points within landscapes of the Maltese Islands. Subsequently, spatial proxy models were developed to link pollinator diversity to the area cover of different land uses. The model

estimates for significant variables were then used to predict the contribution of different landscape units to the delivery of pollination ES within the landscapes.

2.1.2.2 Dilution by atmosphere, freshwater and marine ecosystems

Indicator: *Pollutant deposition velocity (Capacity)*

Indicator: *Dilution of atmospheric pollutants (Flow)*

NO2 dry deposition velocity [Air quality regulation - Capacity] on vegetation was considered as a proxy to assess the ecosystems' capacity to remove pollutants from the atmosphere. The method used here follows the work by Pistocchi et al. (2010) which estimates deposition velocity as a linear function of wind speed at 10 m height. NO2 dry deposition flux [Air Quality Regulation - Flow]: NO2 removal flux was based on the predicted concentration of NO2. A statistical model was used to relate point NO2 concentration data to environmental variables, and then this model was used to predict the NO2 concentration in a grid. Point data was then interpolated using inverse distance weighting. Annual NO2 removal was estimated as the total pollution removal flux in the areas covered by vegetation, calculated as the product of NO2 concentration and deposition velocity maps (see Figure 6.3).

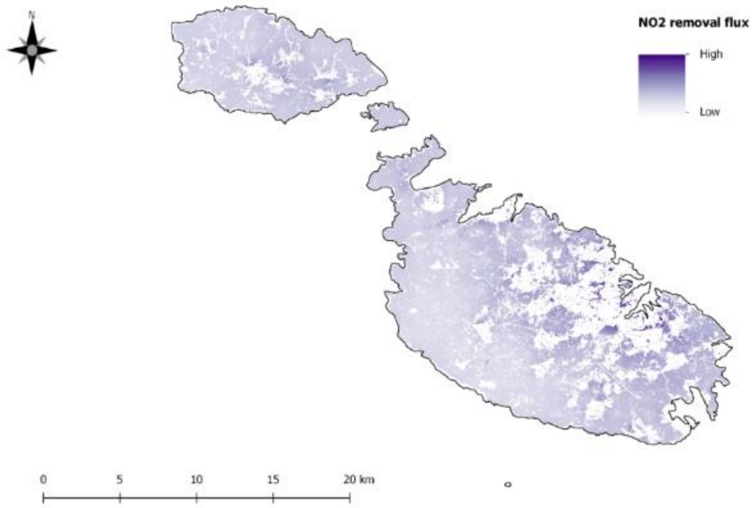


Figure 6.3. Removal of NO2 flux

Mapping of Cultural ES

3.1.1.2 Physical use of land- /seascapes in different environmental settings

Indicator: *Habitats of community importance (Capacity)*

The number of habitats protected in Annex 1 of the Habitats Directive was used as a proxy for the capacity of ecosystems to provide opportunities for experiential uses of landscapes. Point values, extracted from 1 km2 grid cells, were interpolated using inverse distance weighting.

6.4.3. ES mapping and assessment: socio-cultural methods

The used social methods are based on preference assessments conducted with ES users (Tier 1). In the first case, a two-stage process was used for data collection on the importance of local ecosystems for beekeeping and honey production. This methodology involved the use of questionnaires and focus groups. In the assessment of physical use of landscapes, questionnaires were conducted with locals. Data relating to the uses in these sites, as well in green urban areas, were collected in this study but only the data set relating to site visitation is presented here.

Mapping of Provisioning Services

1.1.1.2 Reared animals and their outputs – Honey Production
Indicator: *Honey Production (Capacity)*
A preference assessment exercise was carried out with beekeepers to determine the characteristics of ecosystems preferred for honey production and beekeeping. Questionnaires were used in the initial stages of the research to determine the preferred plants and habitats, and their contribution to the delivery of the ES. This was followed by a focus group with another group of beekeepers, during which they were asked to provide information about the role of different ecosystems across time and space. In this case, an emphasis is placed on collective preferences of service users (see Figure 6.4).

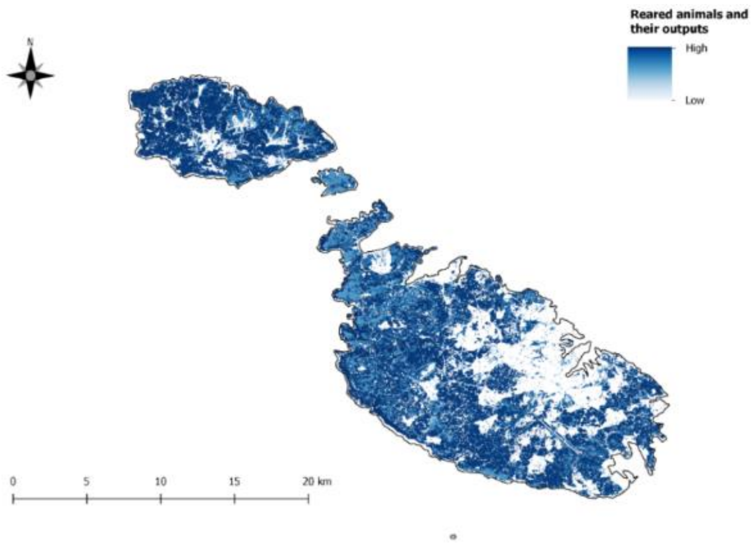


Figure 6.4. Map based on preference assessment for beekeeping and honey production.

Mapping of Cultural ES

3.1.1.2 Physical use of land- /seascapes in different environmental settings.
Indicator: *Site visitation/Preference Assessment (Flow)*
A questionnaire was submitted to locals, who were asked to identify places and landscapes (n=118) in Malta that they have visited and are of high aesthetic value, and the type of activities they normally carry out at these sites.

6.4.4. ES mapping and assessment: economic methods

Economic methods for mapping and assessment of ES were not used in this study.

6.5. Use and integration of ES mapping and assessment results

6.5.1. Addressing the policy question

Results obtained in this study provide a first assessment of the contribution of ecosystems to the delivery of key ES in the multi-functional landscapes of the Maltese Islands, and enhance our understanding of the existing links between biodiversity and ES capacity and flows.

A statistical analysis of the generated ES maps, using multivariate and environmental modelling techniques, demonstrates how Malta's rural landscapes, characterized by patches of semi-natural and agricultural areas, are important for the delivery of these key ES. Results obtained here demonstrate how these ecosystems within multi-functional landscapes contribute to the delivery of more than one ES, effectively resulting bundles of ES that repeatedly appear together across space or time. Moreover, these results indicate that whilst in some cases the capacity and flow of ES overlap spatially (e.g. nursery habitats and experiential use), in other cases capacity and flow vary with environmental characteristics and hence also spatially (e.g. NO_2 deposition velocity and NO_2 removal flux).

6.5.2. Dissemination and communication of results

Results obtained in this case-study have been disseminated during scientific conferences, and were presented to some of the key stakeholders. Through stakeholder participatory meetings with beekeepers, it has been possible to disseminate results and better develop an understanding of the links between their activities/preferences and the environment. This case-study has been presented to the Environment and Resources Authority (ERA). In addition, dissemination meetings conducted for practitioners, students and members of the public have been used to communicate some of the results presented in this case-study. Future activities should work on the science-policy-society interface in order to make the results useful for natural resources management and urban planning.

6.6. References & Annexes

References

Nowak, D.J., Crane, E.D & J.C. Stevens (2006). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening 4, p. 115-123.

Pistocchi, A., Zulian, G., Vizcano, P & D. Marinov (2010). Multimedia Assessment of Pollutant Pathways in the Environment, European Scale Model (MAPPE-EUROPE). Publications Office of the European Union, Luxembourg.

Annexes

Case study booklet for:
WORKSHOP 5: "Testing the methods across biomes and regions"
Madrid, Spain, 04-07 April 2017

7. Spanish National Ecosystem Assessment

22rd March 2017

ESMERALDA partner: Universidad Autónoma de Madrid, UAM

Case Study Coordinators: Fernando Santos Martin

ESMERALDA

Enhancing ES mapping for policy and decision making

7.1. Case study factsheet and study area description

Spanish National Ecosystem Assessment

WS5_cs1

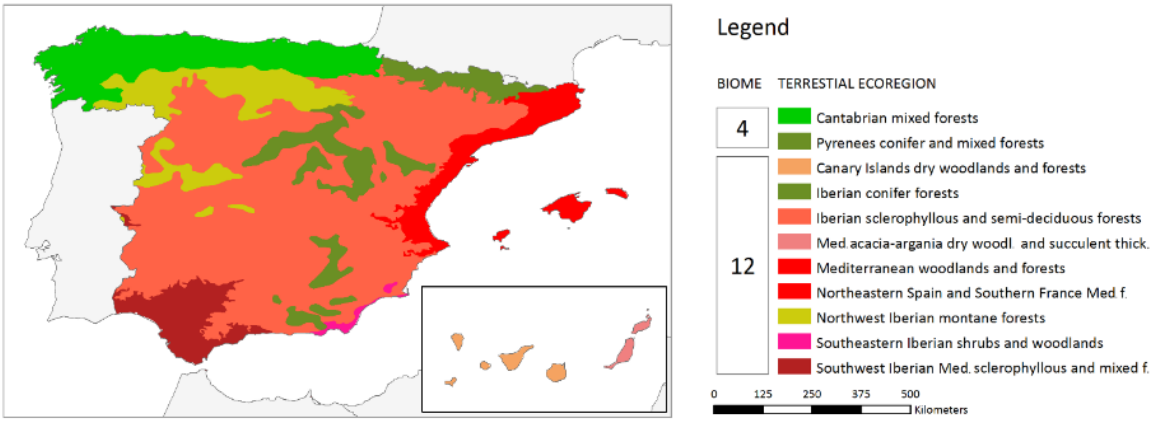
NAME AND LOCATION OF STUDY AREA	Spain
COUNTRY	Spain

STATUS OF MAES IMPLEMENTATION

Stage 1	Stage 2	**Stage 3**

BIOMES IN COUNTRY

1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
5 Temperate Conifer Forests	6 Boreal Forests/Taiga
8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
14 Mangrove	



SCALE

national	sub-national	local

AREAL EXTENSION: **505,990 km²**

THEMES

nature conservation	climate, water and energy	marine policy	natural risk
urban and spatial planning	green infrastructures	agriculture and forestry	business, industry and tourism
health	**ES mapping and assessment**		

ECOSYSTEM TYPES

urban	**cropland**	**grassland**	**woodland and forest**
heatland and shrub	**sparsely vegetated land**	**wetlands**	**rivers and lakes**
marine inlets and transitional waters	**coastal**	shelf	open ocean

Study area description

The Spanish National Ecosystem Assessment (SNEA), supported by the Biodiversity Foundation of the Ministry of Environment, provides the first analysis at national level that evaluates the ability of the Spanish ecosystems and biodiversity to maintain our human well-being. It follows the initiative of the Millennium Ecosystem Assessment promoted by the United Nations. SNEA began in 2009, and completed its biophysical assessment in 2012 and started a new phase in 2013 with the purpose of carrying out an economic and socio-cultural valuation of ES supplied by priority ecosystems in Spain. The aim of the project is to visualize the contribution that ecosystems and biodiversity make to human well-being not only in ecological terms but also in social and economic terms.

The project has taken into account the different types of services (provisioning, regulating and cultural), and the various methodologies to estimate ecological, social and economic values. It is the first nationwide ES valuation, which also capture services outside conventional markets and include social and cultural aspects, for both use and non-use values. As part of the philosophy of the project we have tried to emphasize the importance of the services through their value of use, far from logic exclusively associated with the value of change. Therefore, we seek to understand the degree of usefulness or the aptitude of the services to satisfy needs and provide well-being. In this way the values with a direct use normally have a repercussion on recently mentioned human well-being, whereas the values with an indirect use, option values or values of non-use have a connotation of collective value, with a social repercussion on human well-being. All the information generated in the project, reports, maps, are available at the website (www.ecomilenio.es).

7.2. Main policy question and theme

7.2.1. Objectives of ES mapping and assessment

The main goal of the SNEA in Spain is to help break down barriers and build bridges between interdisciplinary scientific knowledge and decision making to visualize the complex relationships that exist between the conservation of ecosystems and human wellbeing based on empirical data. It is also expected to increase the awareness of Spanish society, including the business sector, regarding the importance of ecosystems and biodiversity for different components of our human wellbeing.

This project is organized around the core questions originally posed to structure the assessment:

- *How is biodiversity changing?*
- *How have ecosystems and their services changed?*
- *What are the main direct and indirect drivers of change?*
- *How these changes affect our human wellbeing?*
- *What is the public´s current understanding of ES?*
- *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?*
- *Why is important to map and assess the value ES at national level?*
- *Which are the priority ES for its valuation?*

7.2.2. Stakeholders and their role

Since its initiation, the SNEA has provided scientific information on the conditions of Spanish ecosystems and mapping key ES and has promoted its dissemination and consideration in sectorial decision making processes. The Ministry of Agriculture, Food and Environment aware of this fact and convinced that the SNEA would facilitate the interface between scientific knowledge in different disciplines and decision making, has promoted, through the Biodiversity Foundation, its support to this initiative.

Approximately 60 researchers from different disciplines in the ecological and social sciences and from more than 20 universities and research centers working under the same conceptual and methodological framework have contributed to the assessment, providing scientific information on the consequences of changes in ecosystems and biodiversity for human wellbeing in Spain during the last five decades. The assessment also promotes a process involving multiple parties and interest groups, such as the government, academics, expert staff, NGOs and the private sector, thus contributing to the development of the project through generating ideas, providing information and reviewing documents or disseminating their results.

The overall coordination of the SNEA is organized around two main units: a scientific unit and a communication and management unit. Both units are in constant communication and, in turn, are interconnected with a collaboration network of research centers, government agencies, policy makers, companies, NGOs, civil society, experts and international platforms and a networks of complementary projects.

A national and international scientific advisory committee for the project has been put in place to ensure the robustness of the results. This unit has developed a research process that is being carried out by a large team of scientists and experts from both the biophysical and social sciences and draws on several lines of inquiry. These lines of inquiry have been followed since 2009, starting from the biophysical basis of the investigation of ecosystems, biodiversity, the ES provided, their impact on human wellbeing and effect of drivers of change. In the second phase, future scenarios and spatial analyses have been developed. Presently, the focus is on the socio-economic valuation of ES in Spain. The research process has been fed by databases, workshops, interviews and questionnaires and interactions with existing scientific forums and networks conducting ES assessments.

The results and future developments of the project are being particularly helpful in providing responses that pave the way for the fulfilment of new obligations and commitments assumed in the context of multilateral environmental agreements and the European Union environmental policy. In that regard, we hope that the Spanish experience could help other countries as a reference point.

7.3. Ecosystem Types and Conditions

7.3.1. Identification and mapping of ecosystem type(s)

The selection of the ecosystem types to be evaluated in Spain was based on a set of general operational issues appropriate for articulating the assessment at a national scale (Table 7.1). Therefore, no attempt has been made to define a typology based on the specific composition or dominance of certain species or physiognomic types. Instead, the goal was to identify the main areas of the expression of nature of Spain

(Figure 7.1). However we made an effort to integrate national scale ecosystem classifications with the existing European level classification (Annex: Table 7.4). The considerations that guided the selection of ecosystem types were as follows:

- The number of ecosystem types evaluated (14) should be sufficient to effectively sample the original natural character of Spain.
- The selection must consider the importance of the chosen ES (22) in relation to the wellbeing of the Spanish population and therefore representative of our natural capital.
- The classification of ecosystem types was performed based on two main characteristics: geophysical conditions (mainly macroclimatic characteristics and the presence or absence of water to support life) and the influence of human control (the contrast between urban and rural ecosystems dominated by agricultural uses).

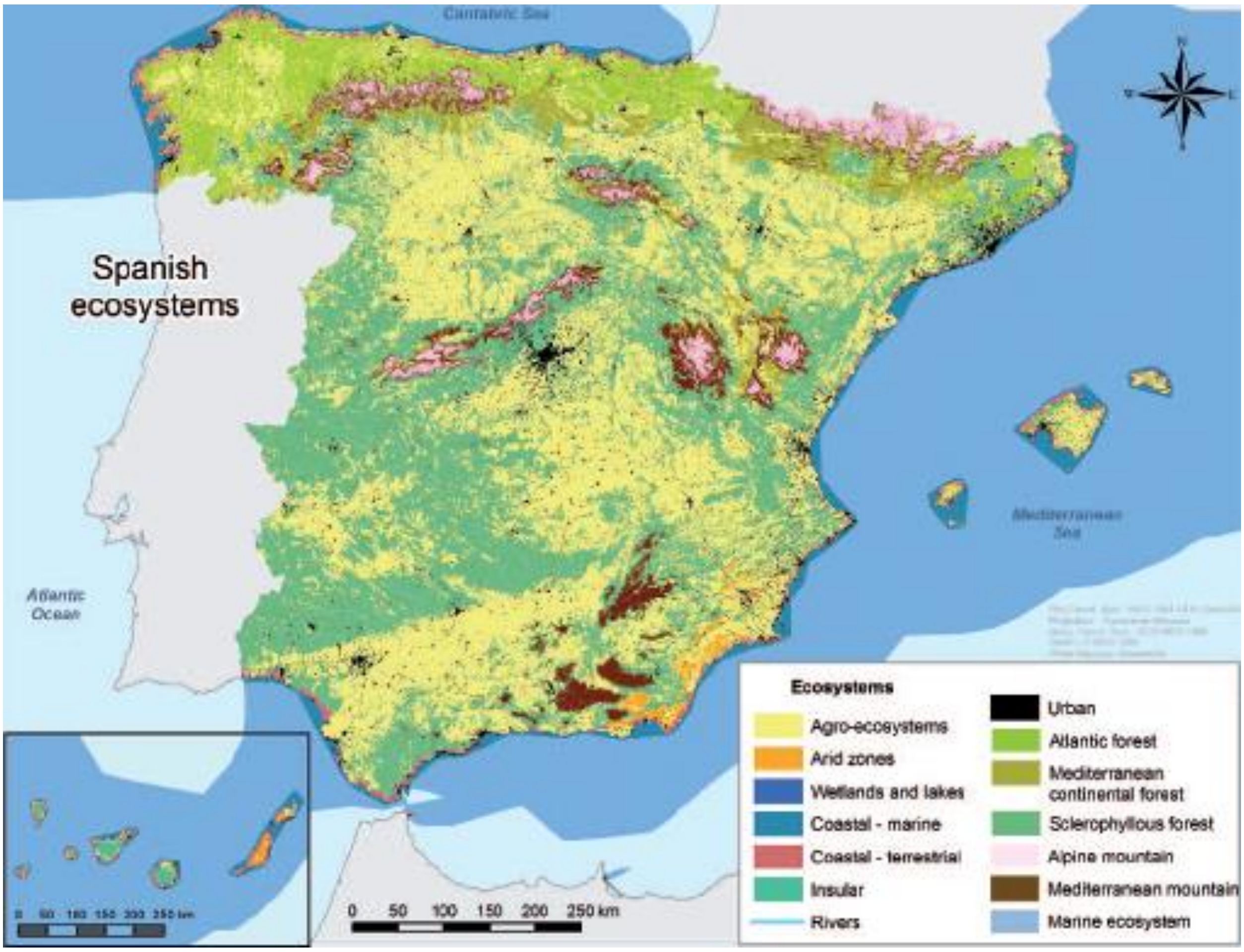


Figure 7.1. Spatial representation of the 14 Ecosystem types assessed in the Spanish NEA (Spanish NEA, 2014).

Ecosystem mapping is the spatial delineation of ecosystems following an agreed upon ecosystem typology (ecosystem types), which strongly depends on the purpose and scale of mapping (Figure 7.3). Under the Spanish NEA, the mapping of ecosystems was conducted with the purpose of providing a spatial sense to each expert group that could be considered through the process of ecosystem assessments.

Table 7.1. Description of the 14 ecosystems types assessed in the Spanish NEA (Source: Spanish NEA, 2014).

