Guidelines and recommendations to support the application of the final methods

Deliverable D5.4

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ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

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1. Preface

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

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

The objective of ESMERALDA is therefore to share experience through an active process of dialogue and knowledge co-creation that will enable participants to achieve the aims of Action 5. The flexible methodology integrates biophysical, social and economic mapping and assessment methods. As shown in Figure 1.1, ESMERALDA is organized based on six work packages, organised through four strands, namely policy, research, application and networking, reflecting the main objectives of the project.

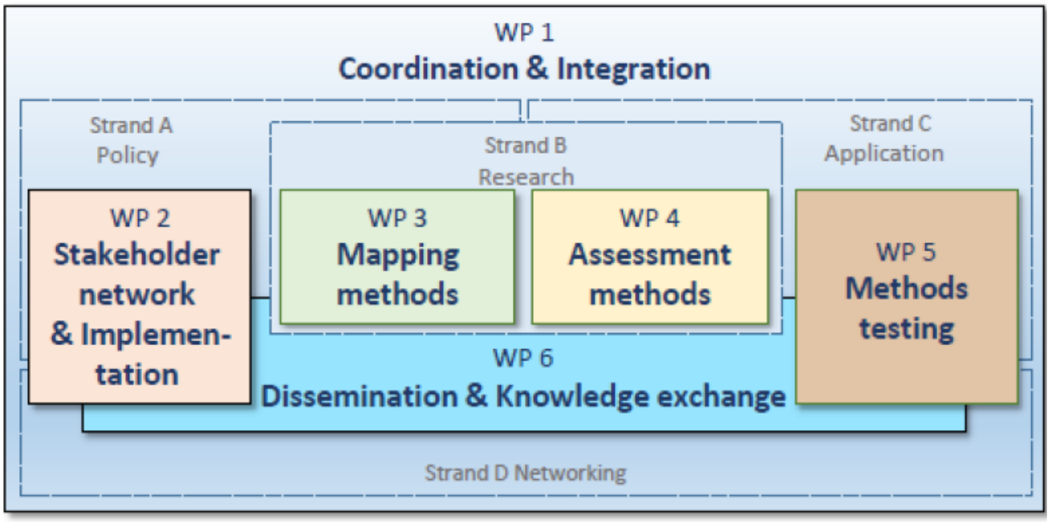


Figure 1.1: ESMERALDA components and their interrelations and integration within the four project strands.

Deliverable 5.4 sits within work package WP 5 "Methods testing", which 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 ESMERALDA flexible methodology, which was being simultaneously developed in WP3 and WP4, with input from WP2 and other work packages as well as different stakeholders (Figure 1.1). Deliverable 5.4 presents a critical analysis of the application of the ESMERALDA flexible methodology for ES mapping and assessment to a set of case studies, and offers guidelines and recommendations for future applications.

2. Introduction

2.1. Aim of Deliverable 5.4

Deliverable 5.4 "Guidelines and recommendations to support the application of the final methods" relates to work carried out in "Task 5.4: Developing guidelines to support the application of the methods". This is the task in which the strengths and weaknesses of the proposed ESMERALDA 'flexible methodology' for ES mapping and assessment were evaluated based on the real-life applications within the selected case studies. Specifically, Task 5.4 includes an account of how critical issues were addressed in the ESMERALDA case studies and collects insights provided by the partners involved in the case studies. Thus, Deliverable 5.4 is the main collaborative outcome of Task 5.4, elaborating different ways in which the proposed ESMERALDA flexible methodology can be used in different themes and regions. Ultimately, Deliverable 5.4 aims to support the application of the ESMERALDA flexible methodology, briefly introduced hereafter, in all EU Member States to deliver under Action 5 of the EU Biodiversity strategy to 2020.

2.2. ESMERALDA Flexible methodology

The work of ESMERALDA takes place within the frame of Action 5, which foresees that the European Commission helps countries set up a knowledge base on ecosystems and ecosystem services (ES) and to use this knowledge in policy and decision-making at different levels of governance. To this end, the ESMERALDA project has developed a "flexible methodology" for mapping and assessment of ES, based on a tiered approach and on integration of different dimensions (biophysical, economic and socio-cultural).

Within the ESMERALDA project, testing of the flexible methodology represents the core of the tasks in WP5. Operationally, testing was conducted through a series of workshops with the ESMERALDA consortium partners and stakeholders, focusing on a set of selected case studies that are representative of specific conditions, contexts and purposes (see Deliverable 5.1 by Geneletti & Adem Esmail, (2016); and Milestone Report 27 by Geneletti et al., (2017)). The testing workshops represented important moments in which the whole consortium and stakeholders could be updated about developments and discuss specific methodological issues as per the DoA. More specifically, a first set of three workshops served to test the first version of the ESMERALDA flexible methodology (refer to Deliverable 5.2 by Adem Esmail et al. (2017); a second set of two workshops focused on the final version of the methods (see Deliverable 5.3 by Geneletti et al (2018a)).

An additional objective of WP5 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. Accordingly, the testing workshops were designed to create opportunities to involve stakeholders, and to collect their feedback on the proposed ESMERALDA flexible methodology. Among other, the testing workshops included dedicated stakeholder break-out groups and panels and field visits to case study areas.

Put simply, the flexible methodology developed in the ESMERALDA project consists of various methods for developing high quality and consistent information on the condition of ecosystems and their services in EU Member States (Burkhard et al 2018, in press). The methodology helps to select the most appropriate (combination of) methods to perform ES mapping and assessment 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).

For a comprehensive illustration of the ESMERALDA flexible methodology, the rationale behind it, and its development process it can be referred to Deliverable 4.8 by Potschin-Young (2018). Here, to provide some background to the reader of Deliverable 5.4, the focus is on three outputs constituting the building blocks of the ESMERALDA flexible methodology for ES mapping and assessment. Namely, (i) the **ESMERALDA MAES Explorer[1];** (ii) the **ESMERALDA MAES Methods Explorer[2]** (), and (iii) the **ESMERALDA Glossary** (Potschin-Young et al. 2018).

2.2.1. ESMERALDA MAES Explorer: Guidance on Ecosystem Service Mapping and Assessment

This is one of the main ESMERALDA outputs providing overall guidance explaining the process of how to map and assess ES as required by Action 5 of the EU Biodiversity Strategy to 2020. Building on the main project outcomes, the **MAES Explorer** enables the end-users to 'navigate' and have access to – following a rational structure - the numerous ESMERALDA products and their respective links. The MAES Explorer, available both in a PDF format and as website, is structured according to seven main stages that characterize the ES mapping and assessment process, entitled as follows:

- **STEP 1 -** What kind of questions do stakeholders have? (Link)
- **Step 2 -** Identification of relevant stakeholders (Link)
- **Step 3 -** Network creation/Involvement of stakeholders (Link)
- **Step 4 -** Mapping and assessment process (Link)
- **Step 5 -** Mapping & assessment case study applications(Link)
- **Step 6 -** Dissemination and Communication (Link)
- **Step 7 -** Implementation (Link)

[1] http://maes-explorer.eu/
[2] http://database.esmeralda-project.eu/

2.2.2. ESMERALDA MAES Methods Explorer and Database of Methods for ES Mapping and Assessment

The **ESMERALDA MAES Methods Explorer** is a web-based tool for exploring the **Database of Methods for ES Mapping and Assessment** developed during the project (see Santos-Martin et al. 2018a). Through a structured querying logic based on a number of filters (**Error! Reference source not found.**), the **ESMERALDA MAES Methods Explorer** can guide the end-user in the process of identification and selection of the ES mapping and assessment method that is most appropriate to address the quest (Reichel & Klug, 2018). The Method Explorer allows end-users to retrieve related support material, including relevant Case Study Booklets and Method Application Cards (documenting the ES mapping and assessment exercise in the selected ESMERALDA case studies), and other useful references to scientific papers based on a comprehensive literature review carried out in WP 3 and WP 4 (Santos-Martin et al. 2018a).

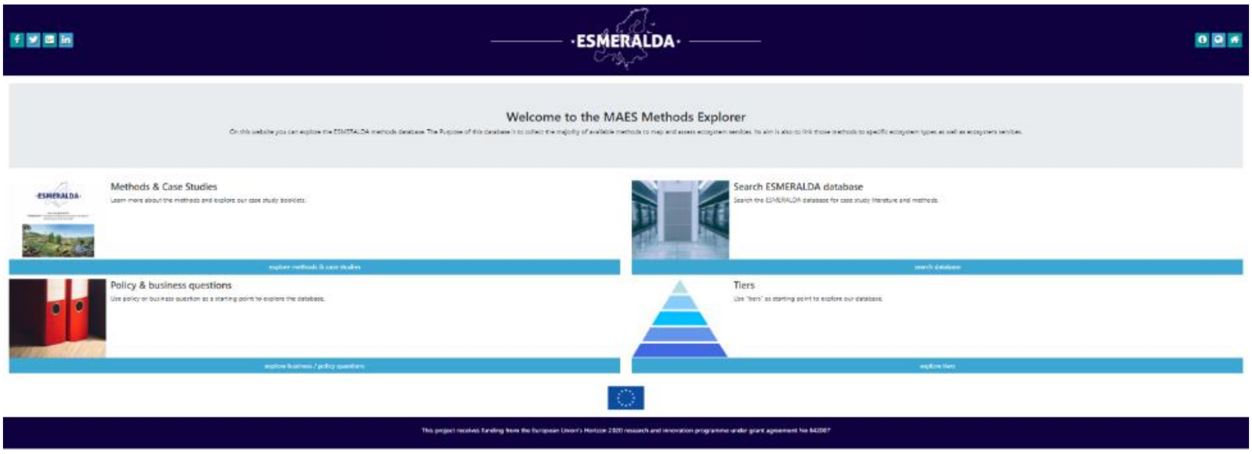


Figure 2.1. ESMERALDA Methods Explorer: a web-based too for exploring the ESMERALDA Database of Methods for ES Mapping and Assessment (available at http://database.esmeralda-project.eu/#/home).

The latest version of the **Methods Explorer** is accessible at http://database.esmeralda-project.eu/#/home. It is possible for users to choose to look for literature or methods, and then select information through the main filters. As shown in **Error! Reference source not found.**, there are many additional filters that can be considered to the query database, to identify the most appropriate methods and the related support material. An alternative way to access information is through the Case Study Booklets, which are classified via a set of structured information on scale, domain, ecosystems assessed, etc. All this information can be translated into a database query with precompiled filters so the tool finds similar cases/literature.

Table 2.1. Filters for querying the ESMERALDA database of methods for ES mapping and assessment

Main Filters	Additional Filters (1)	Additional Filters (2)	Additional Filters (3)
Studies / Literature	Year	Type of study	Method linked to other method
Source of information	Language	Supply / Demand	Mapped / assessed scale
Dimension of the study	Fact sheet available	Business or policy question	Ecosystem types
Ecosystem type mapped	Country	Maps / Metadata available	Biotic ES classes
	Dimension	Method name	Abiotic classes

As illustrated in detail in Santos-Martin et al. (2018a), behind the Methods Explorer there is an actual **Database of Methods for ES Mapping and Assessment**. The ultimate aim of the creation of the database, one of the main outcomes of the work done within WP 3 and WP 4, is to provide guidance on how to identify and apply the appropriate method for ES mapping and assessment. Santos-Martin et al. (2018a) illustrates the creation of a database for existing studies on mapping and assessing ecosystems and their services, which records relevant information to the ecosystem studies (e.g. methods used, the scale, ecosystem type, ecosystem service categories) and other relevant attributes that need to be considered. More specifically, they provide an overview of the database itself (883 entries until April 2018) and the consultation within the ESMERALDA consortium that shaped its development, as well as providing an overview of the final mapping and assessment methods describing their spatial distribution.

2.2.3. ESMERALDA Glossary

As highlighted in the related paper Potschin-Young et al. (2018), ES mapping and assessment integrates across many scientific and policy domains the development of a common language and shared concepts is essential. Accordingly, in the ESMERALDA project, a comprehensive ES mapping and assessment glossary was created (see Potschin-Young et al., 2018). The glossary is based on the integration of several previous glossaries and a wide- ranging consultation process. While there are several ecosystem services glossaries available as from EU supported work such as Oppla, OpenNESS, and ecosystem services related handbooks, the ESMERALDA developed glossary focusses on mapping and assessment of ecosystem services and therefore more directly supports the MAES process. For more information see the Deliverable D1.4 by Potschin-Young & Burkhard (2015) and paper by Potschin-Young et al. (2018).

2.3. Structure and content of Deliverable 5.4

To provide the end-users with a rational structure to navigate and have access to the different products developed in ESMERALDA, Deliverable 5.4 is structured according to the main steps of the MAES Explorer. After providing an overview of the selected ESMERALDA case studies (Section 3), the remainder of Deliverable 5.4 is organized in six sections where the case study materials are organised in a way that address each of steps of the ES mapping and assessment process, as follows:

- **Section 4**: Questions and Themes (Step 1)
- **Section 5:** Stakeholders' Involvement (Step 2 and 3)
- **Section 6**: Mapping and assessment: Initiating the process (Step 4)
- **Section 7**: Mapping and assessment: Methods (Step 4)
- **Section 8**: Dissemination and communication (Step 6)
- **Section 9**: Implementation (Step 7)

Each Section contains a description of how the specific step was carried out in the different case studies, synoptic tables to summarise similarities and differences across case studies, as well as a list of recommendations to support future applications. To enhance readability, Step 2 and 3 have been merged into the same Section, and Step 4 divided into two parts: initiating the MAES process and methods. Step 5 is not included because all the material presented here refer to case study applications.

Content wise, each section is structured in three parts: a first part introducing the specific step of the MAES, a second part providing an overview of the ESMERALDA case study results, and finally, a third part reporting some general recommendations distilled from the case study experiences also based on the input from the partners involved in the case studies. The sections are designed to be consulted independently, while more details can be found in the related ESMERALDA Deliverables.

3. An overview of the ESMERALDA case studies

A key task in the ESMERALDA project dealt with identifying appropriate case studies to test the 'flexible methodology' for ES mapping and assessment in its different stages of development (Geneletti et al. 2018b). Case studies consist of working examples in which ES mapping and assessment was applied to address specific decision making problems. Testing is understood as an iterative process of co-learning that involves project partners and stakeholders, enabling the refinement of the 'flexible methodology' and the development of guidelines to support its application. As shown in Figure 3.1*Figure 1.1*, it was conducted through a series of workshops in different European contexts, each addressing a different set of themes and regions. For more details refer to Deliverable 5.2 (Adem Esmail et al., 2017) and Deliverable 5.3 (Geneletti et al., 2018a)).

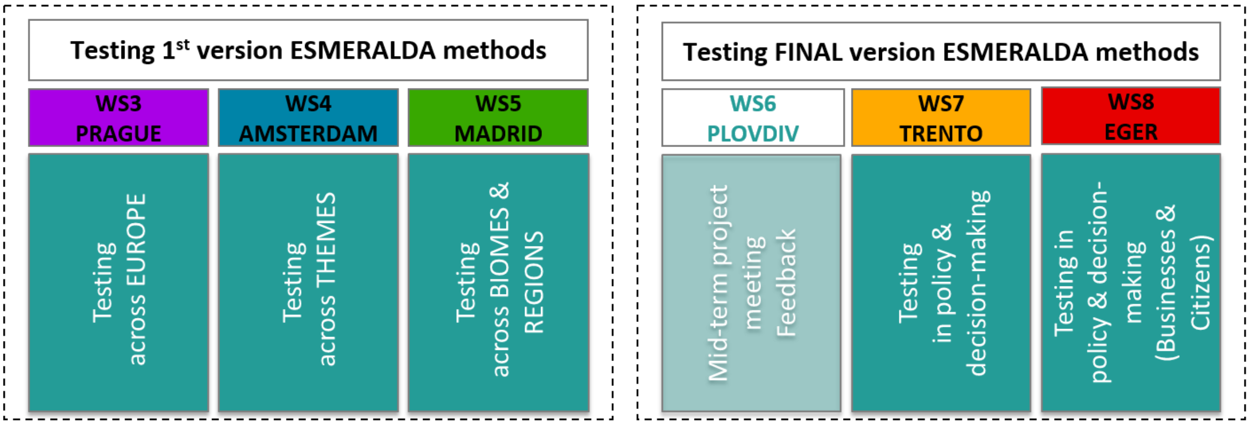


Figure 3.1. Testing concept of the ESMERALDA flexible methodology. **WS3** - September 2016, Prague (Czech Republic); **WS4** - January 2017, Amsterdam (Netherlands); **WS5** - March 2017, Madrid (Spain); **WS7**- January 2018, Trento (Italy); **WS8** - March 2018, Eger (Hungary).

An overview of the 14 case studies selected for testing the ESMERALDA 'flexible methodology' is provided in Figure 3.2 and Table 3.1. All in all, the case studies cover different stages of the MAES within the EU Member States as well as different biomes in continental Europe, scales from local to national, different themes and types of ecosystems (see Figure 3.3). Here, stage of MAES in the countries refers to the status in regard to achieving the EU Biodiversity Strategy's Action 5 targets for mapping and assessment of ecosystems and their services. It is based on the clustering of EU Member States considering their prerequisites and needs to perform MAES (see Deliverable 2.1 by Kopperoinen et al., (2015)). Accordingly, EU Member States were clustered into three groups, i.e. Beginners=Stage 1, Mid-level=Stage 2, and Front-runners=Stage 3. Therefore, the selected sample can be considered representative of diverse range of conditions of ES mapping and assessment application. In the remainder of this section, the context of each case study is illustrated more in detail.

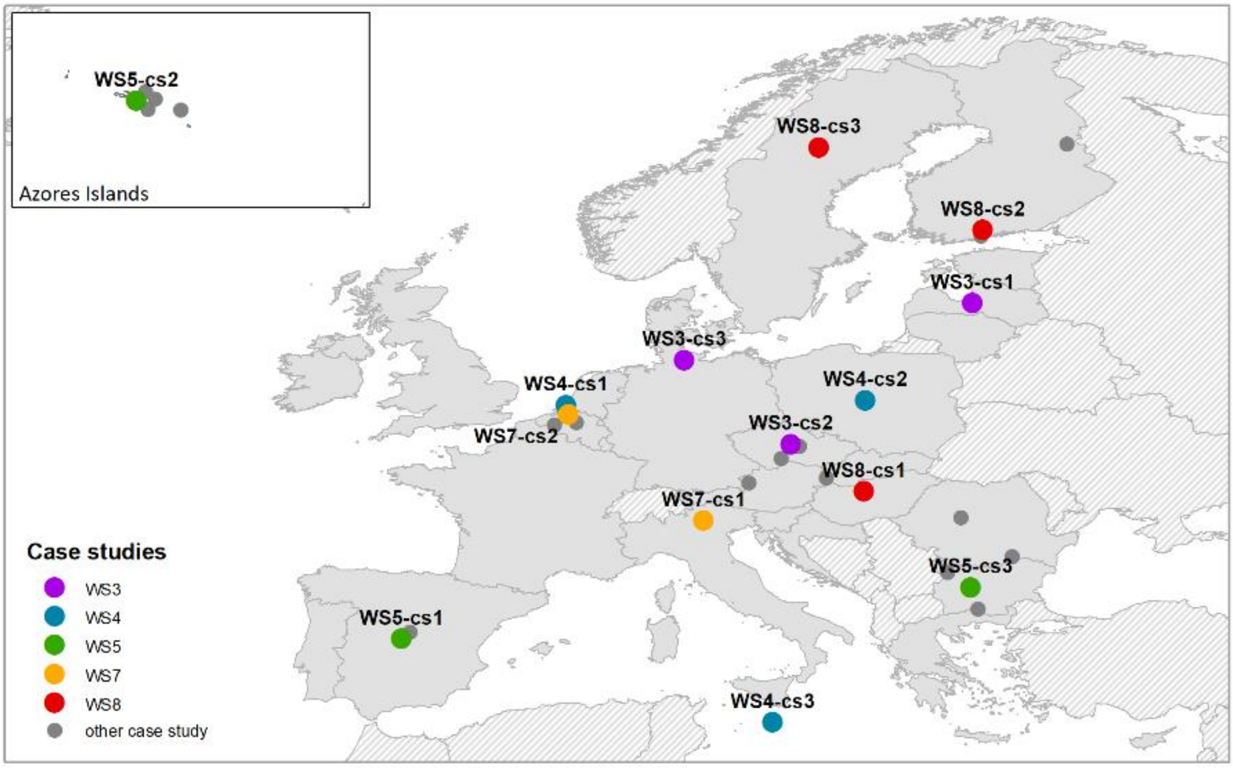


Figure 3.2. Map of the selected case studies for the five ESMERALDA 'flexible methodology' testing workshops. **WS3** - September 2016, Prague (Czech Republic); **WS4** - January 2017, Amsterdam (Netherlands); **WS5** - March 2017, Madrid (Spain); **WS7**- January 2018, Trento (Italy); **WS8** - March 2018, Eger (Hungary).

	STAGE IN MAES	Stage 1	Stage 2	Stage 3	GEOGRAPHIC REGION	Eastern	Northern	Southern	Western	*Outermost	BIOMES	4	5	6	8	11	12	SCALE	Local	Sub-national	National
LATVIA		x					x					x									x
CZECH REPUBLIC			x			x						x	x								x
GERMANY				x					x			x	x						x		
NETHERLANDS				x					x			x							x		
POLONIA			x			x						x	x							x	x
MALTA			x					x									x			x	x
SPAIN				x				x				x					x				x
AZORES				x						x							x			x	
BULGARIA			x			x						x			x		x		x		
ITALY			x					x				x	x				x		x		
BELGIUM				x					x			x							x		
HUNGARY			x			x						x							x		
FINLAND				x			x					x		x		x			x		
SWEDEN			x				x					x		x		x				x	

	THEMES	Nature conservation	Climate, water and energy	Marine and maritime policy	Natural risk	Urban and spatial planning	Green infrastructures	Agriculture and forestry	Business, industry and tourism	Health	ECOSYSTEM TYPE	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
LATVIA		x	x	x		x			x												x	x	
CZECH REPUBLIC		x			x							x	x	x	x			x	x				
GERMANY			x					x					x	x	x				x				
NETHERLANDS		x	x		x		x	x	x				x					x	x		x		
POLONIA		x	x		x	x	x	x	x			x	x	x	x			x	x				
MALTA							x	x					x			x	x			x	x		
SPAIN		x										x	x	x	x	x	x	x	x	x	x		
AZORES		x					x	x							x								
BULGARIA		x			x	x	x	x	x			x		x	x	x							
ITALY			x			x	x			x		x											
BELGIUM			x		x	x	x			x		x											
HUNGARY		x						x	x				x	x	x			x	x				
FINLAND		x				x	x			x		x	x		x				x				
SWEDEN		x				x	x	x	x						x	x	x	x					

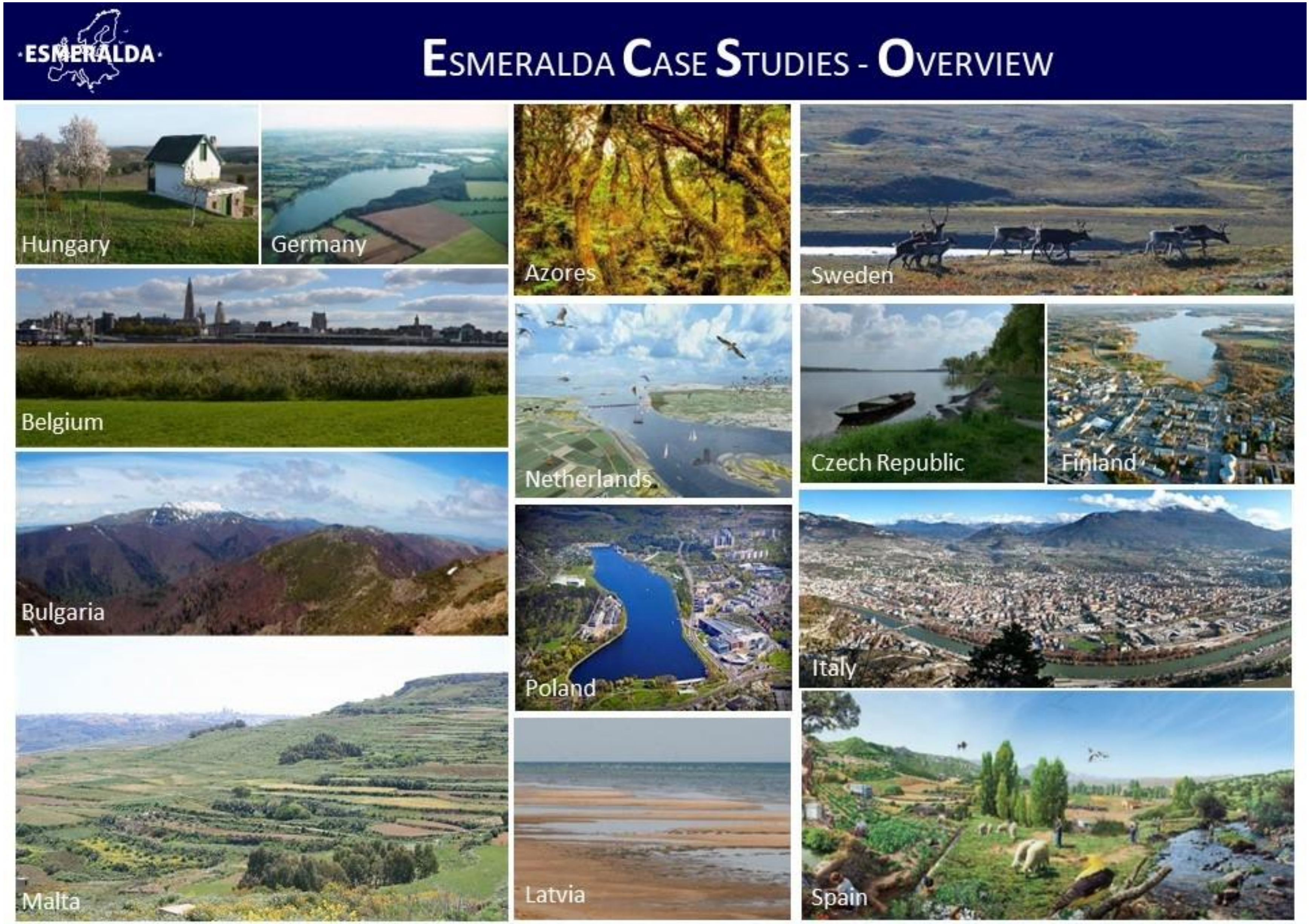
Figure 3.3. An overview of the selected case studies for the five ESMERALDA methods testing workshops

Table 3.1: On overview of the study areas in the selected ESMERALDA case studies.

Country	Case Study	Spatial scale	Extent	Biomes in country*	Stage**
Belgium	Mapping green infrastructures and their ES in Antwerp	Local (10x10m)	204.5 km²	4	Stage 3
Bulgaria	Mapping and assessment of ES in Central Balkan area at multiple scales	Sub-national /Local	2,998.9 km²	4 – 8 - 12	Stage 2
Czech Republic	Pilot National Assessment of ES	National	28,000 km²	4 - 5	Stage 2
Finland	Green infrastructure and urban planning in the City of Järvenpää	Local	40 km²	4 – 6 - 11	Stage 3
Germany	Mapping ES dynamics in an agricultural landscape	Local / Sub-national	60 km²	4 - 5	Stage 3
Hungary	ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park	Local	432 km²	4	Stage 2
Italy	ES mapping and assessment for urban planning in Trento	Local	156 km²	4 – 5 – 12	Stage 2
Latvia	Mapping marine ES in Latvia	National	78,866 km²	4	Stage 1
Malta	Assessing and mapping ES in the mosaic landscapes of the Maltese Islands	National/ Sub-national	316 km²	12	Stage 2
Netherlands	ES-based coastal defence	Local	810 km²	4	Stage 3
Poland	ES in Polish urban areas	Sub-national /local	2-6,000 Km²	4 - 5	Stage 2
Portugal, Azores	BALA - Biodiversity of Arthropods from the Laurisilva of Azores	Sub-national	400 Km²	4 – 12	Stage 3
Spain	Spanish National Ecosystem Assessment	National	505,990 Km²	4 - 12	Stage 3
Sweden	ES mapping and assessment in the Vindelälven-Juhtatdahka river valley	Sub-national	13,300 Km²	4 – 6 - 11	Stage 2

*** Biomes in country**: **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.

**** Stage in ES mapping and assessment***: EU Member States were clustered into three groups, i.e. Beginners=Stage 1, Mid-level=Stage 2, and Front-runners=Stage 3 (see Deliverable 2.1 by Kopperoinen et al., (2015)).


ESMERALDA
ESMERALDA CASE STUDIES - OVERVIEW
Hungary
Germany
Azores
Sweden
Belgium
Netherlands
Czech Republic
Finland
Bulgaria
Poland
Italy
Malta
Latvia
Spain

3.1.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

Antwerp is the second largest city in Belgium. It has 517 000 inhabitants and a surface of 204.5 km². The city is a mix of a highly urbanized central area, with a clear shortage of available green space, some larger important conservation areas at the borders of the city, and an industrial harbour area. The tidal river Scheldt and neighbouring wetlands are also important ecosystems. The city has the ambition to become more "green". To this end, a masterplan on green and blue infrastructure was developed, focusing on five "park-regions". The master plan includes large-scale restoration projects and small-scale initiatives such as garden streets, green facades and urban farming. Beside this citywide strategic plan, nine local green plans at district level and one for the harbour area are currently under development or planned.

Figure 3.4. Key park regions and corridors in the Antwerp green masterplan

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

The study area is located in Central Bulgaria and covers the central part of the Balkan Mountains. The area covers 2,999 km² of which 24% is proclaimed for protected areas of which the most important is the Central Balkan National Park (71,825.5 ha). The average altitude is 913 m and ranges from 265 m in the Karlovo plain to 2376 m at the Botev peak. Although the study area is relatively small, the nature is diverse due to the influence of the Balkan Mountain Range. 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.

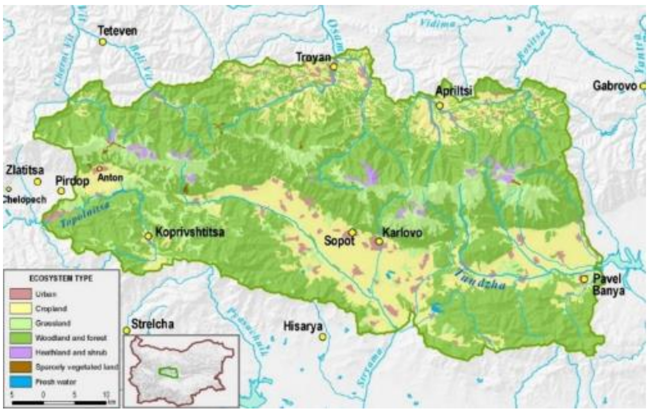


Figure 3.5. Main ecosystem types in Central Balkan case study area.

3.1.3. CZECH REPUBLIC: Pilot National Assessment of ES

The study area incorporates the whole of the Czech Republic, an inland state located in central Europe with 10.6 million inhabitants. The country has an exceptionally variable landscape providing a diversity of habitat types. It overlaps with three main river basins: the Elbe River, the Oder River and the Danube River. Agricultural land use represents more than 53% of the total area, followed by forests covering about 33%, water bodies and built-up areas (both about 2%) and other areas (9%). Protected areas cover 16% of the country.

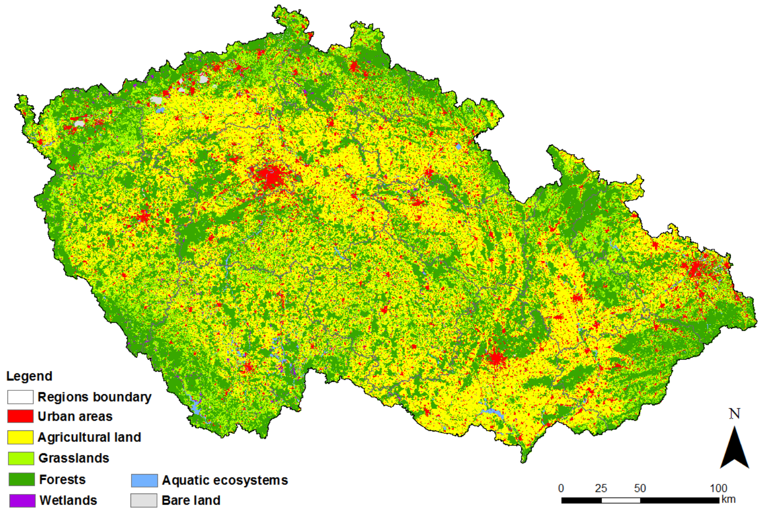


Figure 3.6. Land cover/use map of the Czech Republic (based on the Consolidated Layer of Ecosystems)

3.1.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

The City of Järvenpää is a compact city with tight boundaries in the Helsinki-Uusimaa Region. It is the fourth most densely populated city in Finland, with a population of around 42,000, and is predicted to grow significantly in the coming decades. It is a significant commercial and administrative centre in Central Helsinki-Uusimaa as well as part of the Helsinki Metropolitan Region economic and employment area due to its quick connections to Helsinki. City's compact structure means that new construction sites need to be found among the already built area, mainly in green space. Natural values come right into the city centre because the wetlands in the northern end of Lake Tuusulanjärvi belong to the Natura 2000 network due to their importance for nesting and migratory birds.