	ECOSYSTEM TYPE	Definition
Terrestrial	 Sclerophylous forest and shrub	Occupy about 7 million ha in Spain and are part of the mediterranean *monte*. The *monte* comprises marginal agrarian lands that also contain pastures (another 7 million ha). These include the *dehesa* (nearly 2 million ha) lawns of therophyte plants with scattered pruned trees which look savanna (*montado* in Portugal).
	 Mediterranean continental forest and shrubs	Extremely originals ecosystems and almost exclusive of the Iberian Peninsula (Spain contains about 75% of its European area). It occupies 2.7 million ha (about 15% of forest area). It most characteristic tree species are: Quercus rotundifolia, Quercus faginea and Juniperus thurifera.
	 Atlantic forest	It is located in the northern area of Iberian Peninsula, with an area of approximately 3.3 M ha. Its more characteristics trees species are: *Castanea sativa, Quercus robur, Quercus petraea, Fagus sylvatica* and *Betula sp*.
	 Alpine mountain	Situated on the north of the Iberian Peninsula (Cantabrian Mountains, Pyrenees and Iberian Range) occupy approximately 1.5M ha (3% of state territory). Includes mountain forests, grasslands, crops, and high mountain pastures and rocky areas.
	 Mediterranean mountain	Present in the central and southern Mountain Systems territories they take about 2 M ha (4% of the state area). Ecosystems subtypes include: high mountain pastures and forests, natural bushland, high mountain scrub.
	 Arid zones	Broad representation in the Southeast of Iberian Peninsula, some low areas of the Ebro basin and the two eastern Canary Islands (Fuerteventura and Lanzarote). They occupy an area of approximately 1.6 M ha (3% of the state area). Because of its random productivity and fragility, have become marginal area.
	 Insular	Island included in the Macaronesian biogeographic region. They occupy an area of 772 512 ha (1% of the state territory). Unlike the two eastern islands they have a wide altitudinal range of ecosystems.
	 Agroecosystems	Distributed throughout the peninsula. Is the ecosystem most widely represented in Spain occupying approximately 50% of the state area. The main services provide by agroecosystems are provisioning services related to food production and livestock, but these ecosystems also generate many other essential regulating and cultural services.
Acuatic	 Rivers and riverbanks	Flowing water ecosystems that connect all the terrestrial ecosystems through water cycle.
	 Wetlands and lakes	Wetlands or shallow water ecosystems (> 8-10m) and Lakes or deep standing water ecosystems (> 10 m).
	 Aquifers	Found in effluent streams and wetlands or shorelines that act as drop zones. Identified a total of 740 groundwater bodies.
	 Coastal	Reflect the interaction between the terrestial and marine ecosystems with presence or influence of human activities.
	 Marine waters (sea and ocean)	Area contained between the outer limits of the coastal ecosystem and the Exclusive Economic Zone (EEZ) of Spain. Represents about 103 M ha (about twice the terrestrial surface of Spain).
Urban	 Urban	Represents a total of 1,053 municipalities (13%) with a 80.7% of the population and 4% of total area.

7.3.2. Assessing ecosystem conditions

Spanish ecosystems have changed dramatically over the past 50 years as a result of the uneven transformation of aquatic and terrestrial land uses, resulting in a disproportionate increase of artificial areas, rural abandonment and the intensification of some provisioning services via technology. Coastal, rivers and wetland ecosystems have been the most affected ecosystem types in terms of their original surface area. Within these types of ecosystems, alluvial plain forests and Posidonia sea grasses are the most threatened systems in terms of disappearance.

Regarding ES, continental aquatic ecosystems and coastal areas are the systems that that have suffered the largest deterioration in their ability to generate a flow of services contributing to human wellbeing. Forest and mountain ecosystems are the best conserved in terms of their functions in generating services. The failure of current conservation policies to manage the functions of ecosystems has resulted in the degradation or unsustainable use of 45% of the evaluated services. The most strongly affected type of services are regulating (87%) and provisioning (63%) services, while the least affected are cultural services (29%), especially those demanded by cities.

A decoupling effect exists between urban and ecological systems that is promoting unsustainable use of services. Increasing urban population is promoting unsustainable demands for food, water, and cultural services related to recreation. Consequently, important regulating services and traditional cultural services associated with rural areas are declining. The "natural capital" of Spain should be conceptualized as a mosaic of interdependent terrestrial and aquatic ecosystems, to be managed as a whole under a holistic approach based on the recognition of the secular co-evolution of natural and cultural processes.

7.4. Mapping and assessment of ES

7.4.1. Identification of ES

Under the Spanish NEA, 22 services were selected (Annex: Table 7.5) to evaluate each of the 14 types of ecosystems identified in Spain. We followed the guidelines of the MA (2005) classification of ES because it provided the first classification that was globally recognized and applied in other national, sub-global assessments.

7.4.2. ES mapping and assessment: biophysical methods

The biophysical assessment of the status and trends of ES in Spain was performed using multiple indicators (Annex: Table 7.6). The criteria for the selection of indicators were as follows: (1) being understandable and widely accepted among the multiple types of stakeholders involved in the Spanish National ecosystem assessment; (2) having the ability to express information (being unambiguous and sensitive to changes); (3) being temporally explicit (trends can be measured over time), scalable (can be aggregated to different scale levels) and quantifiable (the information obtained can be easily compared); and (4) having available data during the last five decades (since 1960) and showing credibility (being obtained from official statistical datasets).

We quantified and mapped 8 ES: 4 provisioning (Crop production, Livestock production, Timber production and Fresh water production); 3 regulating (Water infiltration, Soil fertility and Carbon storage) and 1 cultural (Nature recreation) (Figure 7.2). In the following paragraphs we explain the methodology used for each ES.

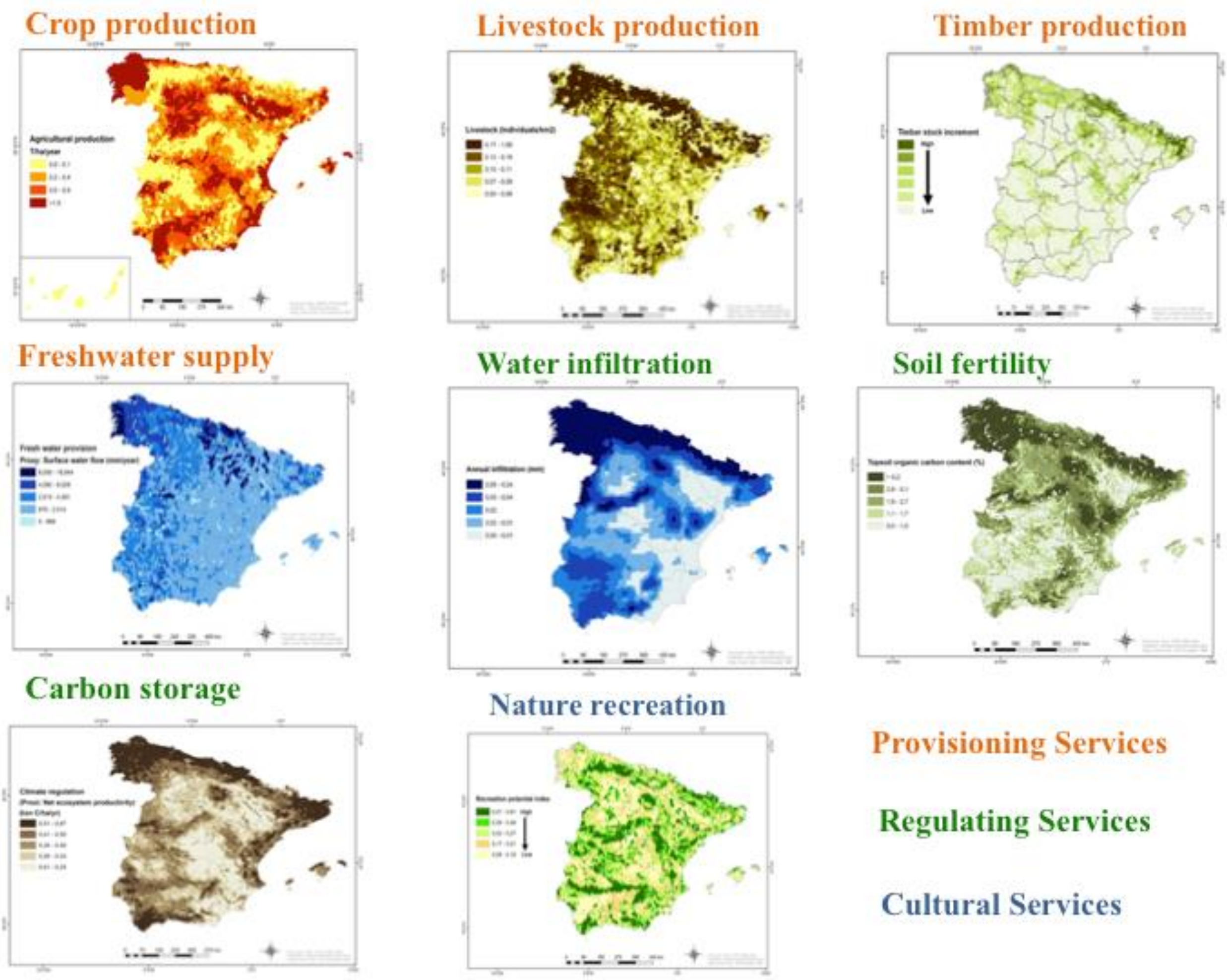


Figure 7.2. Spatial representation of mapping ES for the SNEA.

Mapping of provisioning services

Crop production (i.e. 1.1.1.1 Cultivated crops)

***Indicator**: Total average crop production in agricultural lands; Units: Tons/ha/yr.; spatial resolution: 25 km^2; Source data: Spanish NEA, 2015.*

The total average production of crops on agricultural lands in Spain was assessed based on the average productivity for each individual type of crop from 1996 until 2008 using the data from the Spanish Ministry of Agriculture. The methodology developed is based on knowing the surface area of each type of crop in each municipality of Spain. With the database, we obtained the average figure of hectares for each crop in each municipality for the period 1996-2008. Finally, we used the cartographical information from the National Geographical Institute about all of the municipalities in Spain to spatially represent the results. The results were added by groups of crops and by the average of all of the types of crops present in each municipality. In this way, we obtained some average values for agricultural production, in terms of the three main types of agroecosystems: (i) systems with a dominance of permanent crops (i.e. Fruit trees, vines, olive trees); (ii) arable crops (i.e. Rainfed arable crops, irrigated arable crops, traditional orchards, pastures and meadows) and (iii) horticultural crops (i.e. Mediterranean mosaic, reticulated landscape). Based on this data, we obtained an average agricultural production per hectare in each municipality of Spain. It is important to point out that the results presented were obtained dividing the production of each municipality between the total surface area of the municipality and not the agricultural surface area.

Therefore, the figures for productivity may seem lower than they actually are. The decision was made to divide the data on productivity by the total surface area in order to avoid any bias through which some towns with very little agricultural area could offer too high figures for productivity.

Livestock production *Livestock production (i.e. 1.1.1.2 Reared animals and their outputs)*
Indicator: *Average number of grazing animals (sum of cattle, sheep and goat; Units: heads/Km^2/yr.; Spatial resolution: 0.05 ° (± 4 km^2); Source data: JRC, 2011).*
Livestock services refer to animals raised for domestic or commercial consumption or use such as cattle, pigs and poultry. We followed the methodology for global mapping of grassland production of livestock, from grazing on unimproved grasslands provided by Naidoo et al. (2008). To map livestock production on natural pastures, 3'-resolution global maps of livestock distributions were used and intersected with the spatial distribution of (unimproved) grasslands in Spain. Maps of gridded livestock data are produced by and are available at the FAO statistics database (FAO, 2007[38]). Additionally EUROSTAT holds European livestock data at the spatial resolution of NUTS2 providing numbers of animal populations subdivided in 20 categories as well as the production of milk in ton. Meat production data is only available at national level. This data can be used to extract national conversion factors to convert from livestock numbers to units of mass. EUROSTAT compiles information on livestock density statistics under the agri-environmental indicators with the number of different livestock per utilized agricultural area or per fodder area (consisting of fodder crops and permanent grassland) on the NUTS3 level. Also milk production data are available at the regional level. We used the FAO maps of grazing livestock (the sum of cattle, goat and sheep densities) assuming that their total density reflects the capacity of grasslands to provide livestock services. Grasslands refer to the CLC classes pasture (label 3) as well as scrub and herbaceous vegetation associations (label 2).

Timber production *(i.e. 1.3.1.1 Plant-based resources)*
Indicator: *Forest capacity to produce timber; Units: Average dry matter productivity in forests (m^3/ha/yr.); Spatial resolution: 1 km^2; Source data: JRC, 2011.*
The capacity of forests to produce timber as well as the associated annual timber increment was approximated using the European standing stock inventories for Spain. We used the JRC forest inventory created by the AFOLU action to acquire regional statistics of the total area (ha), the standing stock volume (m^3 per statistical area per year) and the stock increment (m^3 ha^{-1} year^{-1}). These data were subsequently disaggregated using the CLC2000 data displaying the distribution of forests and agro-forestry areas as spatial surrogate. The European Forest Institute (EFI) hosts the European Forest Information Scenario Database (EFISCEN), a forest inventory database of European countries, based on input from national inventory experts. The bases of the EFISCEN Inventory database are the individual national forest inventories of 32 European countries. For each forest type and age class, the forest area, the total and mean volume, the total annual increment and the current annual increment may be retrieved from the EFISCEN Inventory database. Such data are available for all countries which have an even-aged forest structure. Input data on area, growing stock volumes and increment are usually derived from national forest inventories[39]. Based on the EFISCEN inventory, the AFOLU[40] action of the JRC produced provides aggregated statistics on the timber stock, expressed in ha and m^3 and increment (m3 year-1).

[38] http://www.fao.org/geonetwork (keyword gridded livestock)
[39] http://www.efi.int/portal/virtual_library/databases/
[40] http://fi.jrc.ec.europa.eu/Frameset.cfm

Freshwater supply *(i.e. 1.1.2.1 Surface water for drinking + 1.2.2.1 Surface water for non-drinking purposes)*
Indicator*: Average water provision based on surface water flow; Units: mm/yr.; Spatial resolution: 1 km^2; Source data: JRC, 2011.*
Freshwater provision accounts for the availability of fresh water coming from inland bodies of surface (not include groundwater resources) waters for household, industrial and agricultural uses. We defined total fresh water flow as the renewable water supply computed as surface and sub-surface runoff. It is a subcomponent of total precipitation, representing the net fresh water remaining after evapotranspiration losses to the atmosphere. Fresh water represents the sustainable supply of water that emanates from ecosystems and is then transferred through rivers, lakes, and other inland aquatic systems (MEA, 2005).

We used a global hydrological model to map water provision for human consumptive use following Naidoo et al. (2008). They summed consumptive water use across sectors to produce a spatially explicit map of total water use in biophysical units (km^3 per year). Then the volume of water consumption was attributed back to its points of origin by using a basin-level perspective of water production. They calculated the proportional contribution of each 0.5° resolution cell to the total water production of the basin in which it resides, calculated the amount of total water consumption for that basin, and then redistributed the total consumption according to the proportion of basin-wide water production at each grid cell. By redistributing the volume of water consumption in this manner, total water use was attributed to point of origin. Wriedt and Bouraoui (2009) presented an assessment of water availability for Europe. This assessment presents a simplified methodology to break down the net precipitation water (or hydrological excess water) over surface and subsurface runoff. This analysis was done at the spatial resolution of sub catchments. A European catchment database HydroEurope was developed at IES-RWER Unit, providing catchment and river basin information complying with the ArcHydro database scheme. The database was developed to support water balance and nutrient transport modelling at European scale.

We used this information in combination with the spatial location of freshwater ecosystems in Spain, as derived from the CLC dataset, to assess the capacity and flow of freshwater ecosystems to contribute to the provision of fresh water. The capacity of freshwater ecosystems to provide a reserve of freshwater is approximated by the surface area of freshwater ecosystems. The flow of freshwater provision can be approximated by the annual water flow (mm or m^3 year^{-1}) that is available from surface waters. As mentioned earlier, this assessment does not take into consideration the provision of subsurface fresh water reserves in aquifers and deep ground water.

Mapping of regulating and maintenance services

Water infiltration *Water infiltration (i.e. 2.2.2.1 Hydrological cycle and water flow maintenance)*
Indicator*: Water infiltration capacity; Units: (mm /yr.); spatial resolution: 1 km^2; Source: JRC, 2011.*
Water infiltration services refers to the influence ecosystems have on the timing and magnitude of water runoff, flooding and aquifer recharge, particularly in terms of water storage potential of the ecosystem. This service is closely related to water provision. We made the distinction based on surface and subsurface water flows classifying ecosystems that capture the surface flow (rivers, lakes, wetlands) as providers of water and terrestrial systems that store or hold as regulators of water. We used the annually aggregated soil infiltration (mm) as an indicator for the capacity of terrestrial ecosystems to temporarily store surface water. The data used are derived from the MAPPE model (Pistocchi et al. 2008; Pistocchi et al. 2010).

MAPPE stands for Multimedia Assessment of Pollutant Pathways in the Environment of Europe and consists of models that simulate the pollutant pathways in air, soil sediments and surface and sea water at the European continental scale. Monthly infiltration of precipitated water in soils is calculated by distributing the net precipitation over run off and infiltration. The service flow of water regulation by terrestrial ecosystems was approximated by using the annual sub surface water flow (mm or m^3 $year^{-1}$).

Soil Fertility *(i.e. 2.2.1.1. Mass stabilisation and control of erosion rates)*
Indicator*: Topsoil organic carbon content; Units: %; Spatial resolution: 1 km^2; Source: JRC, 2011.*
We define soil fertility as the role ecosystems play in sustaining the soil's biological activity, diversity and productivity; in regulating and portioning water and solute flow and in storing and recycling nutrients. The primary source for all European soil related data is the JRC's European soil data center. Data on soil depth, moisture capacity and organic carbon content are available via the website[41]. Soil data at the global scale are provided by the FAO[42]. Data are available for top soils and subsoils for organic carbon content, moisture storage capacity, nitrogen content, and soil depth and soil productivity. We used the soil carbon content map as a proxy to address the capacity of ecosystems to maintain the quality of soils. The following CLC classes are assumed to contribute in soil quality regulation: Non-irrigated arable land: Permanently irrigated land, Rice fields, Vineyards, Fruit trees and berry plantations, Olive groves, Pastures, Annual crops associated with permanent crops, Complex cultivation patterns, Land principally occupied by agriculture, with significant areas of natural vegetation, Agro-forestry areas, Broad-leaved forest, Coniferous forest, Mixed forest, Natural grasslands, Moors and heathland, Sclerophyllous vegetation, Transitional woodland-shrub, Beaches, dunes, sands, Sparsely vegetated areas.

Climate regulation *(i.e. 2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations)*
Indicator*: Carbon Storage and net ecosystem productivity; Units: Ton C/ha/yr.; Spatial resolution: 1/112° (± 1 km^2); Source: JRC, 2011.*
Climate regulations services are defined as the influence that ecosystems have on the global climate by emitting greenhouse gasses to the atmosphere or by extracting carbon from the atmosphere as well as the influence that ecosystems have on local and regional temperature, precipitation and other climatic factors. In this study, only the first aspect has been taken into consideration. Two classically used indicators to approximate climate regulating services are presented in this study. Carbon storage was assumed as a proxy to estimate the capacity of ecosystems to contribute to climate change mitigation while the annually accumulated net ecosystem productivity was suggested as measure for the carbon service flow. Carbon storage data were taken from de CDIAC website[43]. This spatially-explicit global data set provides estimates and spatial distribution of the above- and below-ground carbon stored in living plant material, and provides an important input to climate, carbon cycle and conservation studies. The data set was created by updating the classic study by Olson et al. (1983,1985) with a contemporary map of global vegetation distribution (Global Land Cover database; GLC2000).