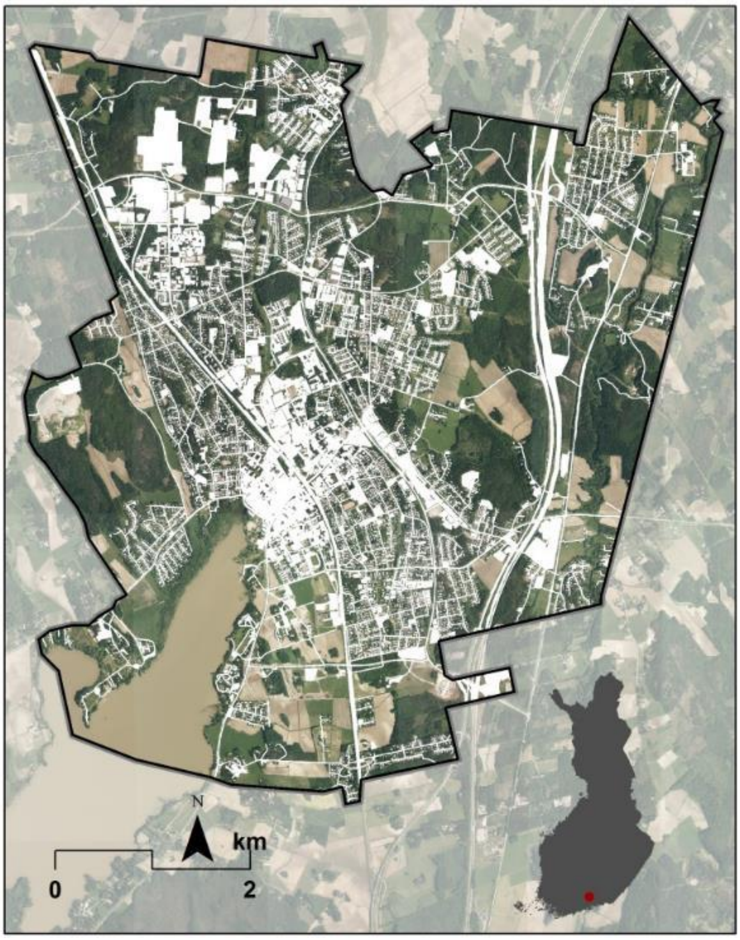


Figure 3.7. Map of the City of Järvenpää with impervious areas presented in white. Lake Tuusulanjärvi is seen in the south-western area.

3.1.5. GERMANY: Mapping ES dynamics in an agricultural landscape

The Bornhöved Lakes District is located 30 km south of the federal state capital Kiel. The study area of 60 km² lies partly within ten municipalities in the two districts of Plön and Segeberg. Six glacially formed lakes (between 0.27-1.4 km²) are predominate features, which are surrounded by forest and agricultural areas. The lakes have been landscape protection areas since 1962 and partly conservation areas since 1983. The Bornhöved Lakes District was the focus of an interdisciplinary ecosystem research project during 1988 – 2001 and is now part of the Long term Ecological Research Network (LTER). The area is an important supplier of multiple ES and is a representative landscape for Northern Germany.

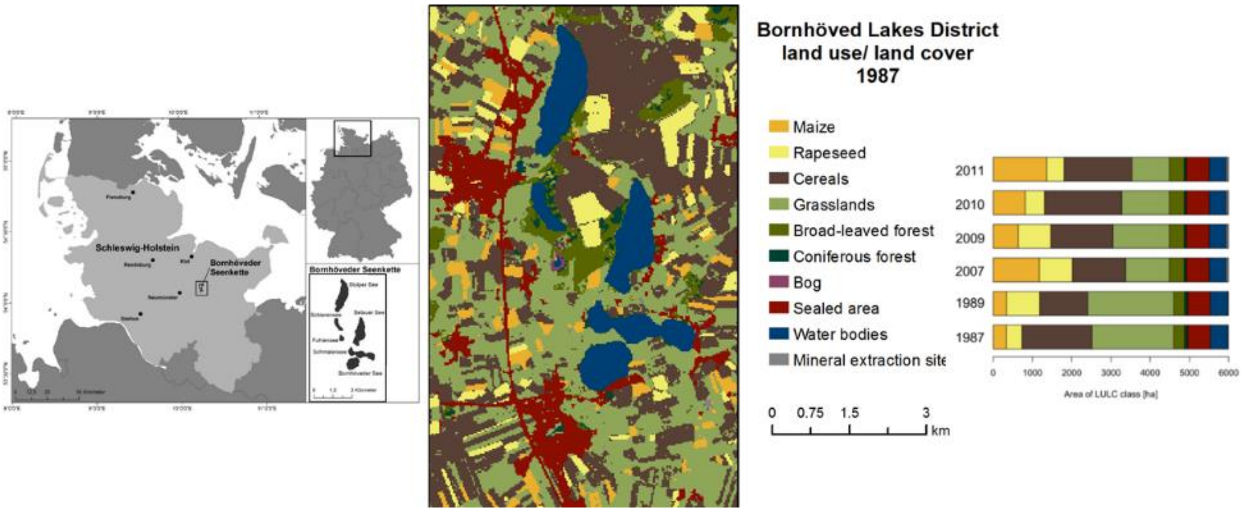


Figure 3.8. Location of the study area (left); example of a land use/land cover map, and their dynamics (right).

3.1.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park

Located in the Northern Mountain Range of Hungary, the Bükk National Park was established in 1977. It covers 43,169 ha, managed and utilized mainly as forest (94%) and to a smaller extent, grassland (3.4%, meadow and pasture), while 2% is withdrawn from cultivation, 0.4% is arable land, and the remaining is vineyards and orchards. Almost 98% of the national park is state owned, with two forestry companies as managing organizations in charge; the remaining is managed by the Bükk National Park Directorate. However, the subject of the project is the wider local social-ecological system containing low-intensity areas of settlements, arable lands, grasslands, vineyards and orchards adjacent to the NP territory, reflecting the significance of these land uses and their opportunities for business and citizens.

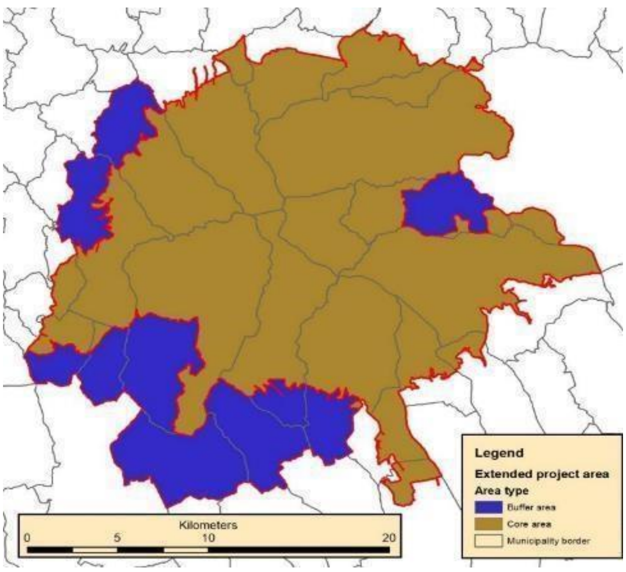


Figure 3.9. Map of Bükk National Park. Boundaries of the larger focus area represent the whole social-ecological system, and an inclusive core area, with all important spatial information.

3.1.7. ITALY: ES mapping and assessment for urban planning in Trento

The city of Trento is located in Northern Italy, in the valley of the River Adige. It is the capital of the Autonomous Province of Trento (Trentino), with a population of around 117,300 inhabitants. The city centre is in the valley floor at 194 m above sea level and hosts around 70% of the population. The remaining 30% lives in small villages spread across the surrounding hills and mountains, which rapidly reach the altitude of more than 2000 m. Overall, of the total city area (156 km^2), 22% is covered by urban areas, while forests account for one third. More than 10 km^2 are natural protected areas, including seven Natura2000 sites and three local reserves.

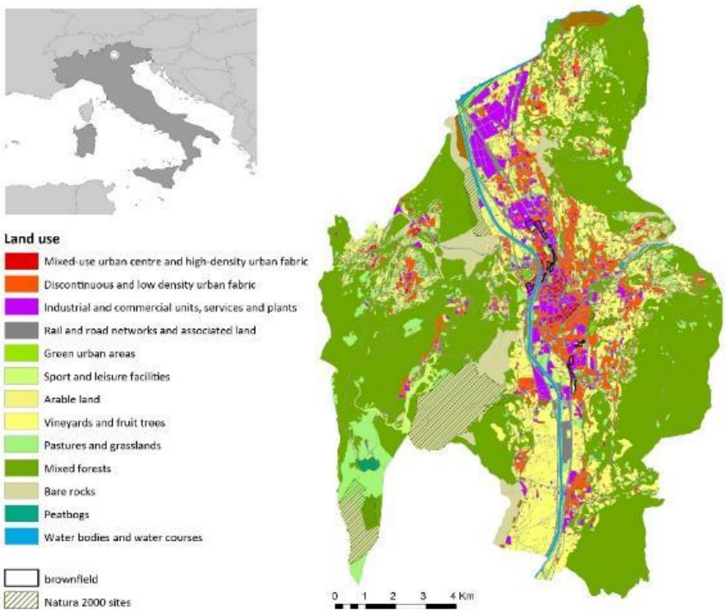


Figure 3.10. Land use map in the Trento case study area.

3.1.8. LATVIA: Mapping marine ES in Latvia

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). It corresponds to 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. It covers 28,517.5 km^2 out of which 10,861 km^2 belongs to the territorial sea.

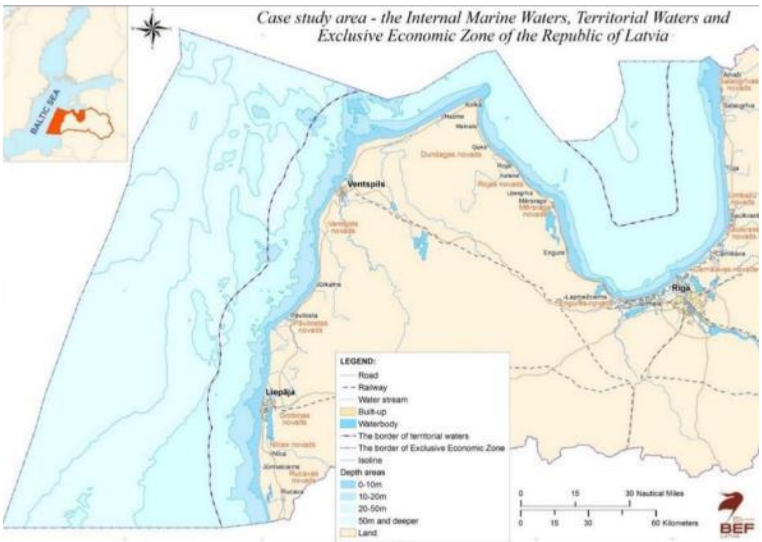


Figure 3.11. Case study area including the internal marine waters, territorial waters and Exclusive EEZ of the Republic of Latvia.

3.1.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

Figure 3.12. Map of the Maltese case study

The Maltese archipelago is a group of low-lying, small islands situated in the Central Mediterranean Sea. 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. 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.

3.1.10. NETHERLANDS: ES-based coastal defence

The Haringvliet used to be the most important river mouth of the rivers Meuse and Rhine in the Netherlands. 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.

3.1.11. POLAND: ES in Polish urban areas

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 Large Urban Zones in Poland, according to Urban Atlas.

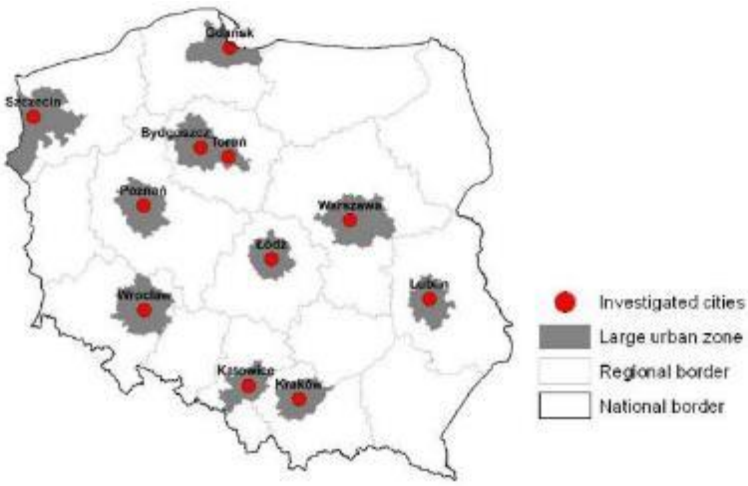


Figure 3.13. Polish agglomerations covered by analysis.

3.1.12. PORTUGAL, AZORES: 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. Of a relatively recent volcanic origin, the Azorean islands extend for about 615 km and are situated across the Mid-Atlantic Ridge. The climate is temperate humid at sea level, and cold oceanic at higher altitudes. A small number of endemic trees and shrubs dominate native forest. Today, most of the islands are covered by new habitats introduced following human colonization 600 years ago, including semi-natural pastures, exotic plantations, intensive pastures, agricultural fields and urban areas; the original forest has less than 5% of pristine areas located in protected areas.

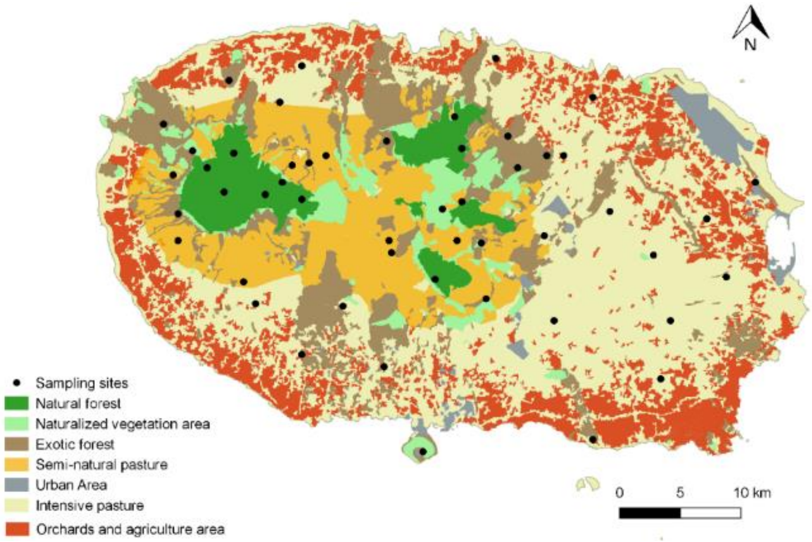


Figure 3.14. A land use and land cover map of Terceira was available from DROTRH (2008) adapted for our purposes and with addition of new data for natural forests from Gaspar et al. (2008). Black points are sampled points for the pollinator assessment (see Picanço et al. (2017a, b).

3.1.13. SPAIN: Spanish National Ecosystem Assessment

The study area incorporates the whole of Spain's territory, including the Iberian Peninsula and two large archipelagos, the Balearic and the Canary Islands. With an area of 505,990 km2, Spain is the largest country in Southern Europe and has the fifth largest population in the European Union. The Spanish National Ecosystem Assessment is 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.

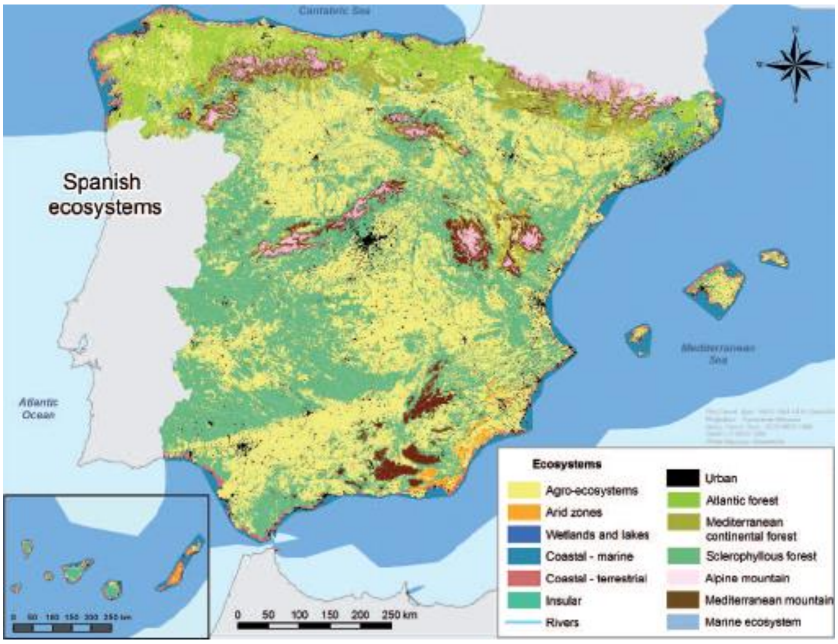


Figure 3.15 Spatial representation of the 14 Ecosystem types assessed in the Spanish NEA (Spanish NEA, 2014).

3.1.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

The Vindelälven-Juhtatdahka river valley stretches about 450 km from a highest point of 1,641 m in the Scandinavian mountain range watershed divide to the Gulf of Bothnia marine coast. It is the southernmost one out of four nationally protected rivers in Sweden. "Juhtatdahka" – migration route – refers in particular to the traditional use of the river and valley for movement and migration. The annual migration of reindeer from the mountains to the coast and back – the backbone of the traditional Sami reindeer husbandry – is of specific value and importance. The river valley is also a natural ecological network for spreading and migration for many species. The area is rich in forest, minerals and other natural resources, and rich in nature conservation values. In total 32% of the area is protected. The Vindelälven-Juhtatdahka river valley area is, formally, in the candidacy process for acceptance as a member reserve in the UNESCO Man and Biosphere Program.