Data on net ecosystem productivity are available in the Geosucces[44] database. The net ecosystem productivity (NEP) takes into account the soil respiratory flux originating from heterotrophic decomposition of soil organic matter. These carbon fluxes are quantified using the C-Fix model which is a

[41] http://eusoils.jrc.ec.europa.eu/
[42] http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/
[43] http://cdiac.ornl.gov/epubs/ndp/ndp017/ndp017b
[44] http://geofront.vgt.vito.be/geosuccess/relay.do?dispatch=NEP_info.

remote sensed-based carbon balance product efficiency model wherein the evolution of the radiation absorption efficiency in the PAR (Photosynthetically Active Radiation) band (or fAPAR) of vegetation is directly inferred from space observations, SPOT-VEGETATION S10 (SPOT VGT S10) images, using the Normalized Difference Vegetation Index (NDVI) (Veroustraete et al. 2002). Data of NEP were accumulated for the year 2000 to result in the annual carbon fixation (gram C m^{-2} $year^{-1}$).

Mapping of cultural services

Nature recreation *(i.e. 3.1.1.1 Experiential use of plants, animals, and land- / seascapes in different environmental settings + 3.1.1.2 Physical use of land- / seascapes in different environmental settings)*
Indicator*: Recreation potential index; Units: Dimensionless; spatial resolution: 25 km^2; Source: Spanish NEA, 2015.*
The recreation potential index was used as an indicator to express the capacity of ecosystems to provide recreational services. In this study the capacity of ecosystems to provide recreation depends on three main factors: naturalness, level of conservation, and accessibility to human population. Recreation potential is mapped with the assumption that it is positively correlated to the degree of naturalness, to the presence of protected areas (following the assumption that they have been identified as holding a higher degree of naturalness, and as providers of recreation services and facilities) and is influenced by the accessibility of higher human population. Following this conceptual model we need to find spatial indicators that approximate the capacity of ecosystems to provide recreation services, the fruition or flow of such a service and the infrastructure in place to support the capacity of ecosystems in order to generate a service flow. Furthermore, in this exercise, landscape components of scenic beauty and culture are not addressed, and the provision of the service by the ecosystems in the strict sense is analyzed. The degree of naturalness is an index that measures the human influence on landscapes and flora. We used Corine Land Cover 2006 to create an index of naturalness associated with each land use. From the land use map, a map of the naturalness index has been constructed, in which a value of 0 has been assigned to urban, industrial or mining areas, 1 to urban green areas, 2 to cultivated land, 3 to agricultural mosaics, agroforestry and saline systems, 4 to natural areas with agroforestry (transitional meadows and shrubs), and 5 to areas of high environmental value (mixed forests, shrublands, grasslands, salt marshes, etc.). The presence of protected areas was mapped using the Natura 2000 database and the Spanish Nature Conservation Areas database. The Natura 2000 database contains sites designated under the Birds Directive (Special Protection Areas, SPAs) and the Habitats Directive (Sites of Community Importance, SCIs, and Special Areas of Conservation, SACs). The nationally designated areas hold information about protected sites and about the national legislative instruments, which directly or indirectly create protected areas. Finally, proximity of human populations was mapped using data of the Spanish Statistics Institute of the population in each municipality and the extension of each municipality to obtain the number of person/km^2. The distance from highly dense human populations was calculated on the basis of CORINE urban classes.

7.4.3. ES mapping and assessment: socio cultural methods

Overall, twelve ES have been valued using three main techniques: (1) a meta-analysis of the studies previously conducted in Spain; (2) spatial representation of the varying values of ES using market-based methods; and (3) a choice experiment conducted in those services that are difficult to measure by other techniques of traditional economic valuation (Table 7.2).

Table 7.2. Final list of ES valued in Spanish NEA using different methods of valuation.

	Market methods	Meta-analysis	Stated preferences (choice experiment)
Food from agriculture, cattle farming, fishing, beekeeping etc.	X	X	
Water for human consumption	X		
Gene pool (agro-biodiversity)			X
Climate regulation (carbon and storage)		X	
Water purification (retention and elimination of nitrates & water quality)	X	X	X
Erosion control		X	X
Natural disturbance (fire control)	X	X	
Biological control		X	
Recreational service or nature tourism	X	X	
Local ecological knowledge			X
Spiritual and religious feeling		X	X
Aesthetic pleasure in landscape		X	

Each one of these types of value appears directly related to different types of services as can be seen in Figure 7.3, but also to different methodologies of valuation. Therefore, there are three major categories of methods: direct markets, revealed preferences and stated preferences, and the challenge is to choose the most appropriate one in terms of the service to be assessed along with the specific context. Market methods use price as the best proxy of value, and therefore they are based on data obtained in direct markets as estimations of the value of direct use. Among their different possibilities they can use market prices, the function of production (how much a service contributes to the production of another), or the cost of replacement or the cost avoided. Whereas the first of these methods is frequently applied to provisioning services (or cultural ones with assigned markets such as nature tourism), the second two (revealed preferences and declared preferences) are generally used to estimate indirectly the value of regulating services.

We believe that expressing the value of ES (ES) in economic and social terms is a powerful tool because: (1) the majority of planning decisions are based on economic information and thus better information about the importance of ecosystems in economic terms is crucial to achieve more accurate decisions, (2) visualizing those ES without market value (i.e. regulating and cultural ones) is necessary to support its conservation, (3) it creates a common language that could be understood between agents from different sectors (e.g. researchers at different disciplines, decision makers, policy makers, managers) (4) it is a prevailing communication tool for the general public (beyond the scientific community).

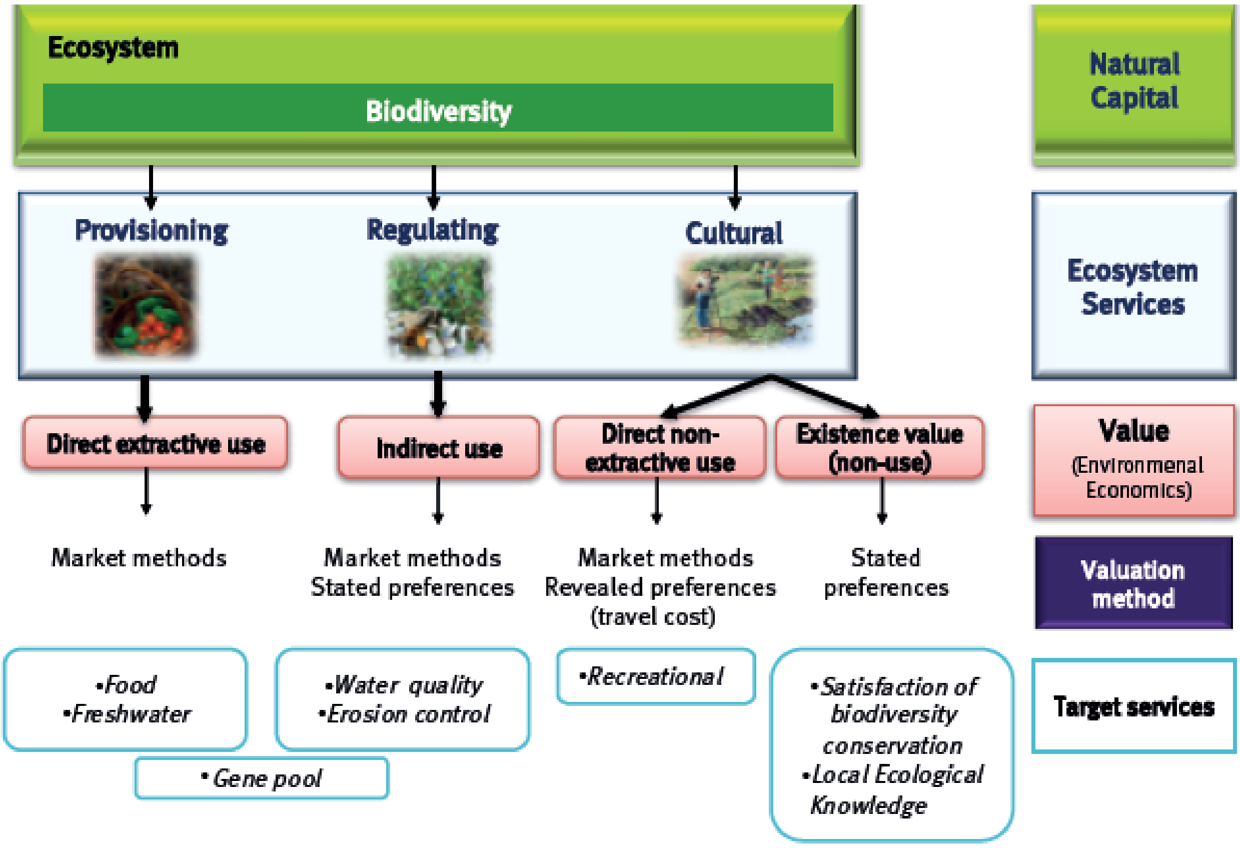


Figure 7.3. Methodological map used in the valuation of ES in Spain, in which one can see the different typologies of services derived from natural capital, and the different types of associated value according to the framework of Environmental Economy. Finally, the most appropriate methodologies for each case are presented for each case, and in blue one can see the services that have been assessed in the project, combining the use of these methodologies (we do not include the services assessed with meta-analysis techniques as they include different techniques). (Source: Santos-Matín et al, 2016).

7.5. Use and integration of ES mapping and assessment results

7.5.1. Addressing the policy question

With this aim, the National Ecosystem Assessment of Spain has addressed the socio-economic valuation based on a robust analysis of the biophysical dimension (SNEA, 2014) and with the implementation of mixed methodologies that include social and cultural aspects in the valuation process (Figure 7.4).

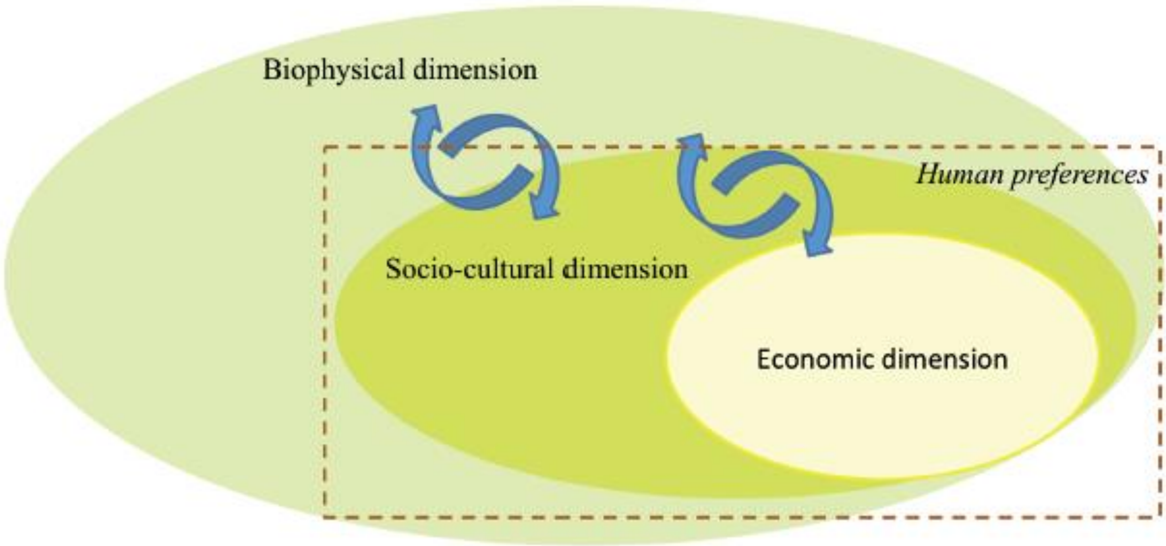


Figure 7.4. Conceptual framework of the integration of results and the concentric relationship between the three dimensions of the assessment. (Source: Santos-Matín et al, 2016).

We consider that any ecosystem assessment should combine the three value domains (biophysical, socio-cultural, and economic) to properly inform the environmental decision-making process. In particular, integrated valuation assessment should try to examine the interdependencies between ecosystem status and the values associated to different ES. For example, an ecosystem's capacity to supply services determines its range of potential uses by society, which influence its socio-cultural and monetary value. Socio-cultural values also have an influence on monetary value because preferences and ethical and moral motivations determine the 'utility' a person obtains from a particular service. These interdependencies (and the different information provided) explain why ES assessment should be based on integrated approaches (see Table 7.3).

Table 7.3. Integration of the different dimensions (biophysical, economic, social) of SNEA. For the economic valuation, we distinguish between the three different techniques of valuation that were used: MAR: markets, MA: meta-analysis, CM: choice models. The spatial column refers to when the results of the valuation are expressed in a spatially explicit manner, whether using the information generated by the SNEA Project or from other sources of cartographical information. (Source: Santos-Matín et al, 2016).

		Biophysical	Economic			Social	Spatial		Available in SNEA
			MAR	MA	CM		SNEA	OTHERS	
Provisioning	1. Food	X	X	X		X	X	X	Biophysical, Economic, Social, Spatial
	2. Water	X	X				X	X	Biophysical, Economic, Spatial
	3. Raw materials	X				X		X	Biophysical, Social, Spatial
	4. Gene pool	X			X				Biophysical, Economic
	5. Natural medicines	X							Biophysical
Regulating	7. Climate regulation	X		X		X		X	Biophysical, Economic, Social, Spatial
	8. Air quality	X				X			Biophysical
	9. Water regulation	X				X		X	Biophysical, Social, Spatial
	10. Water treatment	X	X	X	X		X	X	Biophysical, Economic, Spatial
	11. Erosion control	X		X	X			X	Biophysical, Economic, Spatial
	12. Soil formation	X				X		X	Biophysical, Social, Spatial
	13. Natural disturbances	X	X	X			X		Biophysical, Economic, Spatial
	14. Biological control	X		X					Biophysical, Economic
	15. Pollinating potential							X	Spatial
Cultural	16. Recreational or tourism	X	X	X		X	X		Biophysical, Economic, Social, Spatial
	17. Local Ecological Knowleged	X			X	X	X		Biophysical, Economic, Social, Spatial
	18. Cultural identity	X				X			Biophysical, Social
	19. Scientific knowledge	X							Biophysical
	20. Environmental education	X				X			Biophysical, Economic, Social, Spatial
	21. Spiritual feeling and existence values	X		X	X	X			Biophysical, Economic, Social, Spatial
	22. Aesthetic pleasure	X		X		X			Biophysical, Economic, Social

7.5.2. Dissemination and communication of results

The general aim of the communication strategy of the Spanish NEA is to build a social network around the vision of nature conservation as a necessary action for human wellbeing. Therefore, the focus of this strategy is to attempt to overcome the social perception of nature conservation as something elitist or exclusive and build a shared vision of the vital links between human needs and nature conservation. Thus, the SNEA communication strategy has set the following objectives:

- ❖ Coordinate internal communication elements that allow proper scientific exchange between the research teams involved in the project under the integrated and inclusive framework of the Millennium Ecosystem Assessment.
- ❖ To bring the development of the SNEA to the attention of stakeholders and listen to their needs and contributions regarding ES to ensure that the results will be useful to them as well as taking into account the different actors involved in or dependent on ES.
- ❖ Develop external communication tools tailored to the needs of different target audiences or stakeholders as well as innovative formats and channels for the dissemination of the results of SNEA in different social spheres, e.g. the media, school communities, NGOs and social movements.
- ❖ Characterize the messages that define the approach of the project regarding the human-nature relationship as well as building a graphic identity for the project and amplifying its messages through existing channels and networks.
- ❖ Contribute to the international dissemination and projection of the Millennium Assessment (included the participants in the Sub-global Assessment Network) and other national and international collaboration channels associated with the project.
- ❖ Increase the interaction and information flow between the scientific community, policy-makers, businesses and society in general to improve decision making in the management of ecosystems according to the project's objectives.

Accordingly, the message on ES moves away from the classical conservationist view and attempts to construct a message that includes the interaction between society and nature and chooses not to present the usual catastrophic vision linking the everyday life of people with their environmental impact. The message content is focused on the contribution of ES to wellbeing, revealing its high social importance. It is a positive message, offering the chance to appreciate the relationship between the conservation of nature and a human lifestyle that is possible and worth living.

The actions that derive from these objectives and this approach are threefold: i) generic public communication elements; ii) communication tools, participation and education tailored to different specific population segments (e.g., political and technical staff, students, scientists, NGOs and social movements); and iii) the organization or participation in events (e.g., workshops, conferences, meetings, forums). These actions are contained in the SNEA Communication Plan:

I. Generic public communication elements:
   a) Website: www.ecomilenio.es.
   b) Facebook: Ecomilenio España.
   c) Quarterly Newsletters: quarterly newsletters mailing.
   d) SNEA videos.
   e) Ecosystem videos (available on web site and SNEA YouTube channel).
   f) Brochures and other materials such as postcards, notebooks, etc.

II. Specific public communication elements:
   a) SNEA Reports: Results and Synthesis.
   b) Teaching materials.
      i. Teachers guide.
      ii. Slide presentation.
      iii. Posters: one general poster identifies the ES associated with different types of ecosystems and another poster is specific to urban ecosystems.
   c) Stakeholder surveys: providing basis for a participatory process to build future scenarios.
   d) Communication materials for the Thematic Workshop on future scenario construction.

7.6. References & Annexes

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Annex

Table 7.4. Integrating national-scale ecosystem classifications with the existing European-level classification. (Source: Spanish NEA, 2014.)

Ecosystem category	EU TYPE (EEA, 2012)	Spatial representation, and definitions	SNEA TYPE	Spatial representation and definitions
Terrestrial	Urban	Constructed, industrial and other artificial habitats	Urban	Artificial surfaces associated with urban areas
	Cropland	Regularly or recently cultivated agricultural, horticultural and domestic habitats	Agroecosystems	I. Systems with woody elements II. Monospecific arable III. Polycultures IV. Industrial agriculture
	Grassland	Land dominated by forbs, mosses or lichens		Grasslands
	Woodland and forest	Woodland, forest and other wooded land	Atlantic forest Mediterranean continental forest	Bioclimatic Eurosiberian Region: Colino and Montano floors Matches bioclimatic supramediterranean floor
	Heathland and shrub	Moors, heathland and sclerophyllous vegetation	Sclerophylous forest and shrub	Matches bioclimatic mesomediterranean and thermomediterranean floors
	Sparsely vegetated land	Open spaces with little or no vegetation (bare rocks, glaciers and inland dunes and sand plains included)	Alpine mountain Mediterranean mountain Arid zones	Bioclimatic Eurosiberian Region: altitudes above 1,500 m Bioclimatic Mediterranean Region: altitudes above 1,300 m Less than 300 mm annual rainfall
	Inland wetlands	Mires, bogs and fens (freshwater wetland habitats)	Wetlands and lakes Aquifers	Wetlands: shallow water (þ 8-10m) Lakes: deep water (þ 10 m) Identified a total of 740 groundwater bodies
	Coastal	Coastal habitats (characteristic coastal wetlands and open spaces)	Coastal Insular	- Coastal plain and islands. - Coastal and intertidal shoreline: tidal influence ecosystems - Coastal Marine: shallow water ecosystems (isobaths 50) Macaronesian bioclimatic region
Fresh water	Rivers and lakes	Inland surface waters Water courses and bodies	Rivers and riverbanks	Vector lines distributed over the entire surface of the state territory
Marine	Benthic photic Benthic non-photic Pelagic photic Pelagic non-photic	Littoral and shallow sublittoral habitats Shelf sublittoral and deep sea habitats Coastal, shelf and oceanic marine water habitats Coastal, shelf and oceanic marine water habitats	Marine waters (sea and ocean)	Area within the outer limits established in the coastal ecosystem and the Exclusive Economic Zone (EEZ) of Spain

Table 7.5. . List of ecosystems services assessed in the Spanish NEA. (Source: Spanish NEA, 2014.)