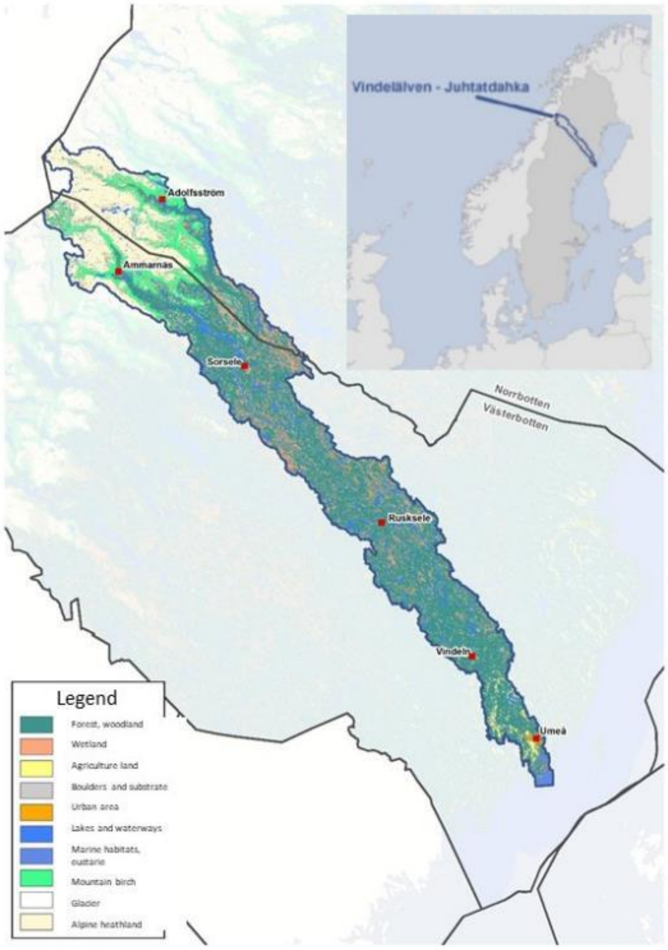
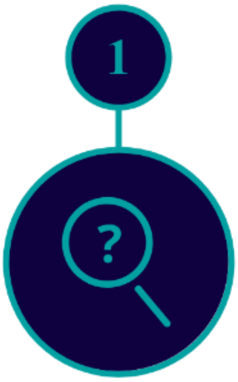


Figure 3.16. Location and land cover types in the Vindelälven-Juhtatdahka river valley. Source: Västerbotten County Administration Board.



4. Questions and Themes

4.1. ES mapping and assessment for decision-making and policy questions

Policy makers acknowledge ecosystem services (ES) as an important concept in supporting decision-making, because of their holistic understanding of interactions between nature and human beings, and their ability to reveal synergies and conflicts between environmental and socio-economic goals. The ES concept provides a comprehensive framework for trade-off analysis, addressing compromises between competing land uses and assisting to facilitate planning and development decisions across sectors, scales and administrative boundaries (Fürst et al. 2017).

The application of the ES concept is strongly related with implementation of other related policies, including water, marine, climate, biodiversity, agriculture, and forestry, as well as regional development (Maes et al. 2014). In the framework of ESMERALDA, for example, a list of policy questions that drive ecosystem assessments in the context of the EU Biodiversity Strategy has been finalized (see Maes et al. (2018). Indeed, ES mapping and assessment results can support sustainable management of natural resources, environmental protection, spatial panning, and landscape planning; and can be applied to the development of nature-based solutions and environmental education.

ES can be included within the impact assessment procedures (e.g. Strategic Environmental Assessment of plans and programs, and Environmental Impact Assessments of projects), thus extending the scope of impact assessment from purely environmental considerations to other dimensions of human well-being. The potential contribution of ES information to impact assessment has been described in Geneletti et al. (2011; 2015; 2016). In short, MAES can improve the overall outcome of actions, reduce the likelihood of plan or project delays due to unforeseen impacts, and reduce reputational risk to public authorities and developers from unintended social impacts. ES can be applied in all stages of impact assessment, including scoping (to indicate ES on which action depends as well as services it affects), consultations (helping to focus debate and engagement of stakeholders), assessing impacts and trade-offs of development alternatives as well as proposing mitigation measures (Geneletti & Mandle, 2017). Furthermore, use of the ES concept in spatial planning provides greater opportunities to integrate environmental considerations into decision-making on land use change or management in strategic and practical levels.

Agriculture and forestry are among the sectors with high potential for applying the ES concept, for instance to increase synergies of recreation and carbon sequestration with timber production in forests, or pollination and biological control in agricultural environments. These sectors are inextricably linked with the supply of ES as well as depending on ES supply (e.g. pollination, pest and disease control, maintaining of soil fertility), and at the same time, having direct impacts on ecosystem condition and the supply of other ES (e.g. maintaining habitats, chemical condition of freshwaters, global climate regulation etc.). The level of supply and impacts of these ES directly depends on the applied management practice. Thus, MAES results can be used to address the trade-offs within and between sectors, to target policy objectives and required measures for improving ES supply and related payment schemes.

Application of ES in spatial planning and policy-making through scenario development, modelling of impacts, and trade-off analysis can provide added value by synthesizing and organizing knowledge from various datasets as well as facilitate cross-scale and cross-sector planning, thus contributing to integrative resource management. Nevertheless, there is still a need to develop guidance and criteria on how to apply ES within different planning contexts as well as through the decision-making process (Fürst, 2017). Furthermore, integration of various MAES methods and tools are required to address the complexity of socio-ecological systems, and support the decision-making process across different scales and sectors.

4.2. Question and themes in ESMERALDA case studies

The selected ESMERALDA case studies address nine themes (policy domains) ranging from nature conservation to marine policy, all the way to health (Table 4.1). Those themes were selected because they were considered as being representative for current policy challenges in EU. Together they cover the variety of cross-EU themes relevant for ES, such as Common Agricultural Policy, Green Infrastructure, Natura2000 network, forestry strategy, water policy, energy, business and industry sectors, and health; across Europe and across themes. Moreover, they cover the variety of policy and planning processes that can be used to mainstream ES in real-life decisions, such as spatial and land use planning, water resource management, flooding under the EU climate adaptation action, energy policy, strategic environmental assessment, and protected area planning. As reported in the remainder of this sub-section, each case study, addresses a main theme in addition to another two or three themes (see Geneletti et al., 2018a).

Table 4.1: An overview of the policy domains (themes) addressed in the selected ESMERALDA case studies.

	EU-relevant Policy Domains								
	Nature conservation	Climate, water and energy	Marine & maritime policy	Natural risk	Urban & Spatial planning	Green infrastructures	Agriculture and forestry	Business, industry & tourism	Health
Belgium		■		■	■	■			■
Bulgaria	■			■	■	■	■	■	
Czech Republic	■			■					
Finland	■				■	■			■
Germany		■					■		
Hungary	■						■	■	
Italy		■			■	■			■
Latvia	■	■	■		■			■	
Malta						■	■		
Netherlands	■	■		■		■	■	■	
Poland	■	■		■	■	■	■	■	
Portugal, Azores	■					■	■		
Spain	■								
Sweden	■				■	■	■	■	

The 14 case studies selected for ESMERALDA together showed a large variety in themes and approaches. However, all were either very policy oriented or gave some suggestions for policy implementation. For this analysis we will shortly discuss them from an urban, rural, nature and scientific point of view.

Urban

About half of the case studies combine nature conservation issues with green infrastructure, often in urban areas. In those case studies it was tried to establish a win-win situation between green infrastructure and environmental or biodiversity issues. It was tried to inspire spatial planners and city officials to increase the livability of their work area by choosing sustainable land use options based on natural values and ES, while developing urban locations. Policy makers in urban areas often struggle with allowing needed city growth without losing the valuable features of the green infrastructure.

Rural

Rural case studies dealt with issues on larger scales. The German case, for instance, investigated how the land cover pattern in an area could stay rather constant, regardless significant changes in agricultural land use. The Swedish case analyzed the indigenous Sami culture who keep on following their local natural and cultural identity and combine natural and social aspects of economy and education to improve human livelihoods and equitable sharing of goods and benefits of natural and managed ecosystems.

Nature areas

The case studies that focused on nature areas gave examples on how protecting nature and ecosystem services could improve the local economy, social welfare and national risk projection, or used economic valuation to illustrate the importance of ecosystem services for society. In Hungary, for instance, they show how the natural heritage of protected areas can serve as an economic development factor in supporting local development based on awareness raising and sustainable management. They also used a participatory approach to start discussions on increasing pro-biodiversity business opportunities and involve various public and private actors into capacity building, networking and know-how transfer. In this way better balance is found between nature conservation and local entrepreneurship based on the conservation of biodiversity and awareness on ecosystem services.

Science oriented studies

Case studies that are more science oriented, still provide support to the local administration, for instance via supporting the design and assessment of alternative planning actions ensuring that impacts on ES are included, and informing decisions aimed at their equal provision for all citizens. Scientific identification of spatially overlapping bundles of ES, could be used to better analyze the impact of policies and developments on the ecosystems' capacity to deliver key ES, which can be included in National Biodiversity Strategies and Action Plans. Measuring the changes in economic, social and environmental terms, can help defining ecological benefits versus changes in natural risks for local citizens, an identify costs and benefits of different measures for ecosystem restoration. Scientific studies could also visualize the contribution that ecosystems and biodiversity make to human well-being in ecological, social, cultural and economic terms. This can help build bridges between interdisciplinary scientific knowledge and decision making to visualize the complex relationships that exist between the conservation of ecosystems and human wellbeing and increase society awareness, including the business sector. One case study also showed how instead of nature conservation providing societal benefits, ES such as pollination needed for fruit production could also help threatened species such as arthropods Portugal, Azores.

4.2.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

Establishing win-win situations for different topics simultaneously with green and blue infrastructure is a key ambition of the city and its strategy. Mapping and assessing the impacts of green infrastructure will help to achieve this. Thus, the city developed the Antwerp Greentool, which contains different ES maps and integrated assessment tools (see https://groentool.antwerpen.be/). The objective of the Greentool is to inspire spatial planners and city officials to take smart and green measures when developing urban locations. It provides different sorts of information including (i) general insights into the advantages of including vegetation and water bodies in urban developments; (ii) an overview of the existing environmental quality to identify environmental challenges; and (iii) maps presenting the impact of possible measures. The tool can be applied to benchmark sites owned by city authorities, support management plans and can be made mandatory for urban development plans to ensure spatial planners take into account environmental challenges and liveability.

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

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. Namely, (i) A flood hazard assessment project to define the supply and demand for flood regulation in mountain watersheds (Nedkov and Burkhard, 2012; Nedkov et al. 2015); (ii) A scientific research on water related ES in the northern part of Central Balkan National Park (Boyanova et al. 2014; 2016); (iii) Assessment of the Central Balkan area in terms of the potential to provide ES for the local economy and for the social welfare (Borisova et al. 2015; Assenov and Borisova, 2016); (iv) A pilot valuation of the ES provided by the forests of the Central Balkan National Park (Dimitrova et al., 2015); and (v) Mapping and assessment of urban ecosystems, ecosystem conditions, and ES in the Karlovo municipality (Zhiyanski et al. 2017).

4.2.3. CZECH REPUBLIC: Pilot National Assessment of ES

This pilot ES assessment and mapping was performed within the framework of the Millennium Ecosystem Assessment, mainly driven by the Aichi Targets (Strategic Goal D) and the EU Biodiversity Strategy to 2020 (Action 5). 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 aimed at providing an initial estimate illustrating the importance of ES for society, to be included in the national wealth and accounting.

4.2.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

The city of Järvenpää has an expected population growth of over 10 % by the year 2030. There is an exceptionally strong need for infill development to provide housing for new inhabitants as the master plan already covers the whole city and the borders of neighbouring municipalities prevent the city to grow in the fringes. The city's interest was to find out how to identify the best infill development sites without losing the most valuable features of the green infrastructure, including both biodiversity and ES. The objective of the case study was to evaluate the green infrastructure in the city by mapping and assessing the supply of and demand for the most important ES and assess the value of each green space area for the overall connectivity of green infrastructure. Initially, the perspective was policy driven aiming to support the city planners in making sustainable land use decisions based on natural values and ES while simultaneously identifying land for future construction.

4.2.5. GERMANY: Mapping ES dynamics in an agricultural landscape

ES mapping and assessment in the case study has been mainly scientifically driven. The availability of several ecological data sets, in fact, allows detecting changes in ecosystem conditions, biodiversity, ecosystem functions, land use and other human activities. In particular, the land cover pattern in the area has been rather constant in the last decades, while significant changes in agricultural land use regarding crop rotation are evident. This is mostly due to recent policies in Germany that have been promoting and supporting the use of renewable energy. Thus, the ES mapping and assessment could be useful to address key policy question, like “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?”

4.2.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

The project 'Ecosystem services of karst protected areas – driving force of local sustainable development (Eco Karst) builds on the opportunity to use the natural heritage of protected areas as an economic development factor. Specifically, to support local development based on the raised awareness and sustainable management of karst ecosystems across the Danube region. The project works with a series of pilot areas including the Bükk National Park in Hungary and combines different disciplines and methods, develops customized methodologies for ES assessment and applies them to the case studies. Ecosystem types are mapped, ES identified, assessed and, where applicable, economically valued and spatially visualized. The results of ES assessment will be a basic resource for the discussion on increasing pro-biodiversity business (PBB) opportunities. Involving various public and private actors into capacity building, networking and know-how transfer, local PBB action plan will be developed by participatory approach. This will contribute to a better balance between nature conservation and local entrepreneurship based on the conservation of biodiversity and awareness on ES.

4.2.7. ITALY: ES mapping and assessment for urban planning in Trento

Initiated as a scientific study, ES mapping and assessment in Trento has progressively moved toward providing support to the local administration within the process of drafting a new urban plan for the city. Under the overall objective of enhancing citizens' wellbeing, scientists and local administration jointly identified two main tasks for ES mapping and assessment. The first task consists in describing how ES and related benefits produced by urban green infrastructure are currently distributed across the city, thus informing decisions aimed at their equal provision for all citizens. The second task consists in supporting the design and assessment of alternative planning actions, thus ensuring that impacts on ES are taken into account. An illustrative application of the latter is the assessment of alternative greening scenarios for the redevelopment of existing brownfields, based on their effects on key urban ES for the city of Trento.

4.2.8. LATVIA: Mapping marine ES in Latvia

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 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).

4.2.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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. 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 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.

4.2.10. NETHERLANDS: ES-based coastal defence

Building upon a previous benefit transfer study, this new primary valuation study focusses on the potential future state of the Haringvliet and aims at measuring the changes in economic, social and environmental terms. The study will use various methods (e.g. surveys) and will generate a range of outcomes (e.g. CBA, value maps). The study is highly policy relevant by addressing the following questions: (i) 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)? (ii) What are the costs & benefits of different measures for ecosystem restoration of the Haringvliet? (iii) Who are the winners and losers of different scenarios in the Haringvliet and are there ways in which the losers could be accommodated?

4.2.11. POLAND: ES in Polish urban areas

Commissioned by the Ministry of the Environment, the main objective 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. Hence, the elaboration suggest procedures for identifying and evaluating selected services, demonstrating their spatial distribution in the urban areas. Finally, based on the results, the recommendations for spatial planning on local and sub-regional levels were proposed.

4.2.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

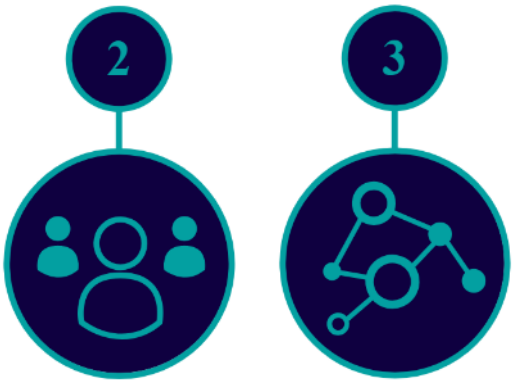
Mainly scientifically-driven, this is the first assessment of ES, based on arthropod diversity, distribution and ecological data in an Azorean island and for islands in the Europe’s nine Outermost Regions and 25 Overseas Countries and Territories. Using the best studied Azorean island (Terceira), the study investigated two key ES: Pollination and seed dispersal and Maintaining nursery populations and habitats. Pollination services are essential to sustain fruit production in orchards, as well as for endemic flowering plants by ensuring reproduction and dispersal. Mapping pollinator ES in agroecosystems and quantifying its economic value is therefore a priority. It is highly relevant in the context of several international policies such as the International Initiative for the Conservation and Sustainable Use of Pollinators, the FAO's Global Action on Pollination Services for Sustainable Agriculture, and the IPBES. Maintaining nursery populations and habitats is crucial to secure the conservation of Azorean threatened arthropods recently assessed using IUCN criteria (see Borges et al. 2017).

4.2.13. SPAIN: Spanish National Ecosystem Assessment (SNEA)

The aim of the SNEA is to visualize the contribution that ecosystems and biodiversity make to human well-being, by considering the different types of services, and the various biophysical, social and economic methodologies to map and assess them. It is the first nationwide ES assessment, which captures services outside conventional markets and include social and cultural aspects, for both use and non-use values. The SNEA in Spain aims to help building 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

4.2.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

The mapping and assessment of ES has been put in the context of planning and implementing sustainable development across a large-scale biotic transition, that display a magnitude of economic, ecological and socio-cultural gradients and that it representative for northern Sweden. With the overarching incentive of increasing the knowledge and capacity for sustainable development following the Sustainable Development Goals and Agenda 2030, the UNESCO MAB program combines natural and social aspects of economy and education for improved human livelihoods and equitable sharing of goods and benefits of natural and managed ecosystems. In particular, the ES mapping and assessment thus follows the local natural and cultural identity and the premises for developing, supporting and conserving those values. Here, the foci are on ES associated with forest habitats, forest management and forests in a landscape context, and with the indigenous Sami culture reindeer husbandry. The Sami people with reindeer husbandry is a culture that is based on services and goods provided by ecosystems and landscapes.



5. Stakeholders' Involvement

"The only way in which a human being can make some approach to knowing the whole of a subject is by hearing what can be said about it by persons of every variety of opinion, and studying all modes in which it can be looked at by every character of mind. No wise man ever acquired his wisdom in any mode but this; nor is it in the nature of human intellect to become wise in any other manner." (John Stuart Mill. 1859. On Liberty).

5.1. Identification of relevant stakeholders & Network creation/Involvement

According to the most accepted definition in the participatory literature, a person is a stakeholder in a decision-making process if he or she may either influence or be influenced by the decision (Reed et al. 2009). In a participatory process, stakeholders have the opportunity to engage in decision-making and express their views that are incorporated into the decisions. This approach provides solutions for addressing the links between social systems and the natural environment. When compiling the ESMERALDA flexible methodology, one of our aims was to provide inspiration to researchers and practitioners who perform ES mapping and assessment projects to choose participatory methods.

The importance of stakeholder involvement in the assessment of ecosystems and their services is emphasized by international recommendations (IPBES, EU MAES), arguing that it promotes the policy uptake of the ES concept and is essential for the adoption and implementation of the results. Apart from that it is essential also from ethical considerations, that different actors of society have a fundamental right to participate in issues that affect them. In addition, potential conflicts between individual stakeholders can be more predictable and easier to resolve in a dialogue where every participant can express their opinion. Incorporating a diversity of knowledge and values, operational results can be achieved which are relevant for the specific situation, legitimate and thus are accepted and trusted by many actors, which is largely increasing the probability of implementation. For these reasons, stakeholder involvement has to be key part of mapping and assessment of ecosystem services.

The first step in the identification of stakeholders and linkage between them is to identify the focal issue which influences the range of stakeholders to be included and their basic interests. The most obvious stakeholders can usually be easily identified after that. The less obvious stakeholders can be further identified by, for example, media and document analysis, focus group discussions and key-informant interviews or by performing social network analysis (see Box 5.1). A national or regional, active network on ecosystem services, biodiversity or natural capital formed by scientists, policymakers and practitioners can enhance considerably the successful implementation of MAES at national and regional level.

5.2. Application in ESMERALDA case studies

All the selected ESMERALDA case studies involved stakeholders during their work. The level of involvement varied from consultation and request for stakeholder opinions to real collaboration, where decision-making powers are shared and understanding, commitment and responsibilities are mutual.

An overview of the categories of stakeholders that have been involved in the MAES process in the selected ESMERALDA case studies is shown in Table 5.1. Broadly, the four categories are competent authorities (e.g. decision-makers and people working for agencies etc.), other experts, business, and the general public. Moreover, the involvement is characterized according to five different levels depending if stakeholders were simply informed, consulted (i.e. to obtain feedback on analysis, alternatives and/or decisions), involved (i.e. to work directly throughout the process with stakeholders), collaborated with creating partnerships, or empower (e.g. capacity building for an autonomous MAES).

Table 5.1: On overview of the categories of stakeholders and their level of involvement in the MAES process in the selected ESMERALDA case studies.

	INVOLVED STAKEHOLDERS				LEVEL OF INVOLVEMENT				
	Competent authorities	Other experts	Business	General Public	Inform	Consult	Involve	Collaborate / Partnership	Empower
Belgium	x	x					■	■	
Bulgaria	x	x			■	■	■	■	
Czech Republic	x							■	
Finland	x	x		x	■	■	■	■	
Germany	x			x	■				
Hungary	■	■	■	■	■	■	■	■	■
Italy	x	x			■	■	■	■	
Latvia	x	x	x	x	■		■	■	■
Malta	x	x			■	■			
Netherlands	■	■	■		■	■	■	■	
Poland	x				■	■			
Portugal, Azores	x	x	x		■	■		■	
Spain	x	x	x	x	■	■	■		
Sweden	x	x	x			■	■		

In the following, for each case study, we provide a brief description of how stakeholders have been actually involved in the specific MAES process.

5.2.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

The development of the tool and all maps was done in close cooperation with the city authorities (Department Sustainable City, with focus on energy and environment). Other departments such as the Biodiversity Department and the Spatial Planning Department were involved in the whole development process. The process strengthened the relations between the different stakeholders. Generally, the tool supports the development of local green plans, which involves the consultation of local citizens.

Recommendations

- Communication/co-creation asks a big effort. Therefore, it needs to be included from the start of the project.
- A role citizens could have in the development of the tool is to do a quality check on some of the produced maps.
- Try to establish a permanent network of stakeholders by e.g. organising targeted discussion groups, social media actions.

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

Most of the 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. Moreover, 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 (Borisova et al. 2015).

Recommendations

- The ES related activities should involve all stakeholders that have interests in these activities. Usually, this is not the case and some important aspect are missing.
- The sustainability of the ES related projects should be better addressed. Most activities usually finish with the end of the project and there are still not really working stakeholders networks.

5.2.3. CZECH REPUBLIC: Pilot National Assessment of ES

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). 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.

Recommendations

- The needs of stakeholders should be taken into account
- The process should bring new knowledge or products which can be used by key stakeholders
- Partnerships need to be built up gradually and take into consideration new needs and requirements

5.2.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

The case study was initiated by the city planners of the City of Järvenpää. Researchers and planners co-operated from the very beginning of the process by identifying relevant ES to be mapped and reviewing the relevant background information and spatial data from the national and city archives. Citizens were involved in the case study in a workshop where they were asked to provide information about their perceptions and values related to (mainly cultural) ES. The participants of the workshop scored different green infrastructure types and features based on how important they were for them from the ES point of view in general, and after that participants were asked to place the most important areas to which they attached cultural ES based values on a map. Moreover, the citizen knowledge had earlier been collected by using an online PGIS survey and this information was reclassified to derive spatially-explicit cultural ES related values of green infrastructure with content analysis. To better comprehend educational values of green and blue infrastructure a map survey was mailed to schools and kindergartens.

In the second phase, this real-life planning-related case study provided a good opportunity to test spatial multi-criteria analysis (SMCA) in engaging practitioners in enhanced integration of urban green spaces and residential infill development. Here the focus was especially in the interaction and the underlying processes behind stakeholders' roles during planning process that can support the future planning. Experts from different sectors of the city had an essential role in the process as they provided input on the criteria and thereafter, weighting of the criteria to find the most optimal sites for infill development.

Recommendations

- Involve stakeholders and practitioners from the very beginning of the process.
- Maintain the dialogue throughout the process by regular meetings.

5.2.5. GERMANY: Mapping ES dynamics in an agricultural landscape

Landowners/farmers were involved in the preceding project "Long-Term Research in the Bornhöved Lake District" to carry out research on their property. 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 to analyses how changes in policy (e.g. incentives for biomass for energy) are affecting their agricultural activities and their behaviour. Furthermore, local people and other land users should be included to quantify recreational activities and other cultural ES, besides the (supraregional) tourists (mainly day trips). The State Agency for Agriculture, the Environment and Rural Areas of Schleswig-Holstein is a key federal state-level stakeholder. Its tasks include state-level fishery, emission protection, water management, nature conservation, waste management and soils, all relevant for biodiversity and ES.

Recommendations

- Sharing early and comprehensive information with the local population increases their willingness to cooperate.
- Cooperating with competent authorities increases the chances to get access to relevant data and further information on activities in the study area.
- Especially when it comes to local performance and cultural heritage, the local population should be involved as they can serve as valuable source of information.

5.2.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

The Bükk National Park Directorate (BNPD) is a key stakeholders in the region. As a non-authority public body, its main task is to secure the good state of natural ecosystems by cooperating with many regional and authorizing the use of the 'National Park Product' brand for local products. Other tasks include public awareness-raising, education, introduction of natural values and eco-tourism as well as organization and management of research programmes. Within the Eco Karst project, assessment of ES, development of local action plans and the facilitation of pro-biodiversity businesses is directly related to stakeholder involvement. The goal of the process is to involve a big enough group of local people with diverse backgrounds, economic status, expertise and experience, given this improves the quality of work significantly and is essential for defining feasible long-term goals. Thus, stakeholder groups and the most important ESs they interact were first identified by the national park administration. Following, stakeholder selection was done with social network analysis.

Recommendations

- Interactions to stakeholders have to be well thought out already from the first requests, because it is the responsibility of the project management to create a positive atmosphere and momentum, and to generate interest and confidence in the project.
- Define the goals of the participatory process in an iterative way in order to find themes that can directly affect the stakeholders, or they have direct experience and knowledge about.
- When selecting stakeholders, look for a diverse representation of organizations and people who, by their profession, can bring different perceptions of the area. Try to find people who are most able to connect others among local actors.

5.2.7. ITALY: ES mapping and assessment for urban planning in Trento

The MAES process in the case study evolved from a mainly scientific endeavour to a formalized collaboration with the city administration, involving key staff from the departments of planning and of green space management. In the first phases, the interaction was limited to the provision of baseline data and to preliminary, informal discussions on the most pressing issues to address. Later on, also following the requirements of the EnRoute project, a "city-lab" was established composed of members from the city administration and the University of Trento. The city lab was the opportunity for a closer collaboration, grounded on the discussion of preliminary results and of their usefulness for planning and management purposes. This helped identifying key requirements and needs to enhance the usability of the results. From discussions in the city lab the idea of involving other experts in some steps of the MAES process emerged. Thus, 20 people including officers from several municipal and provincial departments, researchers and academics, and local practitioners were asked to provide their opinion through an on-line questionnaire and a follow-up table to discuss and validate the results.

Recommendations

- Scientific studies can initiate a process of cooperation and collaboration among different stakeholders (e.g., different departments of the administration).
- Stakeholders' involvement is easier when the potential use and impacts of MAES results are made evident.

5.2.8. LATVIA: Mapping marine ES in Latvia

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.

Recommendations

- Plan sufficient time for explaining the concept of ES, the MAES approach and objectives for all levels of involvement.
- For mapping and assessment of cultural services involvement of local stakeholders (e.g. through focus group discussion) would be advisable, while assessment of provisioning and regulating services can be based on expert knowledge.
- Involvement of sector representatives (e.g. fisherman) would be beneficial for defining the most relevant indicators for assessment of provisioning service supply and demand.

5.2.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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. Specifically, two groups of stakeholders were consulted in the ES assessments, and data collected from stakeholder participation was used to generate maps of these services. 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).

Recommendations

- The assessment of ES at relevant scales is associated with extensive data requirements. Thus, it is recommended that a national network or platform for experts, who may contribute to the development of a national assessment, is established with the objective of developing the scientific and technical knowledge necessary for the implementation of ecosystem assessments. This network requires input from experts from different disciplines (e.g. ecology, marine science and ecology, social-ecological systems science) to support the work done by national authorities in ecosystem assessments and in decision-making to maintain and enhance ES.
- Biophysical approaches should be complemented with socio-economic data regarding the use and benefits derived from ecosystems and their services. Thus, stakeholder participation becomes particularly important if the assessment is intended assess capacity, flow and demand of ES

5.2.10. NETHERLANDS: ES-based coastal defence

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 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. The restoration project of the rivers may also lead to more fish migration to upstream EU countries.

5.2.11. POLAND: ES in Polish urban areas

The Ministry of Environment was the sole stakeholder involved in the project; it discussed or negotiated the procedures on every step of the research. The potential stakeholders, however, 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, esp. Directorates for Environmental Protection.

Recommendations

- Involvement of local authorities is very desirable, not only in terms of information and consultation. They can play significant role to keep the partners on board of the MAES process.
- Cooperation and partnership with stakeholders, especially local authorities and public institutions, in process of MAES can benefiting in many ways, e.g. facilitating the acquisition of necessary data, time saving in relation to the recognition of available data and acquisition, empowering the significance of action, or strengthening the potential for future cooperation.

5.2.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

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 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.

Recommendations

- There is the need to change the status of several Azorean Protected Areas to a high level of conservation.
- By focusing on island agroecosystems and combining cutting-edge ecosystem services (ES)/ ecosystem disservices (ED) assessment tools with traditional taxonomic analyses, there is the need to develop a multifaceted approach to gain more insight to evaluate the relative importance of native and exotic organisms as ES/ED providers
- There is an urgent need to control invasive species in island protected areas.

5.2.13. SPAIN: Spanish National Ecosystem Assessment

The SNEA has provided scientific information on the conditions of Spanish ecosystems through mapping and assessment of key ES and has promoted its 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 centres 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 centres, 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. The research process has been fed by databases, workshops, interviews and questionnaires and interactions with existing scientific forums and networks conducting ES assessments.

Recommendations

- The communication strategy of mapping and assessment studies needs to be planned from the beginning in parallel with research to create a dialogue between researchers, decision makers and the general public. The impact of these studies on public awareness is increasing, and its concepts and theoretical frameworks are taking root in society.
- To bring the attention of stakeholders and listen to their needs and contributions regarding mapping and assessment it is needed to ensure that the results will be useful to them as well as taking into account the different actors involved in or dependent on ecosystem services.
- 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 in different social spheres, such as the media, school communities, NGOs and social movements.

5.2.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

This ES mapping and assessment approach have benefitted from the process of forming and developing the formal UNESCO MAB candidacy for Vindelälven-Juhtatdahka, which was hosted by the County Administrative Board of Västerbotten and the municipalities in the area. This process has included broad and long-term stakeholder involvement and participation to outline strategies for conservation, development and supporting sustainable development. ES are specifically addressed in one of the chapters in the candidacy report. With the focus on Sami people and reindeer husbandry, the final setting of the Vindelälven-Juhtatdahka river valley ESMERALDA ES mapping and assessment report was prepared in dialogue with members of the Ran Sami community and incorporate some of the ES that generically or specifically are related to or generated by reindeer husbandry as a culture and land use in northern Sweden.

Land use, e.g. forestry, reindeer husbandry, agriculture, etc., have modified and affected the supply of ES in both positive and negative ways. The rich natural resources and landscape characteristics support land use and business opportunities. Nature-based tourism is well developed with facilities ranging from inter-nationally recognized downhill skiing resorts to family-driven fishing and wildlife activities.

Recommendations

- Demonstrate the relevance with respect to direction of ongoing projects and processes.
- Demonstrate the relevance with respect to key involved key stakeholders.
- Demonstrate the relevance with respect to national and regional policy on ES and other environmental frameworks

5.3. Recommendations for stakeholders' involvement

In their recommendations, ESMERALDA case study coordinators highlighted the importance of starting stakeholder dialogue early in the process, which can generate interest and confidence in the project and increase their willingness to cooperate. It is also suggested to provide comprehensive information which enables stakeholders to have a good overview of the goals and activities. Goals and activities, however, have to be flexible and adaptive enough, so that stakeholder needs and requirements can be taken into consideration in an iterative process. By this, the co-creation of new knowledge becomes possible which can be taken up and used by key stakeholders. Dialogues not only need to be started early but have to be maintained all through the process, establishing, if possible, a permanent network or platform for experts. This platform allows better cooperation between stakeholders, which ideally lasts even after the ES assessment is finished, creating sustainability for the project results.

Case study coordinators emphasized the importance of targeted discussion groups on one hand, and comprehensiveness on the other, involving all relevant stakeholders and their diverse views. Among them, the involvement of local authorities and public institutions was emphasized as they can play significant role as the cooperating partners. Mutual understanding of the ES concept can strengthen cooperation with authorities and institutions, therefore sufficient time and effort must be taken in the communication of recent scientific results.

Further important target groups are sectoral representatives, especially for the assessment of provisioning ES, experts for provisioning and regulating services and the representatives of local citizens, especially for the assessment of locally relevant cultural ES. Stakeholder participation becomes particularly important if there is separate assessment of capacity, flow and demand of ES. From all stakeholder groups it is suggested to involve the "bridge people" who have connections to many local actors and are able to represent their views. Communication towards the general public is not less important but involves innovative ways for dissemination in social media, school communities, NGOs and social movements, because the impact of ES studies on public awareness is already increasing.

BOX 5.1 Social Network Analysis for Stakeholder Involvement (By Béla Kuslits)

Social Network Analysis (SNA) is a tool to analyse how stakeholders interact or communicate within a study area. The method is able to inform researchers about (1) key individuals, who – due to their special position in the community – have a high ability to influence decisions or information flows, (2) relations between groups that have different legal status or authority, (3) how ecosystem services (ESs) shape human relations in the study area. Besides these, depending on the design of the survey used to construct the network, other relational information can be collected and analysed in a similar manner. SNA can inform students or decision makers about conflicts, insufficient communication, or informal interactions as well.

Main steps of SNA data collection and analysis

Define the base population: while in other cases the boundaries of the group of people to be analysed may be more or less clear, stakeholders in natural resource management almost never form a closed group. Thus, it is important to identify all groups and individuals that should be involved in the process. One way to identify stakeholders is to look at specific social-ecological interactions and search for communication channels that are specific to the participants of that activity.

Identify groups: even if SNA will later be able to identify informal groups based on network properties, institutional and legal arrangements do make significant differences among stakeholders. Usually decision makers and those who directly depend on the use of ESs are different people. Following the framework of Felipe-Lucia et al. (2015) stakeholders can be categorized into groups based on their decision making power and dependence on ESs.