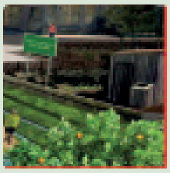
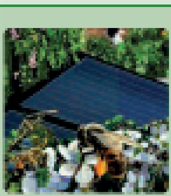
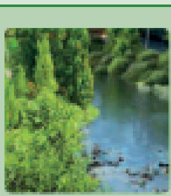
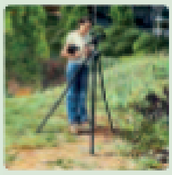
Type of services		Services	Examples
Provisioning services	 	1. Food	Crops, livestock, wild plants and animals and their products, aquaculture product
		2. Water	Agriculture and domestic water use
		3. Biotic Materials	Non-food vegetal fibers
		4. Geotic Materials	Continental and marine salt
		5. Renewable Energy	Hydropower production
		6. Gene pool	Livestock breeds, varieties of crops, varieties and biotechnological genetic information
		7. Natural medicine	Oils, plant acids, alkaloids
Regulating services	 	8. Local & Regional climate regulation	Carbon capture and storage, microclimatic regulation
		9. Regulation of air quality	Retention of pollutants by plants and microbes
		10. Water regulation	Water purification and oxygenation
		11. Maintenance of soil erosion	Attenuation of runoff and discharge rates
		12. Maintenance of soil fertility	Maintenance of nutrients cycles and organic matter
		13. Regulation against hazards	Habitat refuges
		14. Biological control mechanisms	Regulation of pests and pathogens vectors
		15. Pollination	Symbiosis between certain organisms resulting in pollen transport and reproduction
Cultural services	 	16. Scientific knowledge	Ecosystems as laboratories for experimentation and knowledge
		17. Local ecological knowledge	Knowledge of the basic functioning of ecosystems and social function
		18. Sense of place or cultural identity	Certain forms of use of the service and landscape management
		19. Spiritual and religious experience	Sacred places or species
		20. Aesthetic enjoyment of landscapes	Landscape character for recreational opportunities
		21. Recreational activities	Nature tourism
		22. Environmental education	Sensibilization and awareness of the importance of ecosystem services

Table 7.6. Number of indicators selected for each ecosystem and service type included in the SNEA. (Source: Spanish NEA, 2014.)

Ecosystems / Service Type	Provisioning	Regulating	Cultural	Total
Agroecosystems	19	22	12	53
Atlantic forest	28	31	22	81
Mediterranean continental forest and shrubs	24	14	21	59
Sclerophylous forest and shrub	16	9	6	31
Alpine mountain	23	14	22	59
Mediterranean mountain	25	33	33	91
Arid zones	21	7	19	47
Wetlands and lakes	28	15	24	67
Aquifers	11	7	7	25
Coastal	5	7	9	21
Insular	14	11	11	36
Rivers and riverbanks	50	55	33	138
Marine	44	13	31	88
Urban	7	8	7	22

Case study booklet for:
WORKSHOP 5: "Testing the methods across biomes and regions"
Madrid, Spain, 04-07 April 2017

8. BALA - Biodiversity of Arthropods from the Laurisilva of Azores, Portugal

March 2017

ESMERALDA partner: Azorean Biodiversity Group - Centre for Ecology, Evolution and Environmental Change (GBA-cE3c) – University of Azores

Case Study Coordinators: Paulo A.V, Borges, Ana Picanço & Artur Gil

ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

8.1. Case study factsheet and study area description

Biodiversity of Arthropods from the Laurisilva of Azores WS5_cs2

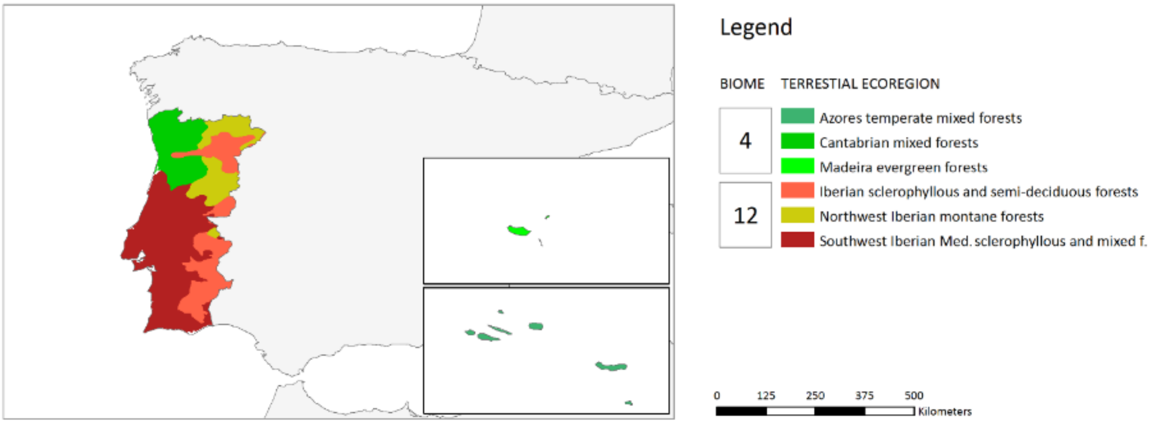
NAME AND LOCATION OF STUDY AREA	Laurel forests in the Archipelago of Azores
COUNTRY	Portugal (Azores)

STATUS OF MAES IMPLEMENTATION

Stage 1	Stage 2	**Stage 3**

BIOMES IN COUNTRY

1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
5 Temperate Conifer Forests	6 Boreal Forests/Taiga
8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
14 Mangrove	



SCALE

national	**sub-national**	local

AREAL EXTENSION: **400.6 km²**

THEMES

nature conservation	climate, water and energy	marine policy	natural risk
urban and spatial planning	**green infrastructures**	**agriculture and forestry**	business, industry and tourism
health	ES mapping and assessment		

ECOSYSTEM TYPES

urban	cropland	**grassland**	**woodland and forest**
heatland and shrub	**sparsely vegetated land**	wetlands	rivers and lakes
marine inlets and transitional waters	coastal	shelf	open ocean

Study area description

The Azores are an oceanic isolated Northern Atlantic archipelago made of nine main islands and some small islets, distributed from Northwest to Southeast, roughly between 37º and 40º N and 24º and 31º W. The Azorean islands extend for about 615 km and are situated across the Mid-Atlantic Ridge, which separates the western group (Flores and Corvo) from the central (Faial, Pico, S. Jorge, Terceira and Graciosa) and the eastern (S. Miguel and S. Maria) groups. All these islands have a relatively recent volcanic origin, ranging from 8.126 Myr B.P. (S. Maria) to 300 000 years B.P. (Pico) (Feraud et al. 1980; Ramalho et al. 2016). The climate is temperate humid at sea level, and cold oceanic at higher altitudes. The atmospheric humidity is high with small temperature fluctuations throughout the year.

A few number of endemic trees and shrubs (*Juniperus brevifolia*, *Laurus azorica*, *Ilex perado* ssp. *azorica*, *Vaccinium cylindraceum* and *Erica azorica*) that covered most of the islands prior to Human colonization dominate native forest. The changes performed by Humans created new habitats in the islands, namely semi-natural pastures, exotic plantations (*Cryptomeria japonica*, Eucalyptus spp.), intensive pastures, agriculture fields (including orchards) and urban areas. These changes promoted the destruction of more than 90% of the original forest that now has less than 5% of pristine areas located in protected areas (Borges et al. 2005; Gaspar et al. 2008; 2011; Triantis et al. 2010).

8.2. Main policy question and theme

8.2.1. Objectives of ES mapping and assessment

The present ES assessment has been mainly scientifically-driven, with the main objective of performing the first assessment of ES, based on arthropod diversity, distribution and ecological data in an Azorean island. We selected one of the best studied Azorean islands (Terceira) and investigated two ES: *Pollination and seed dispersal* and *Maintaining nursery populations and habitats*. The results obtained for *Maintaining nursery populations and habitats* were already used to implement protected areas in Azores (see Borges et al. 2011; Gaspar et al. 2011). The results obtained for *Pollination and seed dispersal* can be used to identify key ES for Azorean agro-ecosystems.

Pollination services are essential to sustain fruit production in orchards, as well as for endemic flowering plants by ensuring reproduction and dispersal. There are some ongoing proposals in Azores to assess the effect of different ecological intensification techniques on pollination efficiency and related increase in crop yield. Mapping pollinator ES in agroecosystems and quantify its economic value is therefore a priority. This objective is highly relevant in the context of several important international policies such as the International Initiative for the Conservation and Sustainable Use of Pollinators, implemented by the United Nations and established by the Convention on Biological Diversity at the 5th Conference of Parties (COP V) in 2000[45]. The above objective is equally relevant in the context of other international policies like the FAO's Global Action on Pollination Services for Sustainable Agriculture[46]. Moreover, this objective is pertinent within the goals of the Intergovernmental Science-Policy Platform on Biodiversity and ES (IPBES) on pollinators, pollination and food production[47].

[45] https://www.cbd.int/agro/planaction.shtml
[46] http://www.fao.org/pollination/en/
[47] http://www.ipbes.net/work-programme/pollination

8.2.2. Stakeholders and their role

Within the ES mapping and assessment process, stakeholders were involved as experts for selected ES or for data requests. In the latter case, governmental departments and authorities provided baseline environmental data (Project INTERREG-ATLANTIS), land-use (DROTRH 2008) and crop production (FRUTER/Frutercoop and Serviço de Desenvolvimento Agrário da Ilha Terceira). During a workshop organized by Azorean Biodiversity Group[48] in June 2015 all the Directors of Natural Parks participated in a World Café Session to discuss the strategies for the conservation of Nature in Azores.

8.3. Ecosystem Types and Conditions

8.3.1. Identification and mapping of ecosystem type(s)

The assessment of ecosystems in Terceira (Azores) was facilitated by the availability of land use data and biodiversity at small scales (transects of 150 m x 50 m). Land use data is available from DROTRH (2008) with some improvements for native forest from Gaspar et al. (2008) – (see Figure 8.1).

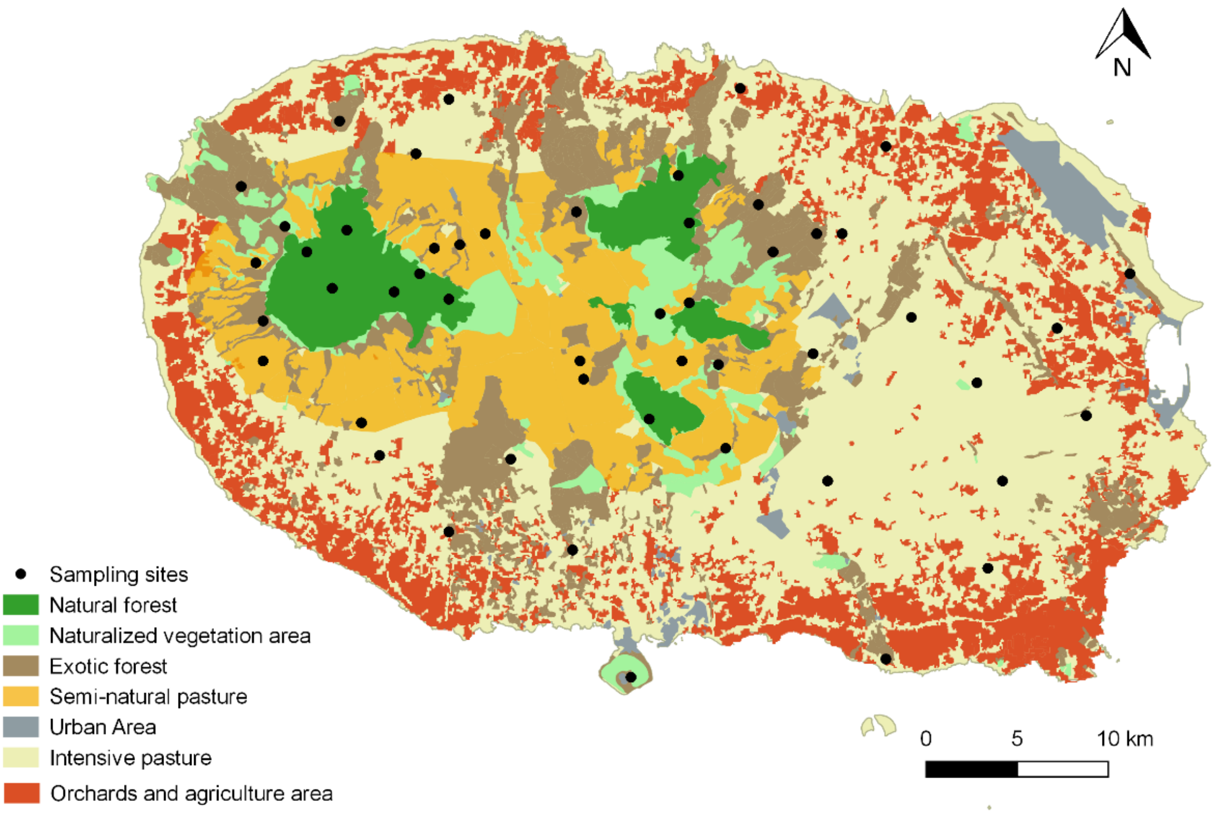


Figure 8.1. A land use land cover map of Terceira was available from DROTRH (2008) adapted by our purposes and with addition of new data for natural forests from Gaspar et al. (2008). Black points are sampled points for the pollinator assessment (see Picanço et al. (2017a, b).

[48] http://gba.uac.pt/fotos/noticias/1435657919.pdf

8.3.2. Assessing ecosystem conditions

The Terceira island ecosystem evaluation was performed in several studies comparing the quality of native forests (Gaspar et al. 2011) and the quality of natural forest in comparison with semi-natural pastures, exotic pastures and *Cryptomeria japonica* plantations (Borges et al. 2008; Cardoso et al. 2009; Florencio et al. 2013, 2015, 2016), including also the importance of non-natural areas for species conservation (Fattorini et al. 2012). The general conclusion was that the natural forests are source habitats for endemic species of arthropods and that for some species semi-natural pastures and *Cryptomeria japonica* plantations can serve as alternative habitats. For pollinators recent studies (Picanço et al. 2017a, b) indicate that contrary to expectations there are no significant differences in the distribution and abundance of native pollinating insects among different habitats on the island. That is, there is a prevalence of endemic and native species in the communities of pollinator insects whether we consider forest habitats, exotic forest, or lands with different intensities of grazing.

An index of "landscape disturbance" (D) was produced for Azorean islands reflecting a gradient of Human interference in ecosystems (see Figure 8.2). Based on land use provided by (DROTRH 2008) and previous fieldwork on native forests from Gaspar et al. (2008) and on the proportion of endemic, native and exotic species typical to each land use type present in the island (Cardoso *et al*. 2009), a land use map of 100×100 m resolution depicting the location of all land use types was built. With this information, inferred the disturbance level of each land use relative to an undisturbed native forest and used it to rank the different land uses. To each rank, a value of "local disturbance" (*L*) was attributed: Natural forests = 0, Natural(ized) vegetation or rocky outcrops = 1, Exotic forests = 2, Semi-natural pastures = 3; Intensively managed pastures = 4; Orchards/agriculture areas = 5; Urban/industrial areas = 6. To the ocean attributed the value of "no data". For the landscape disturbance index of each 100×100 m cell in the island the following equation was used:

$$D_{i,j} = \left(\frac{2L_{i,j} + \sum_{n=1}^{r} \sum_{m=1}^{c} \frac{L_{n,m}}{d^2_{(i,j)(n,m)}}}{2max + \sum_{n=1}^{r} \sum_{m=1}^{c} \frac{max}{d^2_{(i,j)(n,m)}}} \right) \times 100$$

where: *Di,j* is the final index value of the cell in row *i* and column *j*; *L* is the local disturbance value of each cell (as defined above); *r* is number of rows in the map; *c* is number of columns in the map; *d* is the distance between the centroids of each two cells; *max* is the maximum theoretical value of disturbance each cell may take (in this case max = 6, corresponding to urban/industrial areas).

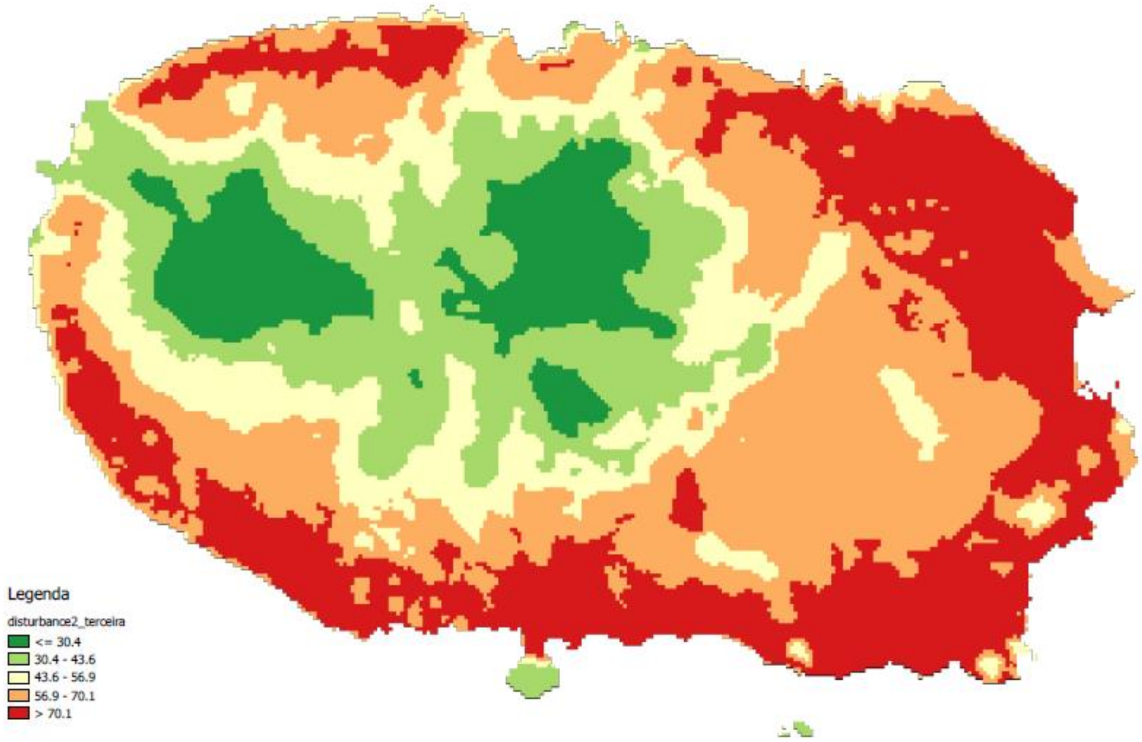


Figure 8.2. Maps of Terceira Island with value of landscape disturbance according to Cardoso et al. (2013). Values of landscape disturbance are represented in a gradient from green for lowest values to red for highest values.

8.4. Mapping and assessment of ES

8.4.1. Identification of ES

We selected two ES for which data was available based on macro-ecological studies (see Table 8.1). These ES are relatively easy to assess based on simple protocols for field work using standardized techniques to sample epigean soil arthropods (CICES 2.3.1.2) and pollinators (CICES 2.3.1.1).

The selection of four indicators for pollinators (i.e. “insect pollinators richness”, “bees richness”, “bees abundance”, “insect pollinators abundance”) was based on the rational that they were easy indicators to be obtained and on the fact that species richness and abundance are surrogates of the diversity of ecosystems (Magurran 2003). Concerning the ES “Maintaining nursery populations and habitats”, the selected indicator is “Proportion of arthropod endemic species” given that it is expected that sites with a high proportion of endemic species have also lower proportion of exotic species (see e.g. Borges et al. 2005, 2006) and consequently are more pristine and adequate to maintain nursery populations and habitats.

Table 8.1. Overview of the ES and related mapping and assessment methods in the Azores case study

Ecosystem Service selected for mapping and assessment	B	S	E
2.3.1.1 Pollination and seed dispersal*	X		
2.3.1.2 Maintaining nursery populations and habitats*	X		

* ES selected for further discussion during ESMERALDA workshops 5 in Madrid;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

8.4.2. ES mapping and assessment: biophysical methods

Mapping of regulating and maintenance services

2.3.1.1 Pollination and seed dispersal

Indicator: *Bees and Insect Pollinator richness and abundance*

The richness and abundance of pollinators was obtained in five main relevant habitat types: natural forests (NatFor), naturalized vegetation areas (NatVeg), exotic forests (ExoFor), semi-natural pastures (SemiPast) and intensively managed pastures (IntPast) (Picanço et al. 2017a). In each habitat a total of ten sites were selected to maximize the environmental diversity following procedures described in Jiménez-Valverde & Lobo (2004) (see the 50 sites in Figure 8.1). Pollinators were sampled in 10 m long line-transects (1 m width) under sunlight (from 9 a.m. to 6 p.m.) and only in sunny weather, with a duration of 180 minutes per transect. Each flower along every 10 m transect was surveyed for 4 minutes to guarantee effective contact of the insect, i.e. probing for nectar or eating/collecting pollen (see more details in Picanço et al. (2017a).

The mapping of the ES was performed using the “Topo to Raster” interpolation technique (in ArcGIS10©) applying an iterative finite difference interpolation technique. This technique allows an optimization with the computational efficiency of local interpolation methods, such as inverse distance weighted (IDW) interpolation, without losing the surface continuity of global interpolation methods, such as Kriging and Spline. Therefore, this mapping is basically a discretized thin plate spline technique for which the roughness penalty has been modified to allow the fitted DEM to follow abrupt changes in terrain. In this work, DEM were created using respectively as elevation data the bees and insect pollinators’ abundance and richness quantitative information collected from field surveys, of the 10 transects of each habitat type (or land use).

In addition, we applied the index of landscape disturbance (D) metric based on the attributes of the landscape matrix (Cardoso et al. 2013). For each analysis, we overlaid the respective pollination services’ interpolation maps delivered by the fieldwork data on bees and other insect pollinators from Picanço et al. (2017a) with the land use and the disturbance index D. We’ve created thresholds to analyze disturbance index D influence on the amount and diversity of bees and other insect pollinators and mapped these categories in eight classes for bees’ abundance (N) and richness (S); and in 12 classes for insect pollinators’ abundance (N) and richness (S). The created thresholds values for the different classes are specified in Table 8.2.

Table 8.2. Distribution of disturbance index (D) for bees’ & insect pollinators’ abundance (N) & richness (S) per classes.

Bees class	D	N	S	IP class	D	N	S
1	D<20	≥10	≥2	1	D<20	≥73	>15
2	D<20	<10	<2	2	D<20	25≤S<73	10<S≤15
3	20<D<30	≥10	≥2	3	D<20	<25	<10
4	20<D<30	<10	<2	4	20<D<30	≥73	>15
5	30<D<40	≥10	≥2	5	20<D<30	25≤S<73	10<S≤15
6	30<D<40	<10	<2	6	20<D<30	<25	<10
7	>40	≥10	≥2	7	30<D<40	≥73	>15
8	>40	<10	<2	8	30<D<40	25≤S<73	10<S≤15
				9	30<D<40	<25	<10
				10	>40	≥73	>15
				11	>40	25≤S<73	10<S<15
				12	>40	<25	<10

Examples of mapping the ES for pollinators are shown in Figure 8.3 to Figure 8.8.

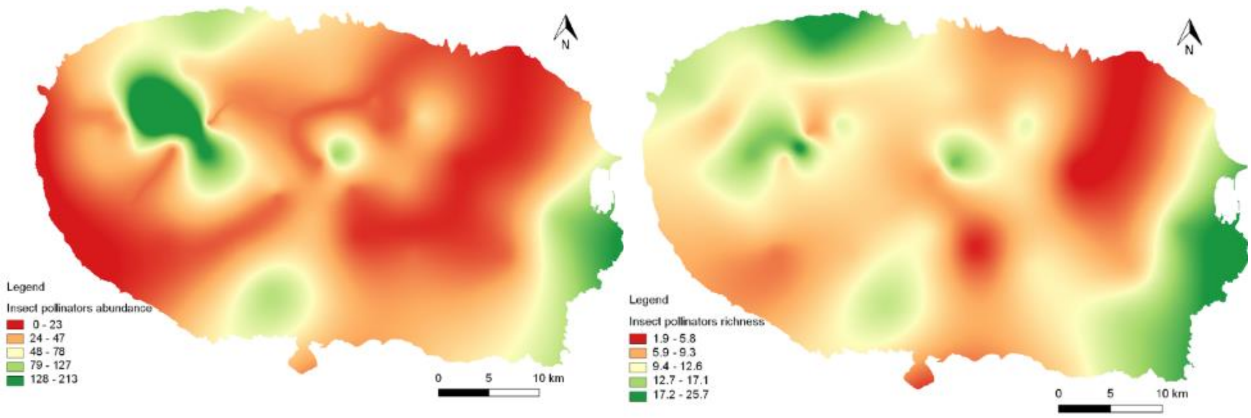


Figure 8.3. Map based on insect pollinator abundance (left) and richness (right) in Terceira Island.

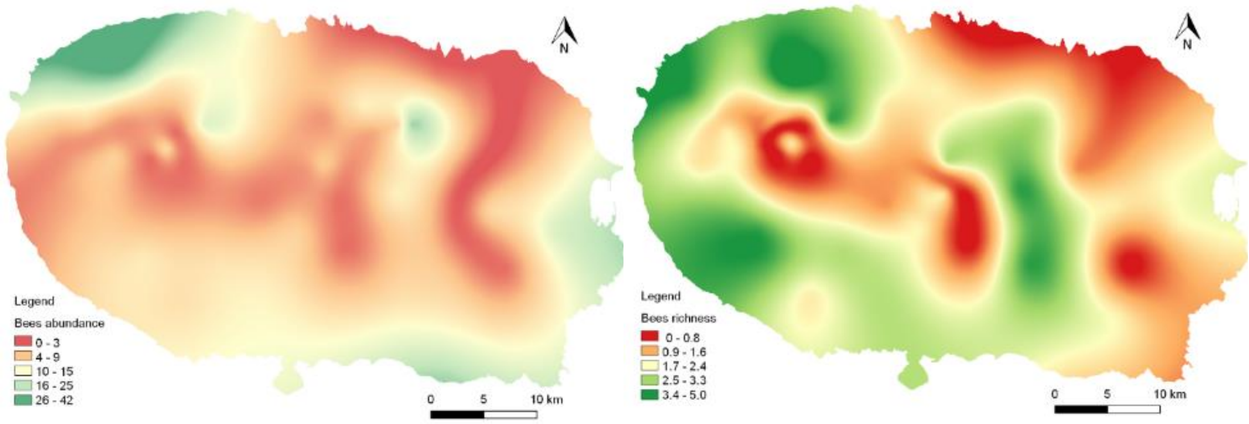


Figure 8.4. Map based on bees' *abundance (left) and richness (right) in Terceira Island.*

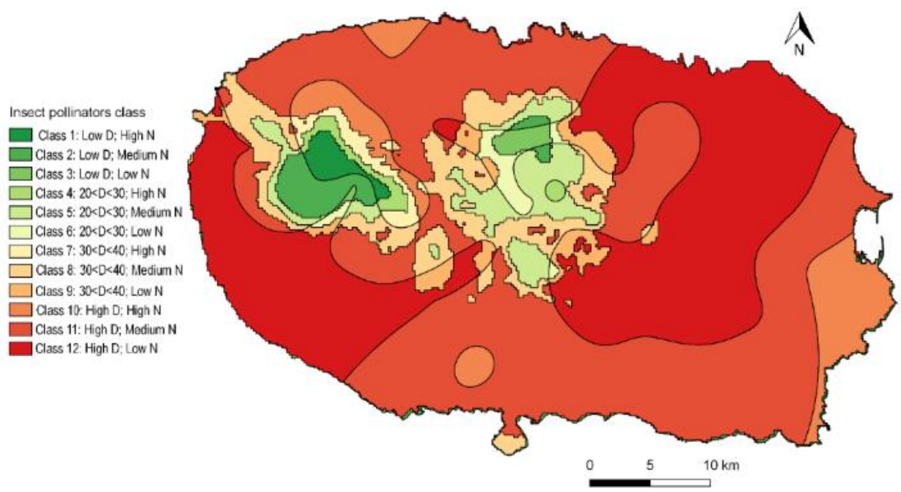


Figure 8.5. Map based on Disturbance and insect pollinator abundance in Terceira Island. Classes 1, 4, 7 and 10 have the highest potential to support pollination, despite the high disturbance on Classes 7 and 10.

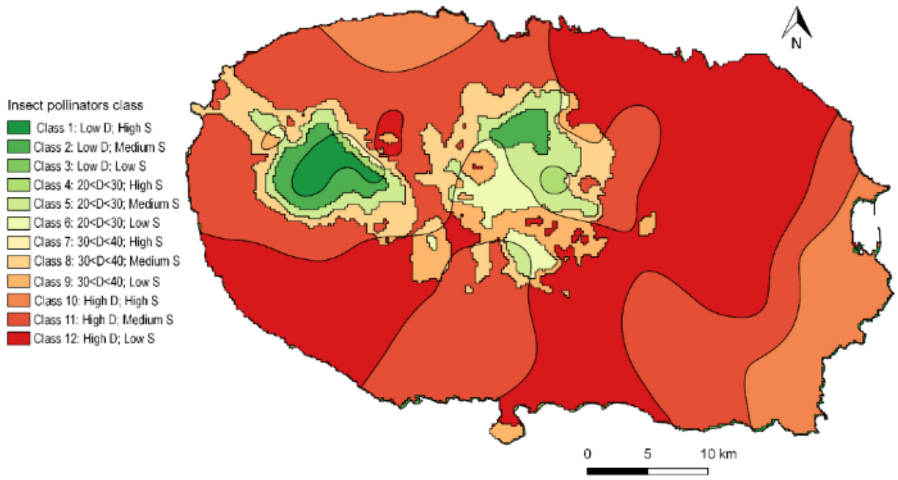


Figure 8.6. Map based on Disturbance and insect pollinator richness in Terceira Island. Classes 1, 4, 7 and 10 have the highest potential to support pollination, despite the high disturbance on Classes 7 and 10.

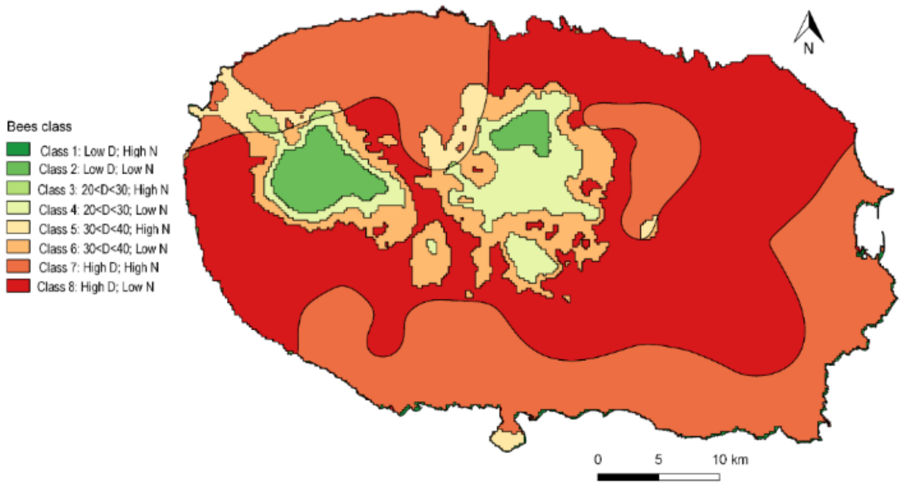


Figure 8.7. Map based on Disturbance and bees' abundance in Terceira Island. Classes 1, 3 and 6 have the highest potential to support pollination, despite the high disturbance on Class 6.

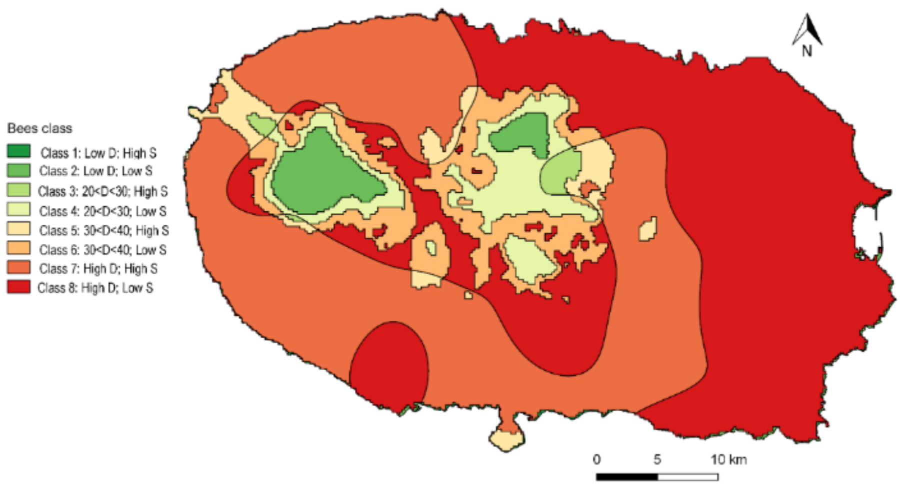


Figure 8.8. Map based on Disturbance and bees' richness in Terceira Island. Classes 1, 3 and 6 have the highest potential to support pollination, despite the high disturbance on Class 6.

2.3.1.2 Maintaining nursery populations and habitats

Indicator: *Proportion of arthropod endemic species*

The richness of epigean arthropods was investigated in 89 sites in four main relevant habitat types: natural forests (NatFor), exotic forests (ExoFor), semi-natural pastures (SemiPast) and intensively managed pastures (IntPast). In each site a transect 150 m x 50 m was setup and a total of 30 pitfall traps were used to sample epigean arthropods during two weeks in summer (for more details see Borges et al. 2005; Cardoso et al. 2009).

As described above, the mapping of the ES was performed using the "Topo to Raster" interpolation technique (in ArcGIS10©) applying an iterative finite difference interpolation technique. In this case, DEM were created using respectively as elevation data the proportion of endemic arthropods in 89 sites from each habitat type (or land use).

Similarly, we applied the index of landscape disturbance (D) metric based on the attributes of the landscape matrix (Cardoso et al. 2013). Table 8.3 lists the 12 classes obtained for thresholds values between the disturbance index (D) and the proportion of endemic arthropods.

Table 8.3. Distribution of disturbance index (D) for the proportion of endemic arthropods (P) in 12 classes.

Class	D	P	Class	D	P
1	D<20	> 0.30	7	30<D<40	> 0.30
2	D<20	0.20<P<0.30	8	30<D<40	0.20<P<0.30
3	D<20	<0.20	9	30<D<40	<0.20
4	20<D<30	> 0.30	10	>40	> 0.30
5	20<D<30	0.20<P<0.30	11	>40	0.20<P<0.30
6	20<D<30	<0.20	12	>40	<0.20

Figure 8.9 and Figure 8.10 are two examples of mapping the ES "Nursery populations and Habitats".

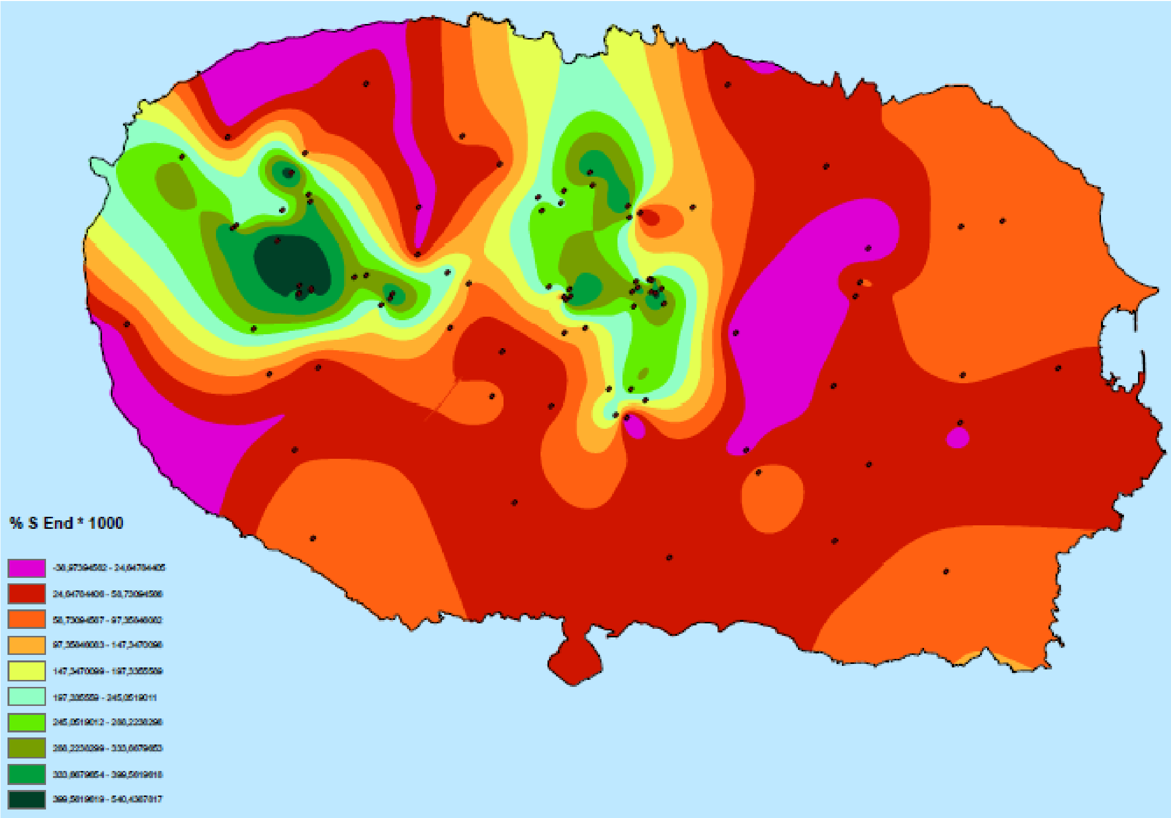


Figure 8.9. Map based on the proportion of arthropod endemic species in Terceira Island.

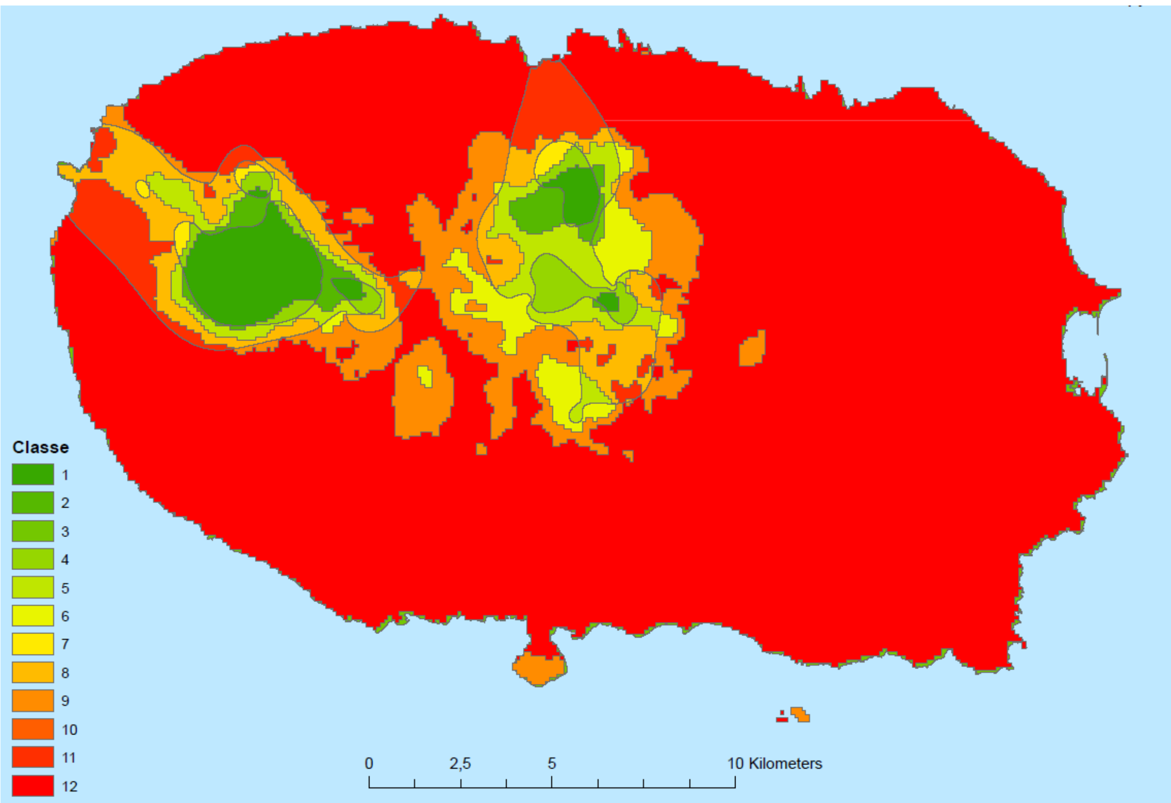


Figure 8.10. Map based on Disturbance and the proportion of arthropod endemic species in Terceira Island. Classes 1, 4 and 7 have the highest potential to support endemic species, despite the high disturbance in Class 7.