Design a survey: questions should be specific and clear from the point of view of the respondent. They should ask for a specific type of connection depending on the interest of the research. To have a broad overview of relationships and also focus on the most relevant connections, Prell et al. (2011) recommends to use pre-defined groups in the questionnaire and set a limit in the number of the possible answers in each section. Example: “Who do you communicate with regularly from restaurant owners in the study area? Please list up to 5 people and their restaurants.”

Data collection: can be done in person with paper-based surveys or online. Paper-based surveys provide higher quality responses especially in communities, where the basic idea of SNA may be strange or suspicious for respondents. People recording the answers do not need much training before completing the task, thus for instance park rangers or other personnel who regularly meet stakeholders can collect answers. Online surveys make data analysis much easier while also hiding misunderstandings. Besides cultural aspects, the size of the target group may be an important factor choosing the data collection method.

Analysis: SNA has a broad literature focusing on cases and methodologies (e.g. Bodin and Prell 2011; Borgatti, Everett, and Johnson 2013). As a short summary, analysis can be done on an individual level: looking at positions, such as centrality measures. In a communication network, the in-degree of a node may indicate its power in the network or the trust in his views. Betweenness centrality may highlight players with high ability to connect distant others, bridging groups in case of conflicts etc. The exact interpretation of these measures depends on the context of the research. Besides analysing individual nodes in the network, the structure as a whole can be analysed as well. Subgroups, strength of connections between groups, external factors influencing the likelihood of a connection, (such as the role of geographical or ecological features) can be all indications of interesting features both for research and policy-making.

Software: For beginners Gephi an open-source software is recommended, for more advanced users UCINET, NetworkX or igraph may be useful.

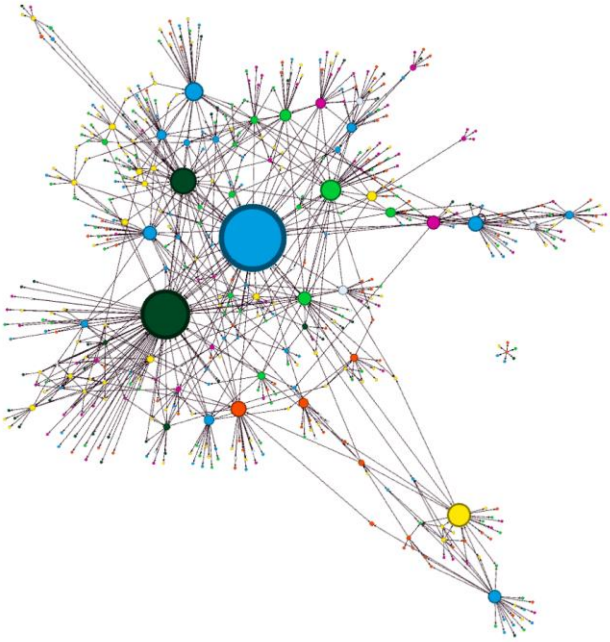


Figure 5.1. An example of a Stakeholder Network Analysis in which the colors indicate pre-identified groups:
BLUE: state administration (the big dot in the middle is Bükk NP)
PURPLE: animal keepers
ORANGE: small producers
YELLOW: tourism
DARK GREEN: forestry
LIGHT GREEN: NGOs

Size refers to betweenness centrality of the nodes

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6. Mapping and assessment: Initiating the process

6.1. Identifying Ecosystem Types

The identification and mapping of ecosystem types in the area of interest is an important starting point in the MAES process. Table 6.1 provides an overview of the ecosystem types identified in the study areas, according to the same classification used in the MAES project (MAES, 2013). The table also illustrates two other preliminary steps that precede the actual ES mapping and assessment discussed later on, namely, assessing ecosystem condition and selecting ES to be mapped and assessed.

In particular, the case studies highlight the need of refined ecosystem types typologies that are consistent with European, national and especially the MAES ecosystem typology as a critical step in the ES mapping and assessment. Depending on scale and target of the study, additional data sources in appropriate scales are needed. Moreover, the case study authors recommend the co-identification of relevant ecosystems and co-creation of an appropriate typology in collaboration with stakeholders. Following, details about the identification of the ecosystem types in the study areas and the related spatial databases is reported.

Table 6.1: An overview of the three preliminary steps of the MAES in the selected ESMERALDA case studies.

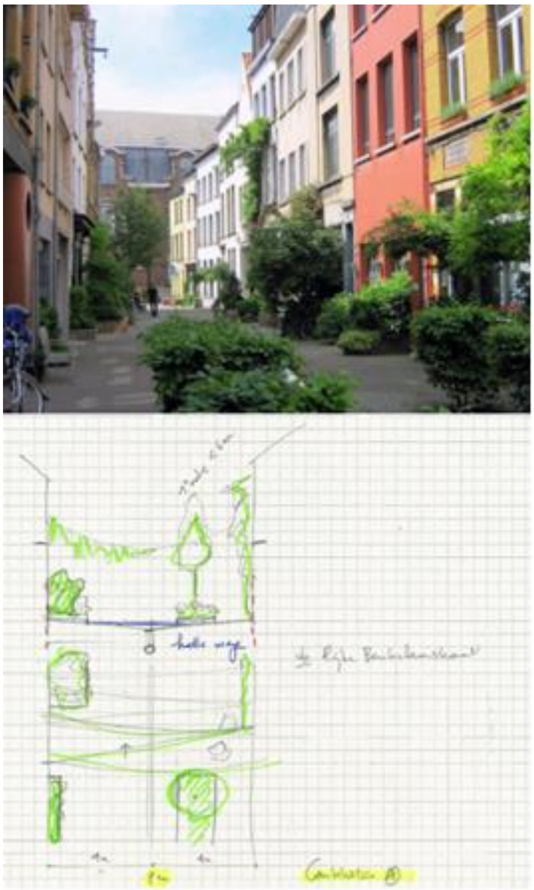
	Ecosystem types											Ecosystem conditions	Selection of Ecosystem Services	
	A	B	C	D	E	F	G	H	I	L	M	Assessment Yes/No	Scientist-driven	Stakeholders' driven
Belgium	■		■	■			■					■	■	■
Bulgaria	■	■	■	■	■	■		■				■	■	
Czech Republic	■	■	■	■	■	■	■	■					■	
Finland	■	■	■	■		■		■					■	■
Germany		■	■	■				■				■	■	
Hungary			■	■								■	■	■
Italy	■											■	■	■
Latvia									■	■	■	■	■	
Malta	■	■	■	■	■	■	■			■		■	■	
Netherlands		■					■	■	■	■			■	■
Poland	■	■	■	■		■	■	■				■	■	
Portugal, Azores		■	■	■	■	■						■	■	
Spain	■	■	■	■	■	■	■	■	■	■		■	■	
Sweden			■	■	■	■	■	■	■	■		■	■	■

A. Urban; **B.** Cropland; **C.** Grassland; **D.** Woodland & forest; **E.** Heathland and shrub; **F.** Sparsely vegetated land; **G.** Wetlands; **H.** Rivers and lakes; **I.** Marine inlets and transitional waters; **L.** Coastal; **M.** Shelf

6.1.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

The major ecosystem type is “Urban”. Other important habitats include forests, wetlands and grasslands. Operationally, a lot of effort was invested in setting up a suitable typology of urban green infrastructure and developing a map of the current situation. This is based on existing morphological classifications of land use maps, green management, green infrastructure (example categories are green roofs intensive, extensive; semi-hardened surface; tree rows; SUDs; grassfield; hedges and shrubs; coniferous – broadleaved forest). Moreover, 12 inspirational street images from Antwerp or other cities were included to roughly estimate the impact of combined measures (see examples in Figure 6.1).

Street typology 1: Garden street Antwerp



Street typology 2: Copenhagen water street

Figure 6.1. Examples of inspirational street typology

Recommendations

- Collecting high resolution data on small green measures takes a tremendous effort but in urban environment it is necessary.
- In addition to the calculations of the ecosystem services, translate them to easy comprehensible impact indicators.

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

The identification of ecosystem types is based on the MAES typology (MAES, 2013) at level 2 and CORINE Land Cover data. The MAES typology 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. 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. Thus, 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.

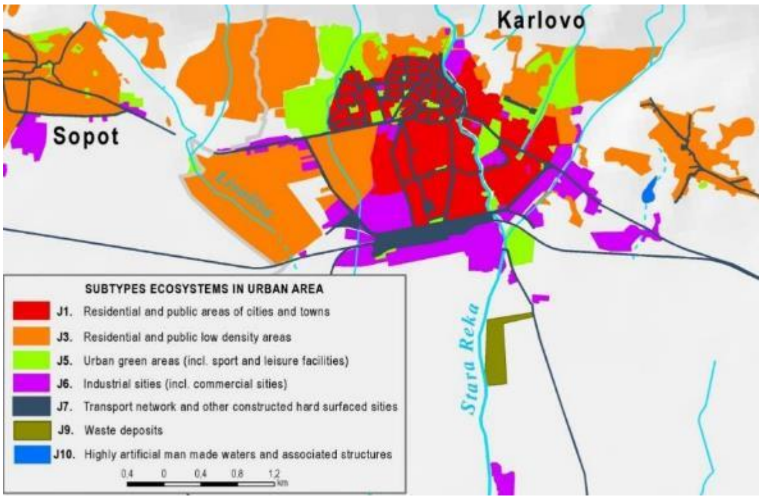


Figure 6.2. Urban ecosystem subtypes in the city of Karlovo.

Recommendations

- The teams of experts that identify different ecosystem types should work in close interaction between themselves to ensure consistency with the national typology.
- The ecosystem types should be mapped together in order to avoid gaps and overlaps.
- The national ecosystem typology should correspond to the policies in the respective sector e.g. forestry, urban planning etc.

6.1.3. CZECH REPUBLIC: Pilot National Assessment of ES

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

Figure 6.3. Example of consolidated layer of ecosystems for the national assessment and mapping of ES at the hierarchical level 4.

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. The most general land cover categories consisted of agricultural land, grasslands, forests, urban areas, aquatic ecosystems and wetlands. Values for the evaluation were made first at the highest level and then for the lower land cover levels.

Recommendations

- Development of tangible product in the partnership with stakeholders can assist ES mapping and assessment process
- Simple methods first can support further collaboration and implementation of ES mapping and assessment

6.1.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää (191 words)

Starting point for this mapping and assessment exercise was the identification and extraction of green and blue areas with sufficient spatial accuracy required for more detailed planning purposes. Aim was to create a typology of green infrastructure (e.g. Cvejić et al. 2015). To capture the most detailed features in the study area, we used the combination of currently available multiple different datasets that were complemented with digitization using temporally accurate high resolution aerial images with 0.5 m resolution. A key dataset was city owned local biotope data including areas of uniform environmental conditions that was used as a baseline for the delineation. As a complementary we used multiple datasets such as environmental features from Finnish National Land Survey database. The green infrastructure typology was a prerequisite for the mapping and assessment, but it was also a result in itself being the most accurate digital representation of the prevailing land cover in the area. This provided a possibility for the land use planners to have more accurate overview of the city green and blue areas.

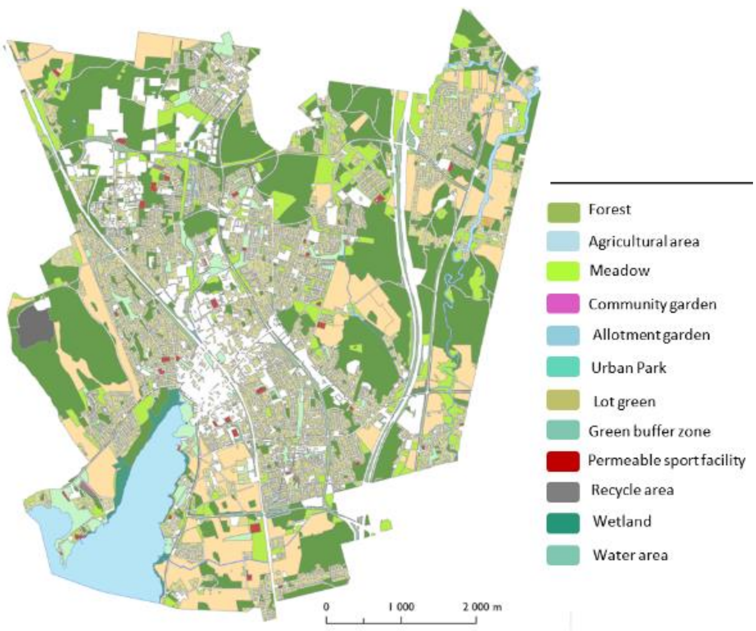


Figure 6.4. Järvenpää green infrastructure typology

Recommendations

- Use adequate data. The scale of a study determines the accuracy of the data needed for the mapping.
- Allocate enough time for data gathering and pre-processing as it is time consuming.
- Mapping results depend strongly on the data quality

6.1.5. GERMANY: Mapping ES dynamics in an agricultural landscape

Corine land cover data (from 1990, 2000 and 2006) were the initial data source for a preliminary study. Following, the focus was brought to a more detailed analysis of crop cultivation and rotation changes using other available official data sets such as ATKIS (Official Topographical Cartographic Information System). However, these initial databases 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 for recent years. The developed approach was aimed at being easy to reproduce and to upscale, to be able to compare changes and impacts and to formulate guidelines for sustainable landscape management and policy-making.

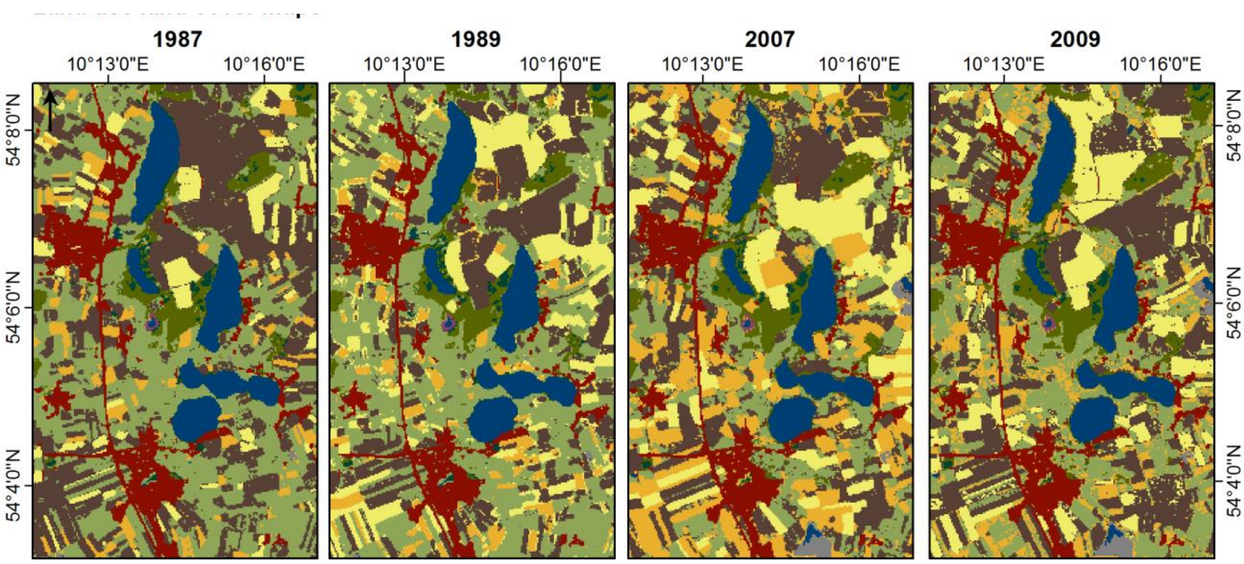


Figure 6.5. Land use / land cover maps for the Bornhöved Lakes District (source Kandziora et al. 2014).

Recommendations

- Develop a methodology which allows future continuation and time-series analysis.
- Method should be easily reproducible to other study areas.
- Ensure comprehensive and understandable documentation on data, data pre-processing and employed methods.

6.1.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

The goal of ecosystem type mapping is to provide the necessary spatial units and basic input for the ES assessment and mapping. The input requirements may differ for the different services and thus the typology and scale of the ecosystem type map needs to be chosen carefully. In this project, we use categories of EUNIS level 3. After assembling available information (e.g. existing vegetation/habitat maps) a conversion table was created, where each original class was assigned a EUNIS category. For most ES, further specific customization of the ecosystem type map is necessary. In most cases 'customizing' means a simplification, in order to reduce the number of categories to be considered. It is most easily done by merging some classes. Since Eco EUNIS is a hierarchical classification, in case of certain ecosystem services we can simply consider using the EUNIS level 2 categorisation of our maps, rather than level 3. But it is also possible to choose other considerations on how to merge the categories according to the ES. Technically the simplest way of carrying out this merging of categories is to create a conversion table (old categories → new categories) and join it to the original ecosystem type map layer.