8.5. Use and integration of ES mapping and assessment results

8.5.1. Addressing the policy question

ES assessment and mapping in Azores are just starting to be implanted, and include the study of pollination and seed dispersal services (e.g. Pereira, 2008; Heleno *et al*., 2009; Olesen *et al.*, 2002, 2012; Picanço *et al*., 2017a,b) and other types of ES assessments (e.g. Cruz *et al*., 2011; Mendonça *et al*., 2013; Vergílio *et al*., 2016). Thus, our study provide one of the first real MAES study at a whole island scale in Azores, contributing for the best understanding of the links between biodiversity conservation and ES.

The interception between the biodiversity indicators and a map of disturbance demonstrates that for the case of pollinators, agro-ecosystems are also hosting a high diversity and abundance of native insect pollinators in Terceira island (see also Picanço *et al*., 2017a). However, for the ES 2.3.1.2 - *Maintaining nursery populations and habitats*, the intersection of the biodiversity indicator with disturbance shows clearly that only sites with low disturbance are able to support nursery populations (See Figure 8.10).

8.5.2. Dissemination and communication of results

The data used for current studies were published by Gaspar *et al.* (2011) and Picanço *et al.* (2017a). In the case of the ES *Maintaining nursery populations and habitats (2.3.1.2),* published by Gaspar *et al.* (2011), results allowed the implementation of the IUCN based network of protected areas in Azores, with the creation of new protected areas in Terceira and Santa Maria islands (see also Borges *et al*., 2011). This case-study has been presented to the Azorean Environment Services Authority several times during the last years and as a consequence we have implemented a monitoring scheme in six islands using SLAM[49] traps (see). The same data was influential in the development of Ecosystem Assessment Profiles within BEST III project for Macaronesia[50] and the creation of Key Biodiversity Areas (KBAs) for Azores.

The follow up of the pollination study will be: i) Determine the characteristics and strength of pollination networks in different Azorean crops highly dependent on pollinators; ii) Evaluate if ecological intensification practices improve pollinator efficiency and these result in an increased crop yield which in turn provide an economic benefit for farmers; iii) Map pollinator ES in agroecosystems and quantify its economic value.

[49] http://gba.uac.pt/research/projects/ver.php?id=18

[50] http://www.azores.gov.pt/Gra/BEST_III_Macaronesia/conteudos/noticias/2016/Maio/NOTICIAS_BEST_27-05-2016.htm

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Annex

Case study booklet for:

WORKSHOP 5: "Testing the methods across biomes and regions"

Madrid, Spain, 04-07 April 2017

(Picture by Petar Nikolov)

9. Mapping and assessment of ES in Central Balkan area in Bulgaria at multiple scales

28th March 2017

ESMERALDA partner: National Institute of Geophysics, Geodesy and Geography (NIGGG), BAS

Case Study Coordinators: Stoyan Nedkov, Bilyana Borisova

ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

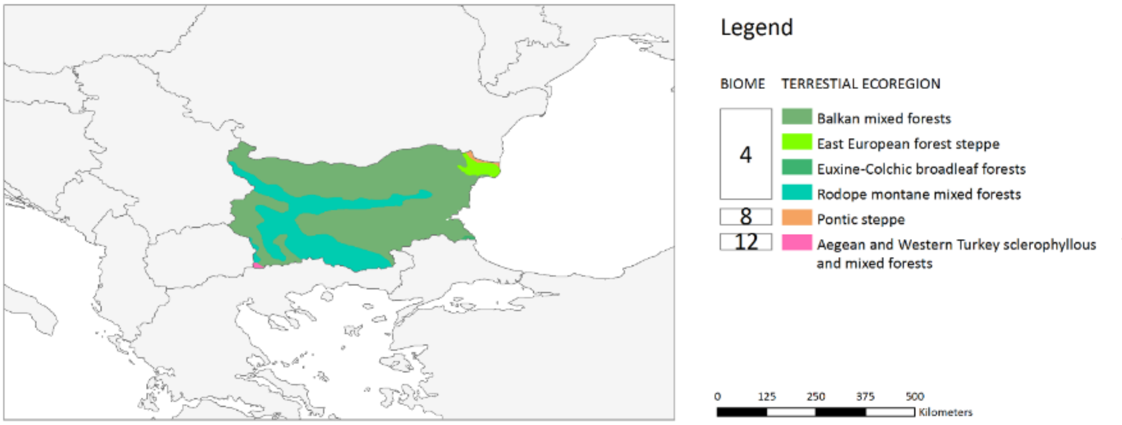
9.1. Case study factsheet and study area description

Central Balkan area WS5_cs3

NAME AND LOCATION OF STUDY AREA	Central Balkan area
COUNTRY	Bulgaria

STATUS OF MAES IMPLEMENTATION			
	Stage 1	**Stage 2**	Stage 3

BIOMES IN COUNTRY		
	1 Tropical & Subtropical Moist Broadleaf Forests	**4 Temperate Broadleaf & Mixed Forests**
	5 Temperate Conifer Forests	6 Boreal Forests/Taiga
	8 Temperate Grasslands, Savannas & Shrublands	11 Tundra
	12 Mediterranean Forests, Woodlands & Scrub	13 Deserts and Xeric Shrublands
	14 Mangrove	



SCALE	national	**sub-national**	**local**
AREAL EXTENSION	**2998.9 km²**		

THEMES				
	nature conservation	climate, water and energy	marine policy	natural risk
	urban and spatial planning	**green infrastructures**	**agriculture and forestry**	**business, industry and tourism**
	health	ES mapping and assessment		

ECOSYSTEM TYPES				
	urban	cropland	**grassland**	**woodland and forest**
	heatland and shrub	sparsely vegetated land	wetlands	rivers and lakes
	marine inlets and transitional waters	coastal	shelf	open ocean

Study area description

The study area is located in Central Bulgaria and covers the central part of the Balkan Mountains (Stara Planina) and the surrounding areas (Figure 9.1). The spatial coverage is outlined by following both natural and administrative criteria including all the municipalities that have parts of their areas in the Central Balkan National Park. In total the area covers 2,998.9 km^2 of which 24% is proclaimed for protected areas (37 areas in total). The most important protected area is the Central Balkan National Park (71,825.5 ha) which encompasses 9 other protected areas within its borders. The average altitude is 913 m and ranges from 265 m in the Karlovo plain to 2376 m at the Botev peak (the highest summit in the Balkan Mountains). Although the study area is relatively small, the nature is diverse due to the influence of the Balkan Mountain Range, which leads to the formation of different hydro-climatic conditions in the higher altitudes and in the northern and southern parts of the mountain. There are three types of climate-temperate continental in the north, transitional to Mediterranean in the south and mountainous in the central part and in the areas above 1000 m. The average annual temperatures vary from south to north from 11.1^{o}C to 10.0^{o}C in Troyan and decrease to 0.7^{o}C at Botev peak. The southern part is drier than the northern part. The mean annual precipitation changes from 550 mm to 800 mm and the quantities raise up to 1100 mm with the increase in altitude. The vegetation is characterized by typical altitudinal zoning. In the lower parts, the vegetation is presented by Oak and Oak-Hornbeam forests followed by beech forests in the areas above 800 m and mountain grasslands at the highest parts of the mountain.

The study covers partially the territory of 9 municipalities – Teteven, Anton, Pirdop, Karlovo, Sopot, Sevlievo, Apriltsi, Troyan and Pavel Banya. Only two of them - Karlovo (103,911 ha) and Sopot (5630 ha) are entirely comprised within the study area. There are 82 settlements with total population of 128,626 residents and 58% of the population (74,205 inhabitants) lives in the urban areas. The biggest towns are Karlovo (25,715 inhabitants) and Troyan (23,623 inhabitants).The population of Karlovo municipality is estimated to 50,650 residents and has decreasing trend due to a negative growth rate. The territorial balance of the Karlovo municipality is dominated by forests (51%) and agricultural lands (45%), with 3% urbanized areas, 0.9 % water bodies and 0.4 % transport and energy infrastructure. The significant forest area determines development of timber industry, hunting, educational, and eco-tourism.

The Central Balkan National Park occupies the higher parts of the mountain and ranges 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. The flora is represented by 2340 species and subspecies of plants. Forests occupy 56% of the total area. There are 59 species of mammals, 224 species of birds, 14 species of reptiles, 8 species of amphibian and 6 species of fish, as well as 2387 species of invertebrates. The national park includes nine nature reserves protected by strict regime and covering 28% of its territory.

9.2. Main policy question and theme

9.2.1. Objectives of ES mapping and assessment

The ES mapping and assessment have been implemented through several activities carried out in the framework of several research projects including regional or national assessment initiatives:

1) The very first mapping and assessment activity was realized through a flood hazard assessment project directed to define the supply of and demand for flood regulation in mountain watersheds (Nedkov and Burkhard, 2012; Nedkov et al. 2015).
2) A scientific research on water related ES in the northern part of Central Balkan National Park of the watersheds of the River Yantra and River Vidima and the upper part of Ogosta basin located in the western part of Balkan Mountains (Boyanova et al. 2014; 2016).
3) The Central Balkan area has been assessed in terms of the area's potential to provide ES that form the current and future basis for the local economy and for the social welfare (Borisova et al. 2015). The analysis focuses on the territory of the administrative units of Apriltsi Municipality and the Mayoralty of Kalofer located in the Central Balkan region (covering 774 km^2). The spreadsheet method in the form of the "matrix" proposed by Burkhard et al. (2009) was used; however, applied to landscapes as basic units for spatial analysis. The evaluation was carried out through expert-based assessment via face-to-face interviews with the local administration and was supported by analysis of the landscape structure, hemeroby assessment, and analysis of strategic documentation. In 2016, the study was expanded to encompass the Karlovo Municipality, in cooperation with a collaborative PhD seminar supported by the projects "The Mountain" (Center of Excellence in the Humanities, Sofia University St. Kl.Ohridski), TUNESinURB, and ESMERALDA. During the seminar, interviews targeting the local population in the Central Balkan area have been conducted and the contingent valuation method (Assenov and Borisova, 2016) was applied.
4) A pilot valuation of the ES provided by the forests of the Central Balkan National Park has been conducted with the financial support of EU Environment Operation Program. The results envision the sustainable management of the National Park (Dimitrova et al., 2015).
5) The area of Karlovo municipality was a case study in the project "Toward better UNderstanding the ES in URBan environments through assessment and mapping" (TUNESinURB, funded under the FM of EEA 2009-2014). The project aims to create an ecosystem based geo-information system of the ES condition and of the ES provided by the urban ecosystems in Bulgaria, excluding the NATURA 2000 zones. The procedure follows the "Methodology for mapping and assessment of urban ecosystems and their services in Bulgaria" (Zhiyanski et al. 2017). It includes the following stages: a) urban ecosystems mapping; b) assessment and mapping of the ecosystems condition (based on 37 indicators); and c) assessment and mapping of 25 classes of ESs. The results are oriented towards a better understanding of the ES concept and its possible implementation in sectoral policies, spatial planning, and territorial development.

9.2.2. Stakeholders and their role

Taking into account the fact that the case study area includes the Central Balkan National Park, most of the above-mentioned studies were conducted with the active cooperation with the Central Balkan NP Directorate. The Directorate provided representative statistical information about the activities and functions in the Park. Additionally, the Public Advisory Council at the Park participated in the workshops aiming to promote the importance of the ES investigation (Dimitrova et al., 2015). Municipal authorities and stakeholders from the local business communities, mainly from the fields of tourism and recreation, pastoral farming, and forestry, were involved as experts in the assessment of selected ES (Reared animals and their outputs, Wild plants, algae and their outputs, Fibres and other materials from plants, Algae and animals for direct use or processing, Plant-based resources, Physical use of land-/seascapes in different environmental settings) (Borisova et al. 2015).

9.3. Ecosystem Types and Conditions

9.3.1. Identification and mapping of ecosystem type(s)

The identification of ecosystem types is based on the MAES typology (MAES, 2013) at level 2 and CORINE Land Cover data. There are seven ecosystem types identified in the case study area (Figure 9.1) – urban, agricultural, grassland, woodland and forest, heathland and shrub, sparsely vegetated land, rivers and lakes. The largest area is occupied by woodland and forest ecosystems (60% of the case study) followed by agricultural (22%) and grassland 12%). The urban ecosystems cover3.2% of the area while shrub (1.1%), sparsely vegetated areas (0.2%), and rivers and lakes (0.2%) have limited extend.

Figure 9.1. *Ecosystem types in Central Balkan case study area*

The MAES typology applied in Bulgaria was further developed at level 3 in the framework of the project Methodological assistance for ecosystems assessment and biophysical valuation (MetEcosMap). Each ecosystem type was divided in subtypes based on the specific natural conditions in Bulgaria and the availability of spatial data. The final version of the typology includes altogether 58 ecosystem subtypes at level 3 which number varies from 3 to 16 between the different ecosystem types (Table 9.1). The subtypes were chosen in correspondence with EUINS habitat classification and the national standards for each ecosystem type. For example the urban ecosystems were defined in correspondence with the National concept for spatial development for the period 2013 – 2025 developed by Ministry of Regional Development. The indices chosen to represent the subtypes correspond to EUNIS nomenclature. For example "J" was chosen for urban ecosystems, "G" for woodland and forest, "D" for wetlands. Woodland and forest typology was even further developed at level 4.

Table 9.1. Ecosystems typology in Bulgaria

Level 1	Level 2	Level 3 (EUNIS 2) - BG specific
Terrestrial	Urban	J1-10 (10 subtypes)
	Cropland	1-5 (5 subtypes)
	Grassland	1-5 (5 subtypes)
	Woodland and forest	G1-4 (4 subtypes) (level 4)
	Heathland and shrub	F2, 3, 9 (subtypes)
	Sparsely vegetated land	1-5 (5 subtypes)
	Wetlands	D1, 4, 5 (3 subtypes)
Fresh water	River and Lakes	C, J, X (16 subtypes)
Marine	Marine inlets and transitional waters	1-8 (8 subtypes)
	Coastal area	
	Shelf	

The urban ecosystems in the area of Karlovo municipality were identified and mapped at level 3 of the typology (Zhiyanski et al. 2015). At national level, there are 10 urban ecosystem subtypes and seven of which are identified in Karlovo (Figure 9.2).

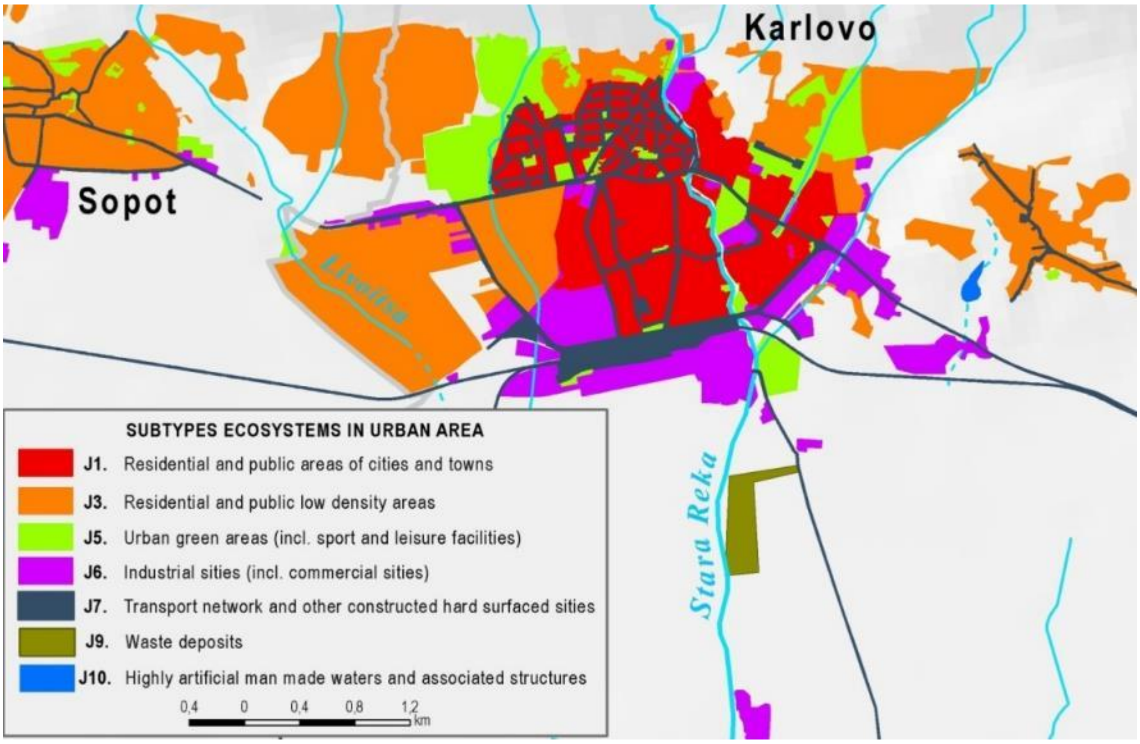


Figure 9.2. Urban ecosystem subtypes in the city of Karlovo.

9.3.2. Assessing ecosystem conditions

The condition of the ecosystems in the municipalities comprised of the Central Balkan NP was assessed within the study on national assessment of the urban ecosystems. The concept is based on the ecosystem integrity. The methodological framework is described in the project MetEcosMap and the used indicators are presented in Table 9.2.

An operational set of 37 indicators (10 mandatory and 27 recommended) was selected. This set reflects both the geographical conditions and the interactions between people and urban environment as factors that influence the current state of the urban ecosystems. The impacts have been studied in terms of the system's biotic diversity, abiotic heterogeneity, energy, matter, and water budget. Each indicator meets four general criteria: policy relevance, analytical soundness, primary data contribution and measurability, and level of aggregation. For each indicator, according to the type of the initial database, an individual assessment scale that matches the final score of the urban ecosystem state has been developed (scale from 1 - very bad, to 5 - very good). The expert-based assessment of the selected indicators was applied to each unit (GIS polygon) of the urban ecosystem subtypes. The preliminary results show that urban ecosystems in Bulgaria are predominantly in a "moderate" to "good" condition and only individual subsystems (J6 - industrial sites) indicate "bad" condition. The condition of urban ecosystems at national level was mapped in a set of 61 map sheets at scale 1:125000 (Figure 9.3).

Table 9.2. 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 production
		Habitat diversity			Metabolic efficiency
		Invasive species			Other energy budget
		Oher biotic heterogeneity		**Matter budget**	Matter balance
	Abiotic heterogeneity	Soil heterogeneity			Element
		Hydrological heterogeneity			Efficiency measures
		Air heterogeneity		**Water budget**	Water balance (input,
		Geomorphological			Water storage
		Other abiotic			Other state indicator
					Efficiency measures

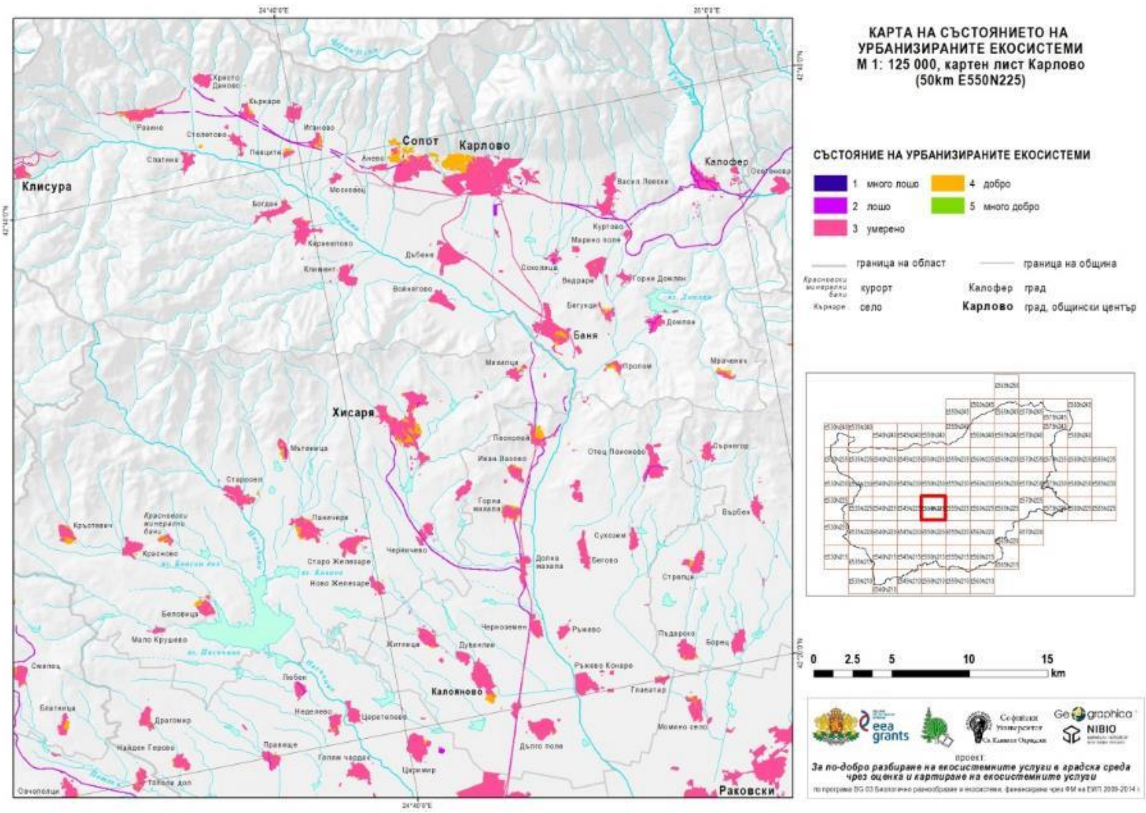


Figure 9.3. Condition of urban ecosystems in Karlovo map sheet (The area of the Central Balkan case study falls within two map sheets – E550N220 and E550N225).

9.4. Mapping and assessment of ES

9.4.1. Identification of ES

Following the above-mentioned activities, several ES identified in the study area have been considered for further analysis. In the project TUNESinURB, 25 urban ES have been selected, mapped and assessed (Annex: Table 9.4). The services selected in the other projects and activities partially overlap with the services in TUNESinURB but differ in their spatial dimensions and methods used for mapping and assessment. For the ESMERALDA we focused on seven ES assessed by biophysical, socio-cultural, and economic methods (Table 9.3). Two of them, surface water for drinking and flood regulation, are mapped at multiple scales and represent multiple tiers. Surface water for drinking was assessed during activity 2 (see section 9.2.1) at local scale using hydrological modeling tool which corresponds to Tier 3. The same service in activity 4 was assessed at national level using spatially related statistical data which corresponds to Tier 2. Flood regulation was assessed in activities 1 and 4 which correspond to Tier 3 (hydrologic modeling) and Tier 2 (statistical data) respectively.

Table 9.3. Overview of the ES and related mapping and assessment methods in the Bulgaria case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.2.1 Surface water for drinking*	x		
1.2.2.1 Surface water for non-drinking purposes	x		
2.2.2.2 Flood regulation	x		
2.3.5.1 Global climate regulation	x		
2.3.5.2 Micro and regional climate regulation	x		
3.1.1.1 Experiential use of plants, animals and land/seascapes			x
3.1.2.5 Aesthetic*		x	

* ES selected for further discussion during ESMERALDA workshops 5 in Madrid;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

9.4.2. ES mapping and assessment: biophysical methods

Several biophysical methods, which rely on different types of data, have been applied in the study area. The urban ecosystems are mapped and assessed by using the polygons from the GIS database of the ecosystem subtypes as mapping units, expert assessment (Tier 1) and statistical data for quantification (Tier 2). Global climate regulation, micro and regional climate regulation and aesthetic value are mapped and assessed using different kind of quantitative data which correspond to Tier 2. Expert assessment and land cover based units are used for genetic materials and pest control mapping. Some water related ES are assessed by using large scale LULC datasets, topographic and soil data in combination with process-based modelling (Tier 3). Such approach is applied for surface water for drinking and flood regulation.

Mapping of provisioning services

1.1.2.1 Surface water for drinking

Indicator: *Evapotranspiration*

The combination of process based modelling, spread-sheet analysis, and the footprint concept (blue and green footprint) was applied for mapping of freshwater supply. The approach relies on GIS-based hydrological modelling performed through the ArcSWAT tool. This tool utilizes SWAT model in ArcGIS environment and is appropriate for application in medium to large watersheds. The model simulates water balance parameters used to quantify the water retention of different ecosystems within the watershed. The outputs are runoff, infiltration, sediment yield and evapotranspiration. The latter is used as indicator to quantify the amount of water retained of the ecosystems in the watershed and develop a map representing the freshwater supply capacity (Figure 9.4).

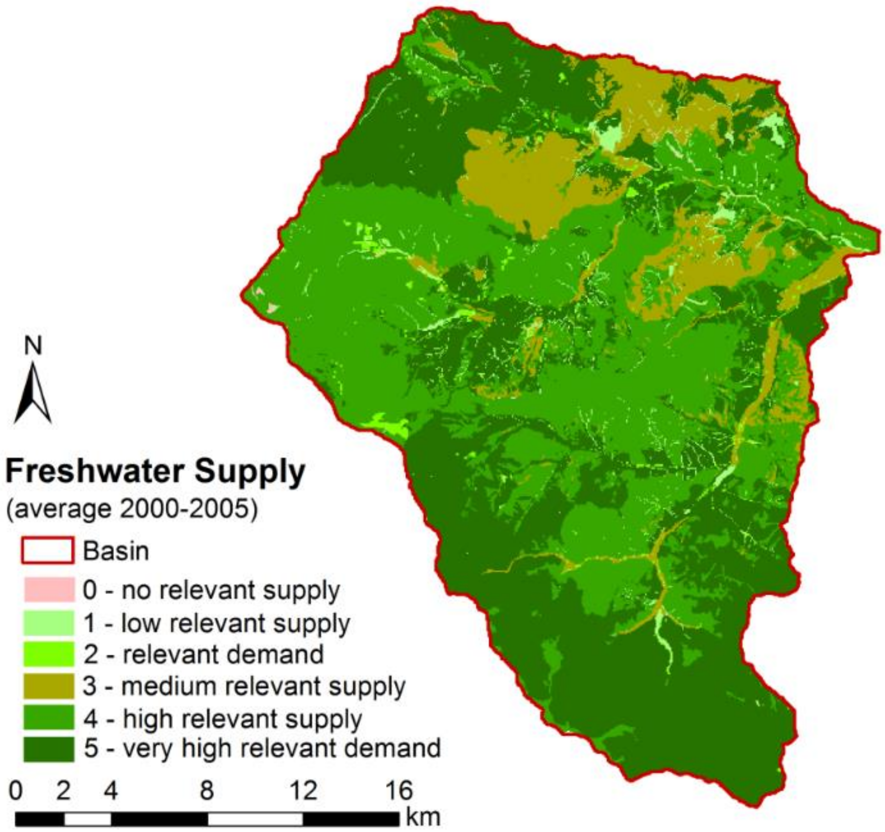


Figure 9.4. Fresh water supply in upper Ogosta river basin.

1.2.2.1 Surface water for non-drinking purposes

Indicator: *precipitation; evapotranspiration; and surface water*

The surface water for non-drinking purpose is assessed at national scale for the urban ecosystems within the frame of TUNESinURB project. It relies on three indicators – precipitation; evapotranspiration; and surface water. The precipitation and evapotranspiration were quantified by using spatial proxy models based on measured point sources and regression relationship between the two variables and the elevation. The third indicator was defined with the presence of surface water body and the information was derived from integrated index of spatial structure of urban ecosystems (Nedkov et al. 2016).

Mapping of regulating and maintenance services

2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations

Indicator: *carbon storage per ecosystem*

The spatial proxy method was applied for mapping and assessment of global climate regulation service. The approach was developed for assessment of urban ES at national level in Bulgaria. Carbon storage per ecosystem is defined as an indicator that represents the regulation function of the ecosystems that controls CO_2 concentration in the atmosphere. It relies on delineation of urban ecosystems, calculation of three ecosystem condition parameters (integrated index of spatial structure, soil organic carbon and vegetation cover), and the spatial approximation of carbon content in soils and vegetation. The amount of carbon is calculated for each polygon of the GIS database using data for vegetation cover, vegetation type (trees, shrub or grass), and average amount of carbon in vegetation types by value transfer from literature and soil carbon contend by value transfer.

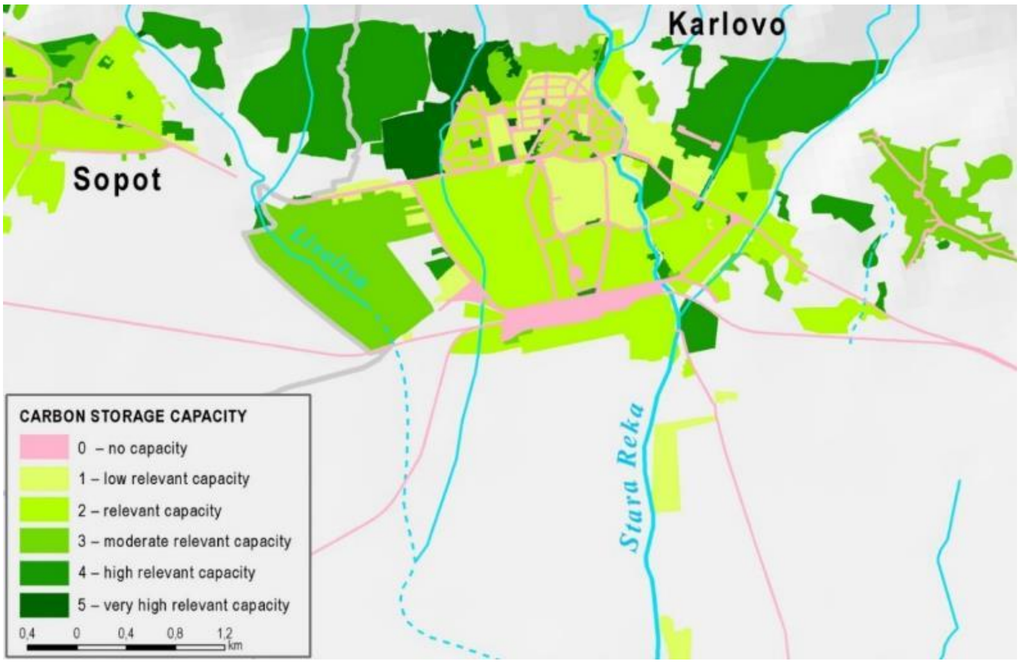


Figure 9.5. Global climate regulation supply capacity of the urban ecosystems in the city of Karlovo.

2.3.5.2 Micro and regional climate regulation

Integrated Assessment based on Indicators: *Integrated Index of Spatial Structure, Vegetation Cover and Water Bodies*

The method apply cartographic analysis, related to the spatial structure (composition and configuration) of urban ecosystems with a focus on the elements of the green infrastructure. The procedure of complex assessment is based on the sum of the following three indicators: 1) “Integrated Index of Spatial Structure” - on a scale from 1 to 5 (1 - very low potential, 2 - low potential, 3 - average potential, 4 - high potential 5 - very high potential) – which represents the potential of the indicator to influence the urban ecosystem state; 2) „Vegetation Cover” - using the same scale from 1 to 5 – which shows the potential of the indicator to influence the urban ecosystem state and 3) “Water bodies” – with a value of 0 or 1 (0 - absence /1 – presence of water bodies in the unit/polygon of the urban ecosystem types). Visualization of areas of different potential to supply the respective ES follows GIS spatial analysis of the integrated assessment's results of each unit/polygon of the urban ecosystem types on a scale from 1 to 5 (1 - very low potential, 2 - low potential, 3 - average potential, 4 - high potential 5 - very high potential).

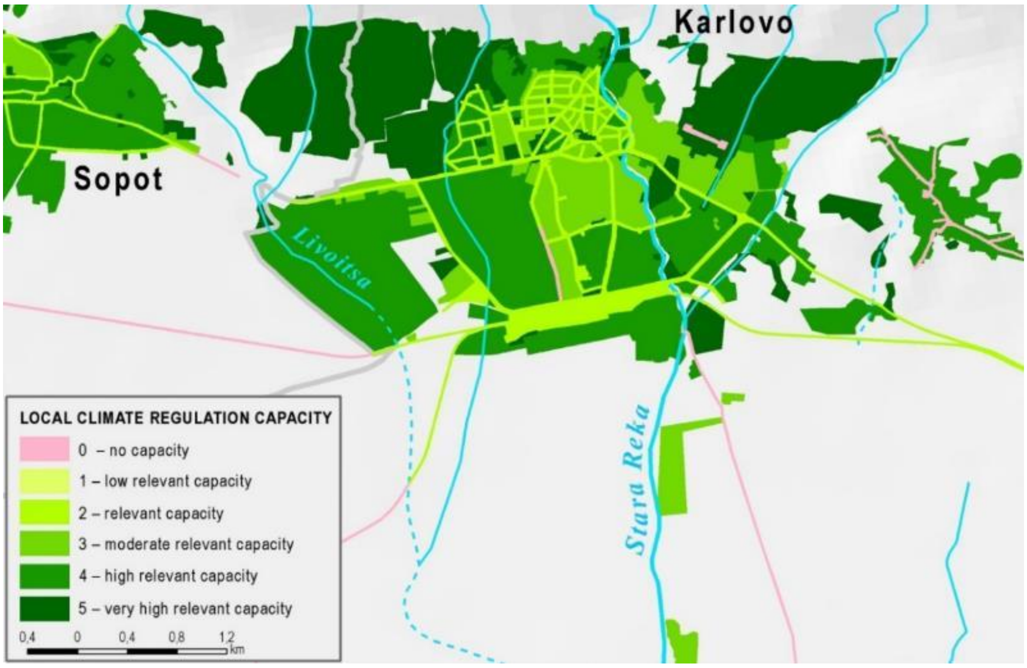


Figure 9.6. Micro and regional climate regulation supply capacity of the urban ecosystems in the city of Karlovo.

2.2.2.2 Flood protection

Indicator: *Infiltration, surface runoff and peak flow*

Flood protection ES was mapped and assessed in three watersheds in the northern part of the case study area by the process based modelling method. The approach relies on GIS based hydrological modelling performed through the extension ArcGIS AGWA2. It incorporates KINEROS (and SWAT) model, which is suitable for application in relatively small (up to 100 km^2) watersheds with predominantly surface runoff. The model simulates water balance parameters within the watershed, which are used to quantify the regulation function for the different ecosystems. The outputs of the model used as indicators for flood regulation are infiltration, surface runoff and peak flow. They represent the ability of the ecosystem (through vegetation and soil) to "absorb" part of the precipitation water thus reducing the amount of runoff during flood events. Therefore, they allow to quantify the flood prevention function of the ecosystems in the watershed which ensures flood protection ecosystem service.

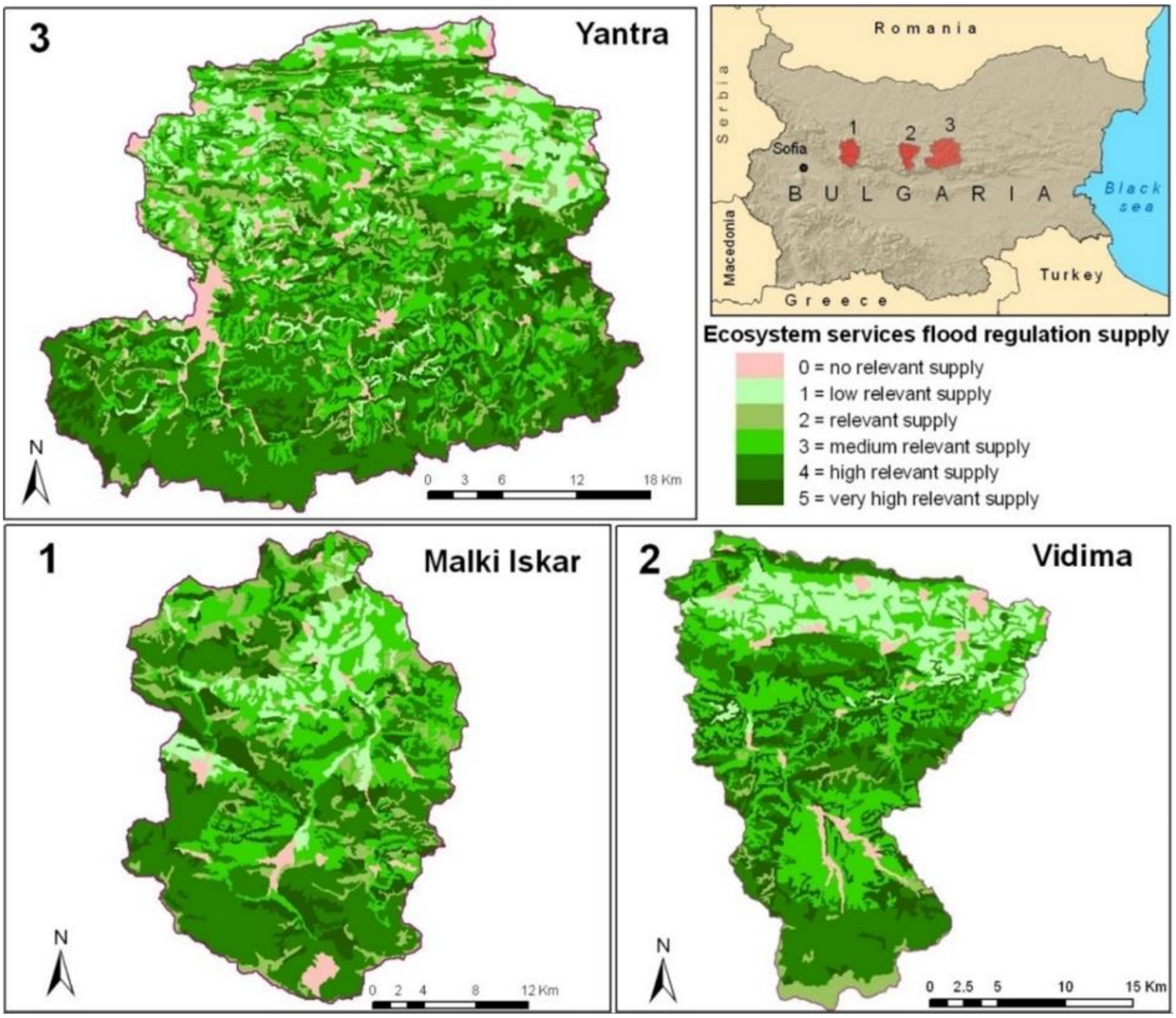


Figure 10. *Flood regulation supply capacity in three watersheds of Central Balkan area*

9.4.3. ES mapping and assessment: socio-cultural methods

Social methods for mapping and assessment were applied only for cultural ES in the framework of TUNESinURB project.

Mapping of cultural services

3.1.2.5 Aesthetic

Indicator: *Number of pictures*

The method of photo elicitation survey was applied to aesthetic ecosystem services (AES), which refer to the visual, sensitive, and intellectual interactions with the physical environment. A representative documentation about these interactions are photos that people take and upload in the social media or other public virtual space. The application of the method includes delineation of ES subtypes in the study area; integration of the urban ecosystem subtypes map with the Google Earth pictures uploaded in the map frame; selection of all pictures in each polygon, excluding of the pictures with personal information and counting the number of all pictures related to each polygon; aggregation of the resulting information and scoring. Therefore, the number of pictures uploaded within the area of a polygon of particular ecosystem subtypes is assumed as measure of its aesthetic value. The study was implemented in four case study areas - Varna, Karlovo, Maritsa and Makresh that represent different types of urban areas in Bulgaria. The scoring of AES capacity was applied individually for each case study area. As shown in Figure 9.7, the scoring intervals for Karlovo are as follows: 1 (1-2 pictures); 2 (2-9); 3 (10-42); 4 (42-76); 5 (76-324). The assessment at national level was conducted by integration of the case studies' results and the ecosystem subtypes.