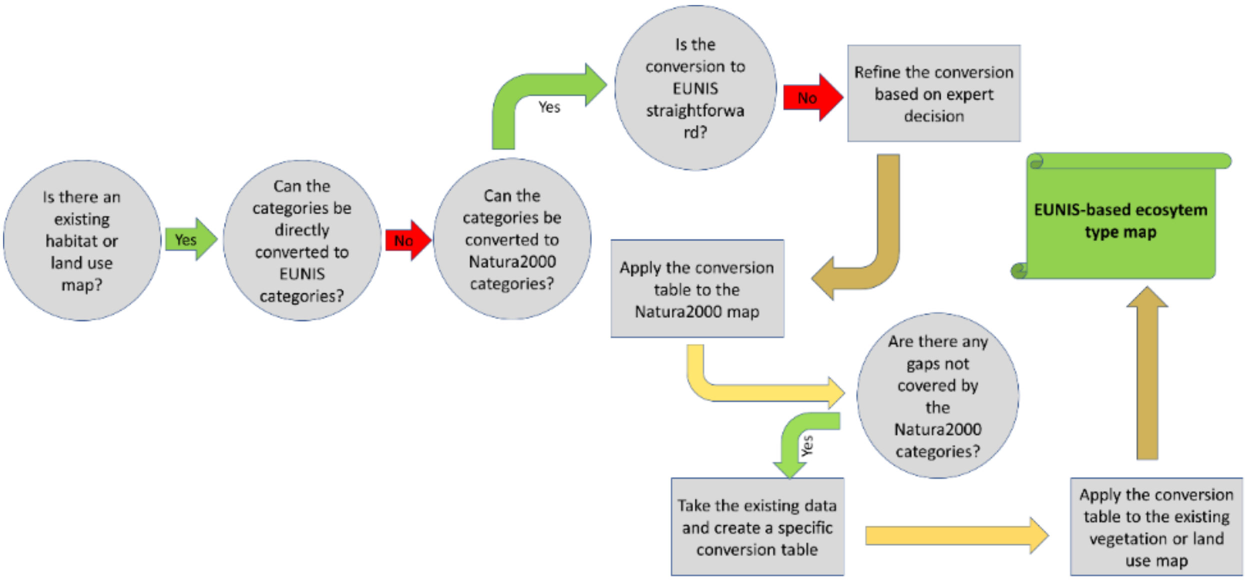


Figure 6.6. Workflow for creating ecosystem type map of the Bükk NP

Recommendations

- The EUNIS classification, also used by MAES, is suitable to provide comparability between multiple pilot areas in European projects, since EUNIS level 2 maps are available online for the whole of Europe.
- For the detailed level EUNIS 3, however, in many cases there is no established correspondence yet with national categorisation of habitats, defining the EUNIS equivalent of the national categories will require expert knowledge.

6.1.7. ITALY: ES mapping and assessment for urban planning in Trento

The MAES process in Trento focused on urban infrastructure. Although relatively few data are specifically collected for the purpose of analysing and monitoring urban green infrastructure, the combination of currently available datasets allowed gaining the information necessary for the ES mapping and assessment exercise. The most relevant data were the high-resolution aerial photograph produced in 2015 and the recent land use map purposely-realized by the municipality to provide a base layer for the drafting of the new plan. Other key information was retrieved from the municipal databases of public green areas and public trees. The database of public green areas is a highly detailed mapping of urban green areas managed by the municipality, providing information on all the elements that compose the area (walking and cycling paths, tree and water areas, flowerbeds, etc.) as well as on their use and management. The database of public trees collects valuable information about species, dimensions, ages, and management activities. Detailed data for public green infrastructure from the two databases were integrated with more rough and coarse data about private areas.

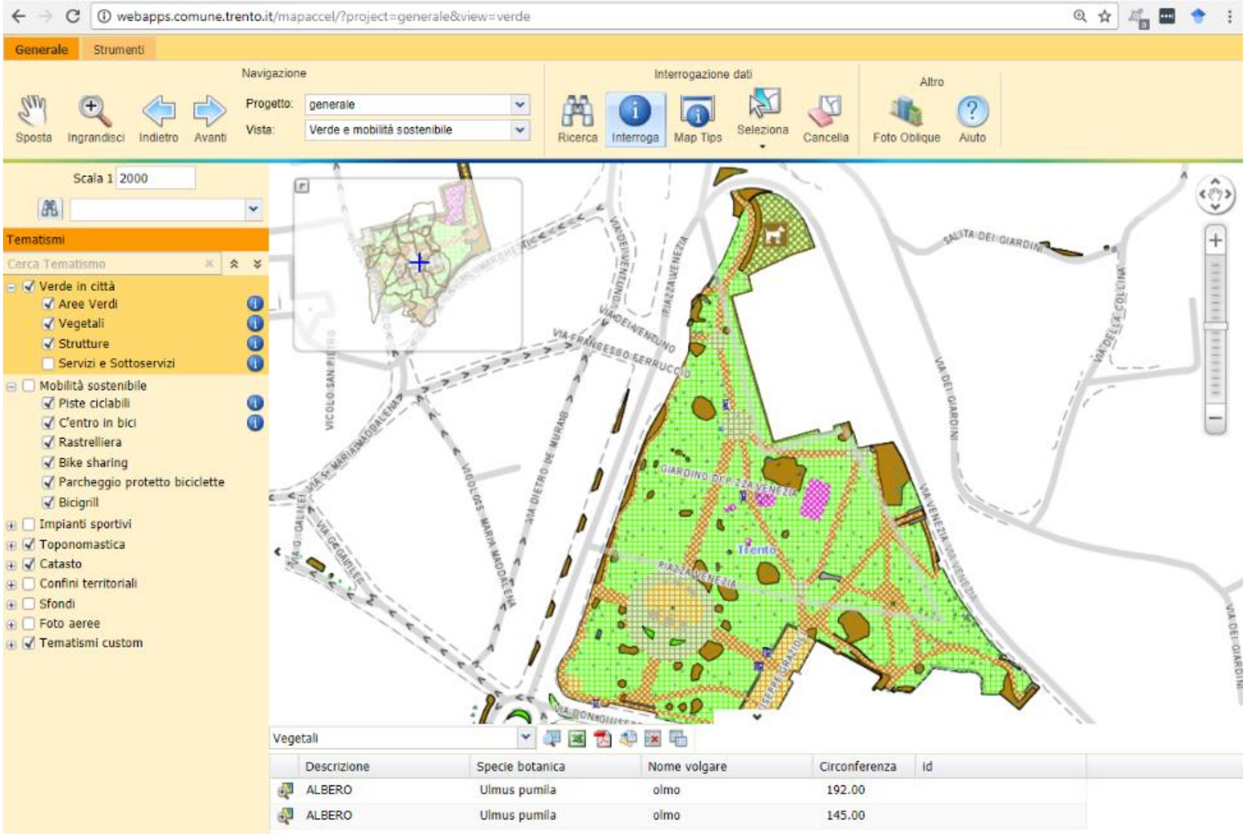


Figure 6.7. An example of the municipal dataset on the Green Infrastructure in Trento city.

Recommendations

- Data are never as good as we would like them to be. But they can be good enough for the purpose.
- MAES may highlight the need for collecting more detailed or better data.

6.1.8. LATVIA: Mapping marine ES in Latvia

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). 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. 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).

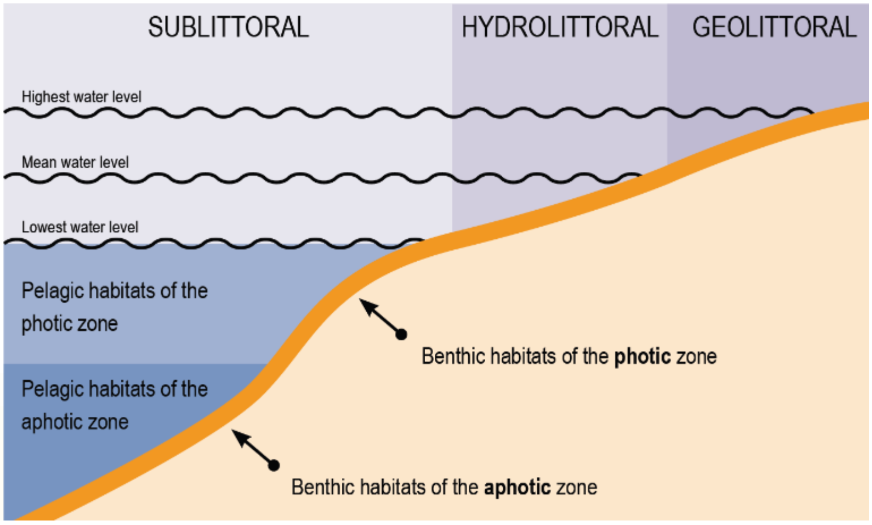


Figure 6.8. Zonation of marine habitats. Source: Baltic Environmental forum, 2009; adopted from D. Boedeker, Federal Agency of Nature Conservation, Germany, 1998.

Recommendations

- Corine land cover not suitable for identification of ecosystem types in marine and coastal ecosystem. A benthic habitat map can be a suitable solution for provisioning and regulating services, but it might be not suitable for mapping cultural ES. However, ES related to pelagic habitats shall be also taken into account to address the multidimensional character of marine ecosystem.
- Other spatial units (e.g. grid cell) can be applied instead of ecosystem types, if mapping based on empiric data/survey results.
- It is difficult to attribute cultural ES assessment to particular habitat types, since supply of such ES usually is related to complex of coastal habitats and adjacent terrestrial areas (land-sea interface)

6.1.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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

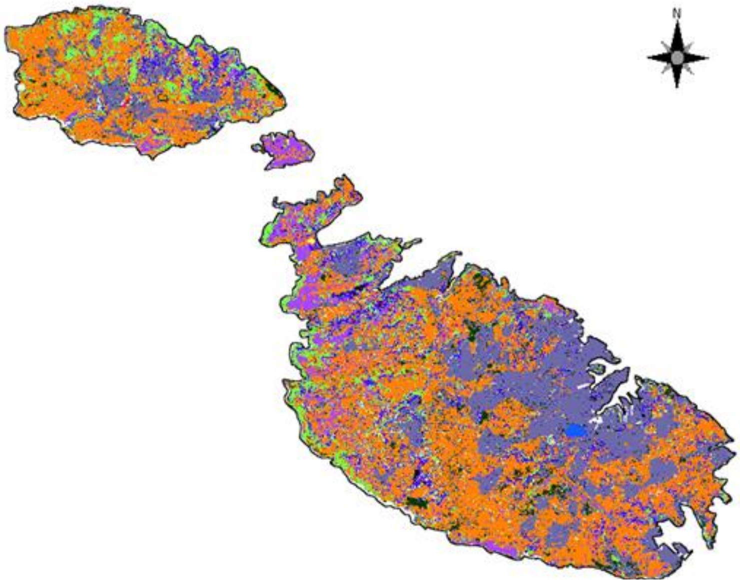


Figure 6.9. A land use land cover map of Malta was developed using Sentinel 2 satellite images.

developed 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.

Recommendations

- Improved access to existent data is considered particularly important to permit the development of novel and more specific approaches for the assessment of ES in Malta. This is a critical aspect in the development of a science-policy interface for more effective environmental governance. It is recommended that access to environmental data, and more specifically spatial information, is made available through online portals allowing for this data to be used for further analysis.
- The development of land use and land cover maps for the assessment of ES has been the first step in the ESMERALDA Malta case-study given the limited usability of other coarser baseline maps. The choice of the scale of the map, and or satellite images or orthophotos, therefore becomes a critical aspect that requires consideration when new maps are developed.

6.1.10. NETHERLANDS: ES-based coastal defence

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). 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.

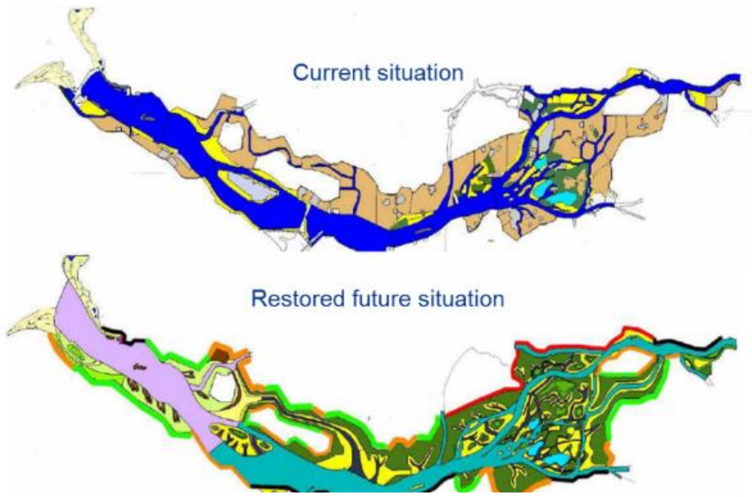


Figure 6.10. Ecosystem maps of the Haringvliet for current and potential "restored" future situation

6.1.11. POLAND: ES in Polish urban areas

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 data about grasslands (i.e. meadows, pastures and natural swards) and inland waterlogged areas based on the Corine Land Cover 2012.

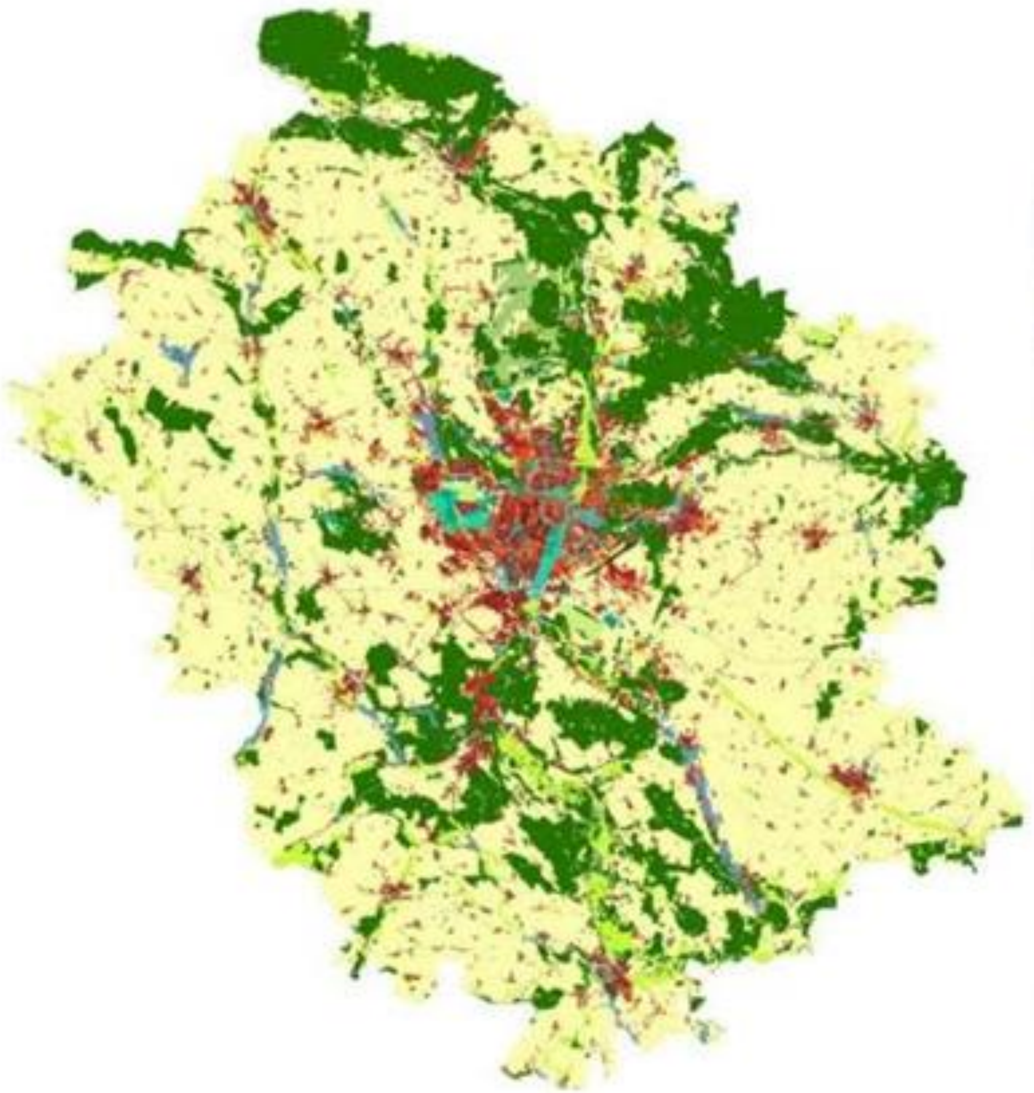


Figure 6.11. Ecosystem mapping for Poznan agglomeration

Recommendations

- Urban Atlas is a valuable source of information for comparative studies; however, more detailed data are recommended for local analysis.
- Data containing more structural information about land cover is more valuable for ES mapping than data based on functional criteria.
- The resolution and thematic detail of the data is a very important factor influencing on the results of research, including identification of ecosystem types and further the quantification of ES. Hence, the resolution of the LULC data or other spatial data should be considered critically in the aspect of the study scale, data availability, cost of its purchase, and requirements of methods used in the MAES process.

6.1.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

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).