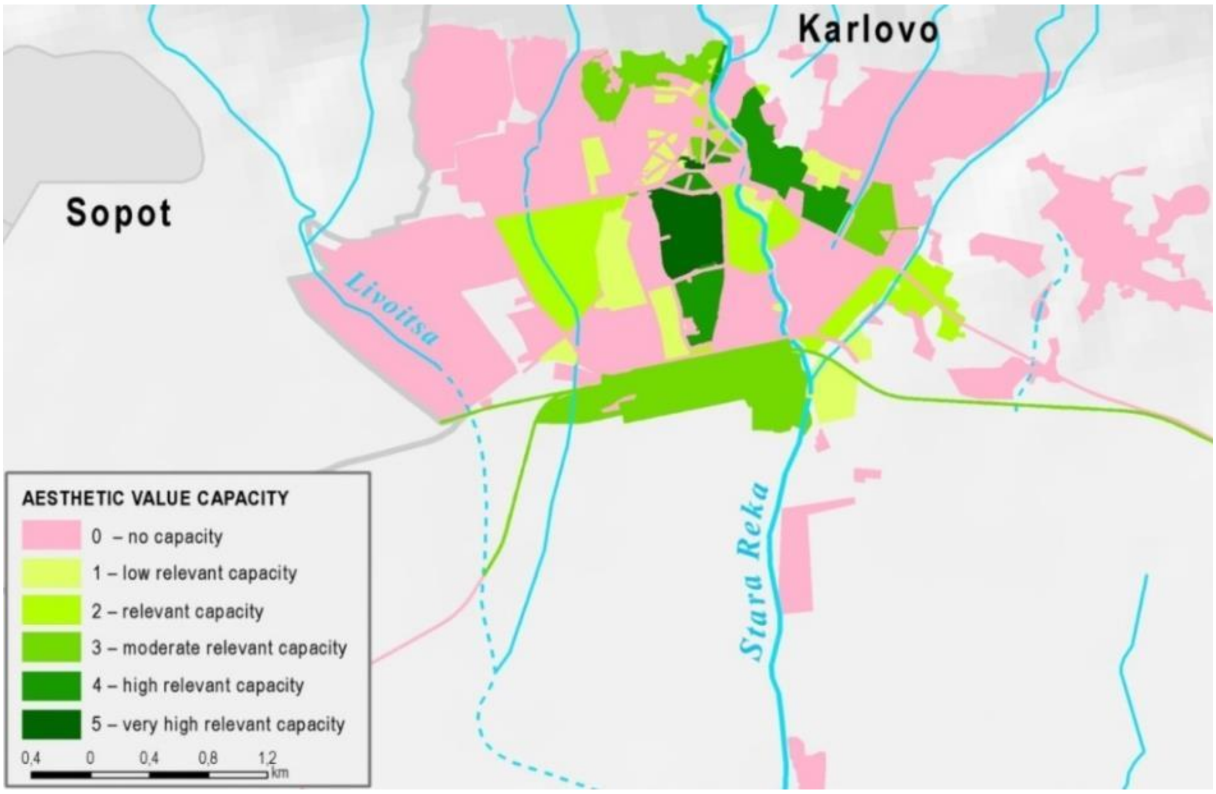


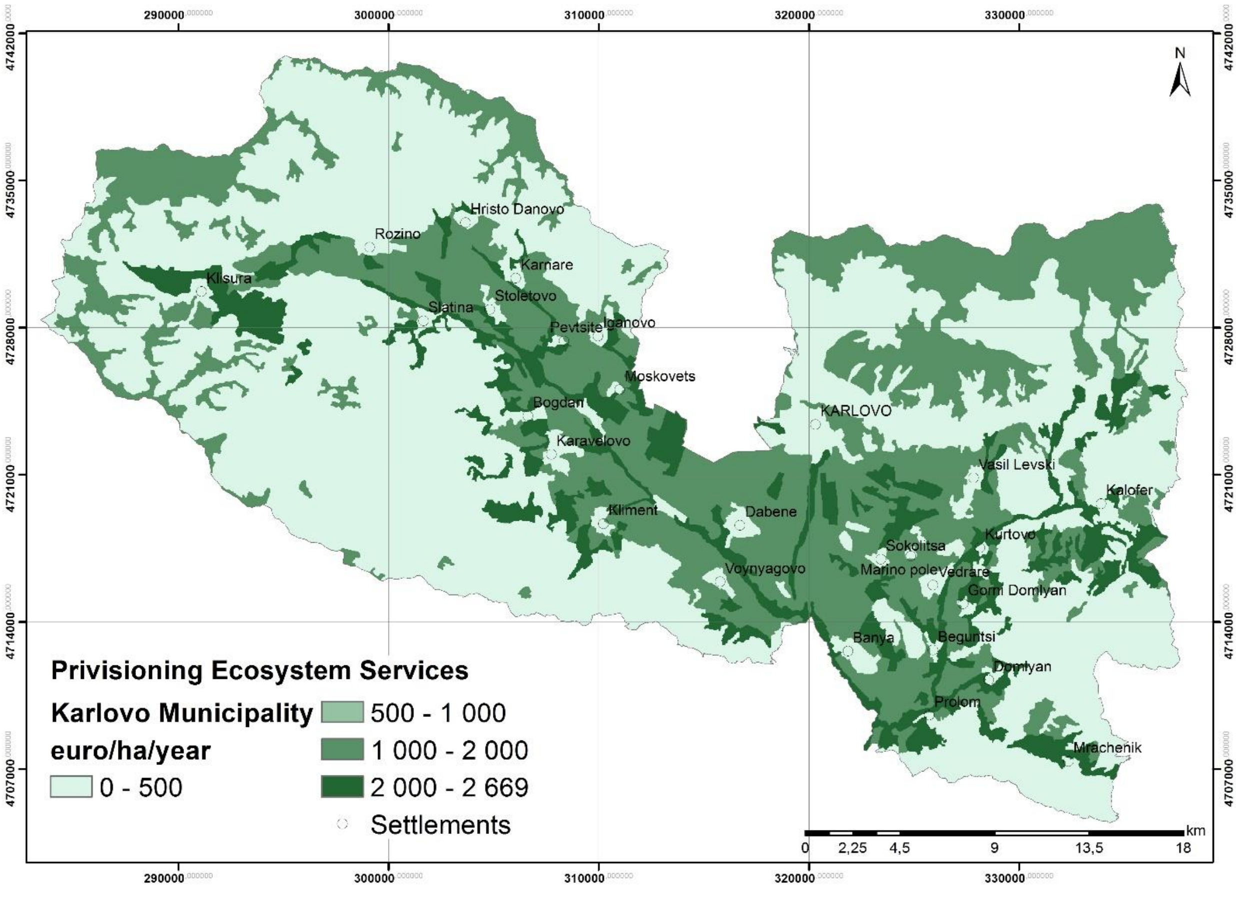
Figure 9.7. Aesthetic value of urban ecosystems in the city of Karlovo.

9.4.4. ES mapping and assessment: economic methods

The selection of economic valuation methods for the ES in Karlovo municipality is described in detail in the research work of Koulov et al., (2017, in press). The investigation is a result of a preliminary analysis, which takes into account the applicability of key indicators provided by the national and regional statistics (Average yield per year, t/ha/yr; Number and capacity of accommodation sites, Site visitation, number/yr; Investments in forest plantations), the possibility and applicability of transferring data or using generalizations, as well as the spatial variations of representative ES (Tier 2). The study relies mostly on the method of market prices, in combination with the replacement cost method, net financial contribution (NFCu), and the transfer value method, based on data from Bulgarian mountain municipalities with similar physical and human geographic characteristics. In addition, the study methodology integrates economic and biophysical methods. The investigation interprets the CORINE Land Cover, 2012 classes as spatial units for identification of ecosystem types – classes and sub-classes (MAES, 2013) and for valuation of the ecosystem services - classes and class types (CICES 4.3). The results include: a) the Total Economic Value (TEV) of the Karlovo municipality (euro/ha/yr.) and b) the combined value of the significant ES for the local economy and welfare provided by the dominant in the particular municipality ecosystem classes - Urban, Cropland, Grassland, Woodland &Forest, and sparsely vegetated areas (LULC 2012). Geospatial analysis was used to identify ES distribution, hotspots, synergies and trade-off.

Mapping of provisioning Services

1.1.1.1 Cultivated crops
1.1.1.2 Reared animals and their outputs
1.1.1.3 Wild plants, algae and their outputs
1.1.2.1 Surface water for drinking purposes
1.2.1.1 Fibres and other materials from plants, algae and animals for direct use or processing
1.2.1.2 Materials from plants, algae and animals for agricultural use
1.2.1.3 Genetic materials from all biota
Indicator: *euro/ha/yr.*
The combined economic value generated by the annual supply of the above mentioned ES was attributed to the total area of their spatial sources, i.e. to their ecosystem types, respectively.



Mapping of regulating and maintenance services

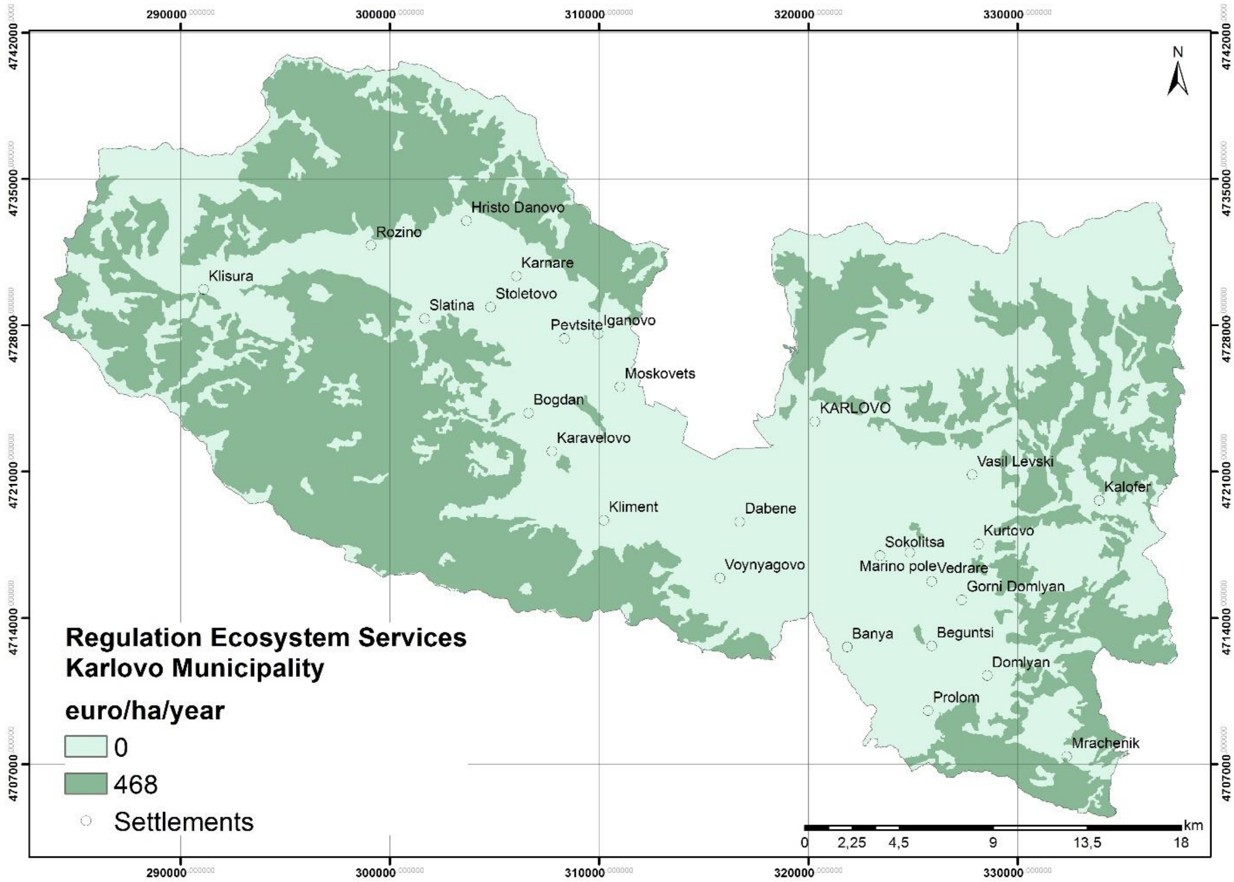
2.2.1.1 Mass stabilization and control of erosion rates
Indicator: *Cost of restoring soil quality*

2.2.2.1 Hydrological cycle and Water flow maintenance
Indicator: *Investments in forest plantations*

2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations

Indicator: *Carbon sequestration from forest ecosystems (CO2/yr./ha)*

The above listed indicators were used to value the supply of the respective services (Koulov et al., 2017, in press). The obtained values were allocated to the total area of Woodland and Forest ecosystems in the Central Balkan area.

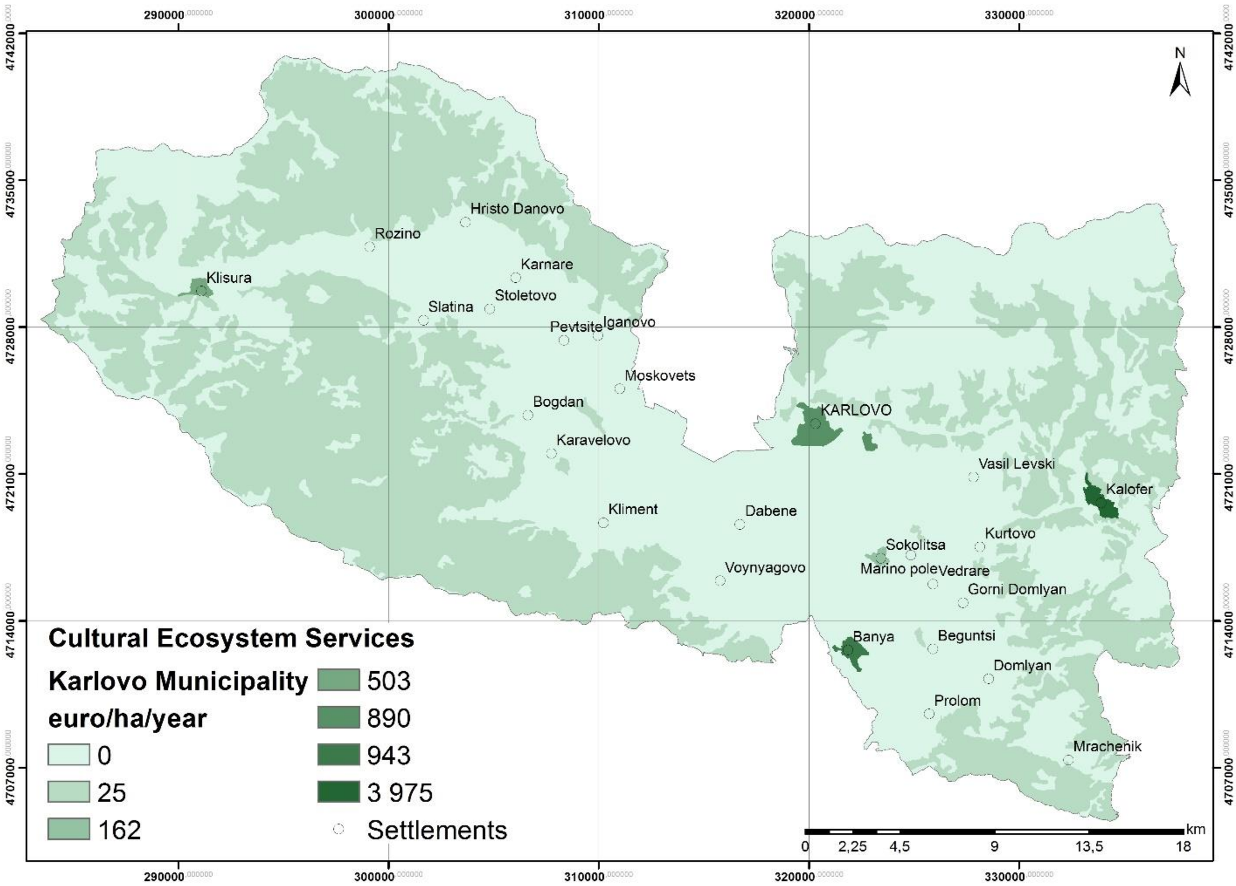


Mapping of cultural Services

3.1.1.1 Physical use of land-/seascapes in different environmental settings***Indicator:*** *number and capacity of accommodation sites* (number/yr.)

Indicator: *site visits* (number/yr.)

The above mentioned indicators were applied to identify, evaluate and map the supply of the ES recreation and tourism relative to the total area of Wood land and Forest and Urban ecosystems (Koulov et al., 2017, in press)



9.5. Use and integration of ES mapping and assessment results

9.5.1. Addressing the policy question

The integration of the results was achieved mainly in the assessment of the ecosystems' condition and of the ES. The outcomes referring to some indicators for urban ecosystem condition were successfully applied in the assessment of urban ES. For example, the integrated index of spatial structure was used as an indicator (direct use) for global climate regulation and air quality regulation while some of its elements were used in quantification of some indicators (indirect use) for the assessment of cultivated crops, surface water for drinking purposes, erosion regulation, pollination and local climate regulation.

9.5.2. Dissemination and communication of results

The results have been disseminated at a number of scientific conferences and PhD seminars (including field observation at the municipalities of Karlovo and Troyan), as well as workshops with stakeholders from the local authorities, local business communities, Central Balkan NP Directorate and the CBNP Public Advisory Council. A synergetic effect was achieved within the interdisciplinary teams of scientists from the Bulgarian Academy of Sciences and Sofia University St. Kliment Ohridski.

9.6. References & Annexes

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TUNESinURB project - http://tunesinurb.org/en/

The MOUNTAIN project - http://ukh.uni-sofia.bg/en/page.php?c=26&d=123

Annexes

Table 9.4. *ES selected for urban ecosystems assessment in project TUNESinURB*

Section	*Division*	*Group*	*Class (codes CICES)*
Provisioning	**Nutrition**	**Biomass**	P1. Cultivated crops (1111)
			P2. Reared animals and their outputs (1112)
			P3. Wild plants, algae and their outputs (1113, 1115)
			P4. Wild animals and their outputs (1114, 1116)
	Materials	**Water**	P5. Ground water for drinking (1122)
			P6. Surface water for non-drinking purposes (1221)
			P7. Ground water for non-drinking purposes (1222)
		Material	P8. Fibres and other materials (1211, 1212)
			P9. Genetic materials from all biota (1213)
	Energy	**Biomass-based energy sources**	P10. Plant and animal-based resources for energy (1311,1312)
			P11. Animal-based mechanical energy (1321)
Regulating and maintenance	**Mediation 1**	**Mediation by ecos.**	R1. Regulation of pollution and other impacts (2121,2122,2123)
	Mediation of flows	**Mass flows**	R2. Mitigation of erosion (2211,2212)
		Liquid flows	R3. Water flow maintenance and flood protection (2221,2222)
		Gaseous / air flows	R4. Regulation of air flows and atmospheric risks (2231,2232)
	Maintenance of physical, chemical, biological conditions	**Lifecycle maint. etc**	R5. Pollination and seed dispersal (2311)
		Pest and disease cntr	R6. Pest and disease control (2321,2322)
		Soil formation	R7. Regulation of soil formation and composition (2331,2332)
		Atmospheric and climate regulation	R8. Global climate regulation (2351)
			R9. Micro and regional climate regulation (2352)
Cultural	**Physical and intellectual interactions**	**Physical interactions**	C1. Recreation (3111,3112)
		Intellectual and representative	C2. Scientific and Educational (3121,3122)
			C3. Cultural heritage (3123)
	Spiritual, symbolic and other	**Spiritual**	C4. Aesthetic and spiritual (3125,3211,3212)
		Other cultural outputs	C5. Existence and bequest (3221,3222)