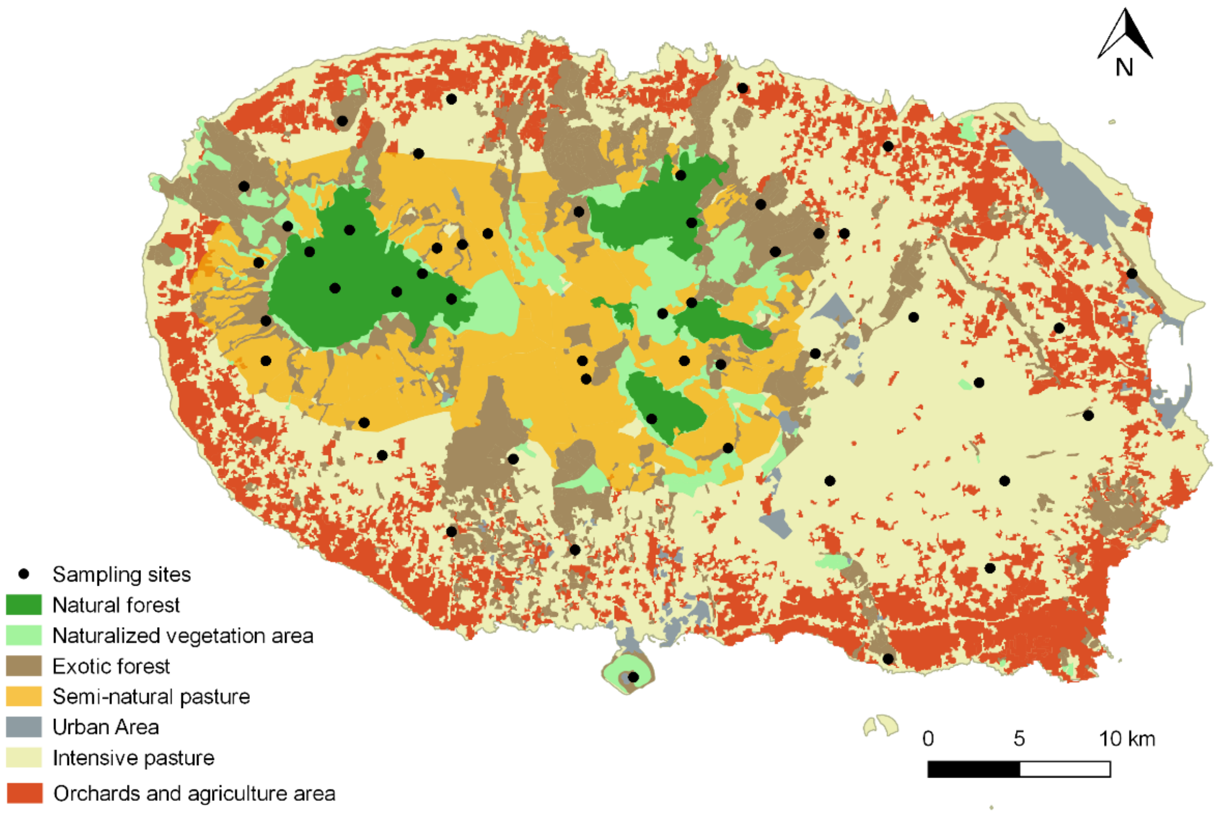


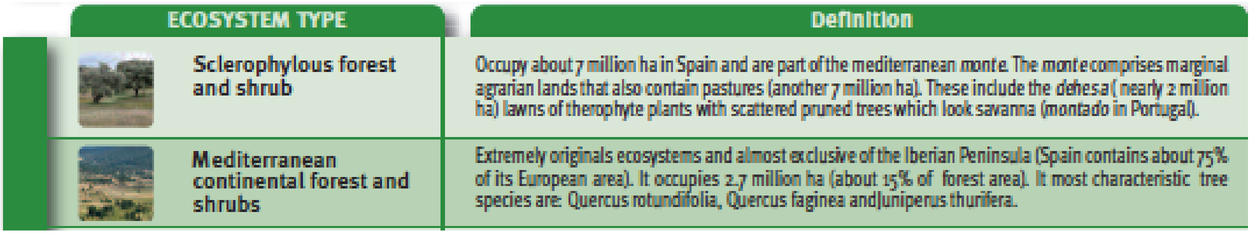
Figure 6.12. A land use land cover map of Terceira was available from DROTRH (2008) adapted by our purposes and with addition of new data for natural forests from Gaspar et al. (2008). Black points are sampled points for the pollinator assessment (see Picanço et al. (2017a, b).

Recommendations

- In islands small scale data on land-use and key environmental variables are necessary, since orography complexity and direction of prevailing winds implies rapid changes in local environment at small distances.
- There is the need of standardized biodiversity data across islands.
- Long-term monitoring schemes for island ecosystems are urgently needed to provide quantitative baselines for detecting changes within island ecosystems

6.1.13. SPAIN: Spanish National Ecosystem Assessment

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. 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. The considerations that guided the selection of ecosystem types were as follows: (i) the number of ecosystem types evaluated (14) should be sufficient to effectively sample the original natural character of Spain; (ii) 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; (iii) 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).



ECOSYSTEM TYPE	Definition
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.

Figure 6.13. Example of description of the 14 ecosystems types assessed in the Spanish NEA (Source: SNEA, 2014).

Recommendations

- The proposed European-scale ecosystem classification (EEA, 2012) is compatible with ecosystem classifications conducted for national scale studies and allows consistent assessments from the national to the European scale.
- Information obtained from more detailed classifications developed at a local scale and at a higher spatial resolution should be compatible with these classifications and could be aggregated in a consistent manner.
- The real methods and techniques to map ecosystem need to be mentioned, but in some cases this information and data sources is not available in the background reports or publications.

6.1.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

The area represents an elongated transition from the coastal boreal to the alpine biome. Forests and woodlands are predominant and cover about 535.1 kha (52%). Other nature types, in decreasing order, are alpine and subalpine heathland (18%), peat-forming wetlands (12%), subalpine mountain birch forest (8%), water bodies (6%), agricultural land (2%), marine habitat (<1%), built areas (<1%), glaciers (<1%), estuary (<1%) and rocky and substrate land (<1%). The Vindelälven-Juhtatdahka landscape contains natural and cultural premises that support a rich pool of provisioning, regulation and maintenance and cultural ES. Furthermore, the watershed scale, from the uppermost divide in the Scandinavian mountain range and the valley hillsides to the mouth in the Gulf of Bothnia, represents a holistic landscape with a continuum of ecosystems and ecological processes. The configuration of habitat types follow natural gradients and terrain formation. Unique natural features of significant values includes for instance primary succession on post-glacial rising coastlines (the official rate 8.5 mm uplift per year along the Gulf of Bothnia coastline) and characteristic (e.g., Arctic fox) and endemic (e.g. Ammarnäs perch) species. The study area harbor 20 priority species according to the Habitats Directive, 51 priority species according to the Birds Directive, 19 species on the global IUCN priority list, and 488 species on the national red list. The river ecosystem itself, in particular with respect to its natural state, provides a range of ecological, economic and socio-cultural premises.

Recommendations

- Priority habitats according to pan-national, national and regional schemes
- Ecosystems within land-cover types that dominate in the area
- Ecosystems types that frequently represent ES bundles and are locally relevant

6.2. Recommendations for identification of ecosystem types

Based on the ESMERALDA case studies the following general recommendations for the identification of ecosystem types can be identified.

The first step is the development of an appropriate ecosystem type's typology that is consistence with existing national and EU typologies. Typologies for studies relevant for the MAES process needs to be consistence with the European ecosystem map developed by the European Environmental Agency (EEA, 2015) and the MAES definitions of ecosystem types at level 2. These level of detail should be the basis for further, compatible refinements. The goal of the study and the scale of the study area (national, regional, local) define the needed level of detail of the typology.

In most cases it will be suitable to refine the level 2 ecosystem types provided by the EEA to a third level with ecosystem types relevant in the study area. This work can be carried out on the basis of supplementary data sources like Corine land cover maps, habitat maps (e.g. in the EUNIS typology), the EU urban atlas, remote sensing data (e.g. satellite images from the Copernicus programme) or topographic databases provided by local or regional authorities. The ESMERALDA case studies dealing with green and blue infrastructure in an urban planning context underpins the need of high resolution maps created on the basis of high resolution remote sensing data and thematic data provided by the municipalities.

In the case of islands with complex orography and rapid changes in the local environment (e.g. many islands in the EU oversea territories), a small scale map of ecosystem types is needed. Therefore detailed land use, key environmental and high resolution satellite data is needed. The definition of marine and coastal ecosystem types should reflect the multidimensional character of these and be consistent with relevant classification systems such as EUNIS or the marine region specific classifications, e.g. the HELCOM HUB classification in the Baltic Sea.

Beside the general consistency with existing typologies and an appropriate level of detail, the typology should also reflect the relevant ecosystem types frequently present in the study area. Additionally, the typology should address priority habitats according to European, national and regional schemes. Therefore, the close interaction of experts and the co-identification of relevant ecosystem types together with stakeholders is useful. This procedure allows the creation of a common understanding of the typology which can assist in the following ES mapping and assessment process. The identification of relevant ecosystem types is a time consuming but critical process in the mapping and assessment of ecosystem services. Therefore, enough time should be allocated for this step. To benefit of the work carried out, the developed method to create the typology should allow future continuation based on changed input data and thereby time-series analysis. Additionally, it should be easily reproducible to other study areas.

6.3. Assessing Ecosystem Conditions

Following up on the overview provided in Table 6.1, Table 6.2 details how ecosystem condition was assessed in the selected case studies. It specifies the applied data and/or method (e.g. Art. 17 assessment; WFD assessment; MSFD assessment; data including air pollutant concentration; habitat connectivity; land use change; soil degradation) as well reports some illustrative indicators used. More details about the process of assessment of the ecosystem condition in the case studies are provided in the remainder of the section.

Generally, the 14 ESMERALDA case studies highlight the need for concise and precise indicators for different ecosystem types relevant for the study area. As in the development of an ecosystem typology, local knowledge and stakeholder should be incorporated in the identification of the indicators. Availability of relevant data sources is mentioned to be crucial for a successful and relevant assessment. Long-term monitoring data on relevant parameters is critical to enable the analysis of changes in time and should be implemented when missing.

Table 6.2: On overview of the assessment of the condition of the ecosystems in the selected ESMERALDA case studies.

Case Study	**Assessment**	**Applied Data and/or method**	**Example of indicators used**
Belgium	Assessment of separate conditions of the green infrastructure and pressures on the city	Land cover map + key protected areas and corridors for assessing biodiversity Pressure maps: Process based models	Land use; Protected or not; air quality (µg/m³ Nox, PM10, PM2,5), noise hindrance (dB(A)), urban heat (radiation temperature), flood risk sewage network, areas with shortage local green
Bulgaria	Yes	Set of indicators based on concept of ecosystem integrity	Plant diversity, soil heterogeneity, habitat diversity, air quality
Czech Republic	No		
Finland	Yes	Participatory mapping by citizens of locations where there is harmful flooding due to rain water; Mapping of soil sealing; Mapping of connectivity of green infrastructure using Morphological Spatial Pattern Analysis (MSPA) and MatrixGreen methods; Including ecosystem condition related datasets in the GreenFrame analysis of the ES provision potential of the green infrastructure, such as high nature value farmlands, water areas having good ecological quality, etc.; Including spatial data on noise levels, good air quality, no disturbing odours, and areas needing regeneration due to landscape / townscape damages in Multi-criteria decision analysis	Flooded locations due to rain; % of impermeable land per sub-watersheds in current and planned future situation; Uniform green areas of different sizes (less than 3 ha, 3-10 ha, more than 10 ha), green connections, edges of green areas, etc.: % of green infrastructure belonging to each of the groups; Importance of each separate green area to the overall connectivity of green infrastructure (a score); Relative variation in the ES provision potential of the green infrastructure (score); A criterion / An indicator of avoiding nuisance and disturbances (sub-indicators: areas with low noise level, areas with good air quality, areas with no disturbing odours)
Germany	General assessment of ecosystem condition in very early studies.	Conceptual approach	
Hungary	Yes	Presence of biodiversity: the composition/diversity of the biotic components of an ecosystem is one of its most relevant characteristics determining capacities for a number of services.	(i) presence/abundance of a (few) selected key species (groups) (remarkable biodiversity); (ii) a naturalness index giving an aggregate evaluation of the "capacity" of the sites to maintain high levels of remarkable or general biodiversity (iii) Presence/abundance for a few particularly problematic invasive species primary species records (e.g. distribution maps), biodiversity proxies, species distribution model outputs, ecosystem type, expert knowledge
Italy	Only indirectly	Land use land cover and map of canopy coverage from aerial photographs.	type of soil cover and percentage of tree canopy coverage

Latvia	Yes: (i) Environmental status of marine waters, (ii) Benthic habitat condition, (iii) Ecological value of marine ecosystem	(i) MSFD Initial assessment; (ii) Habitats Directive reporting according to Art. 17 requirements, (iii) A map of ecological values based on distribution of benthic habitats, algae, birds and fish species.	(i) Benthic Quality Index, Spawning stock biomass, Zooplankton mean size vs. total stock, Summer chlorophyll a concentration; Depth distribution of Fucus vesiculosus and Furcellaria lumbricalis, Population structure of Macoma balthica; (ii) Conservation status of reef habitats; (iii) Ecological value per grid cell defined as sum of the following criteria: biodiversity, aggregation, rarity, naturalness, proportional significance.
Malta	Only indirectly	Land use land cover based on satellite image.	The characterization of the habitats and landscapes through the use of satellite images as a starting point for the assessment of ecosystem conditions. A proxy of the habitat and species characteristics and the pressures and disturbances acting on ecosystems
Netherlands			
Poland	Yes	Green Infrastructure Fragmentation; analysis using Fragstats software	Mean patch area; Patch density; Euqlides Nearest Neighbour Distance; Mean Edge Contrast Index Distribution
Portugal, Azores	Yes	Standardized sampling of arthropods in nature areas and pollinators in several types of land-uses	Disturbance Index in each Land-Use Type, Conservation status of habitats and species
Spain	Yes: Provided scientific information on the conditions of Spanish ecosystems through mapping and assessment key ES.	Multidimensional framework for assessing ecosystem services, including methods ranging from biophysical (supply-side) to socio-cultural and economic approaches (demand-side). The assessment of the status and trends of ecosystem services in Spain was performed using multiple indicators	Mapping and assessment diverse values of agricultural ecosystem services: First, we quantified and mapped the importance of crop production expressed in biophysical (T/ha/yr) and monetary (€/ha/yr) units. Secondly, we mapped the ecological value of agro-ecosystems based on "High Nature Value farming areas" index. Thirdly we explored the spatial correlations between economic and ecological values to identify major land use patterns and trade-offs. Fourthly, we conducted a public consultation about Spanish population environmental concerns and the importance attributed towards ecosystem services.
Sweden			

6.3.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

The Antwerp Greentool includes both condition indicators and pressor indicators. Conditions indicators are based on a land cover map taking into account a tree inventory and the presence of green roofs (proportions of land use) as well as the identification of key protected areas and corridors for biodiversity. Pressure indicators, on the other hand, include air quality (yearly average concentrations EC, NOx, PM10, PM2,5 in µg/m³); noise hindrance (dB); urban heat (radiation temperature during a heat event in °C); flood risk pluvial flooding (risk: non critical risks < T 20years; low critical T 20 years; highly critical T 5 years; very critical T 2 years); and areas with shortage of local green (m² of green area per inhabitant).

Recommendations

- A combination of condition and pressure gives a good image on where potential shortages in the delivery of ecosystem services are.

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

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, while the methodological framework is described in the project MetEcosMap. Accordingly, 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.

Table 6.3. Indicators for ecosystem condition in Bulgaria based on the concepts of ecosystem integrity.

<table>
<tr><td rowspan="11">ECOSYSTEM STRUCTURE</td><td rowspan="5">Biotic heterogeneity</td><td>Plant diversity</td><td rowspan="11">ECOSYSTEM PROCESS</td><td rowspan="4">Energy budget</td><td>Energy balance</td></tr>
<tr><td>Animal diversity</td><td>Entropy production</td></tr>
<tr><td>Habitat diversity</td><td>Metabolic efficiency</td></tr>
<tr><td>Invasive species</td><td>Other energy budget</td></tr>
<tr><td>Oher biotic heterogeneity</td><td rowspan="3">Matter budget</td><td>Matter balance</td></tr>
<tr><td rowspan="6">Abiotic heterogeneity</td><td>Soil heterogeneity</td><td>Element</td></tr>
<tr><td>Hydrological heterogeneity</td><td>Efficiency measures</td></tr>
<tr><td>Air heterogeneity</td><td rowspan="4">Water budget</td><td>Water balance (input,</td></tr>
<tr><td>Geomorphological</td><td>Water storage</td></tr>
<tr><td>Other abiotic heterogeneity</td><td>Other state indicator</td></tr>
<tr><td></td><td>Efficiency measures</td></tr>
</table>

Recommendations

- The access to data about environmental characteristics need to be facilitated.
- Long term monitoring schemes of the parameters of ecosystem condition need to be developed. It should be done in close coordination between different institutions which implement the monitoring schemes. National MAES group could provide such coordination.
- The indicators of different ecosystem types need to concise in order to ensure effective integration into the mapping and assessment process.

6.3.3. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

Direct ecosystem condition assessment was not included in this study. However, ecosystem condition is directly linked to ecosystem relative service provision potential that was assessed in this study. Information about ecosystem conditions relevant for the case study were mostly related to structural analysis of urban green infrastructure components (e.g. connectivity) that is essential for the ecosystem sustainability and service provision.

6.3.4. GERMANY: Mapping ES dynamics in an agricultural landscape

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 neighbouring arable land ecosystem. Both ecosystems had a similar agricultural use before the forest was planted.

In a next step, the ecological integrity indicators were (hypothetically) related to the main categories of ES (see **Table 4.1**). These hypotheses and individual relations should be tested in further studies.

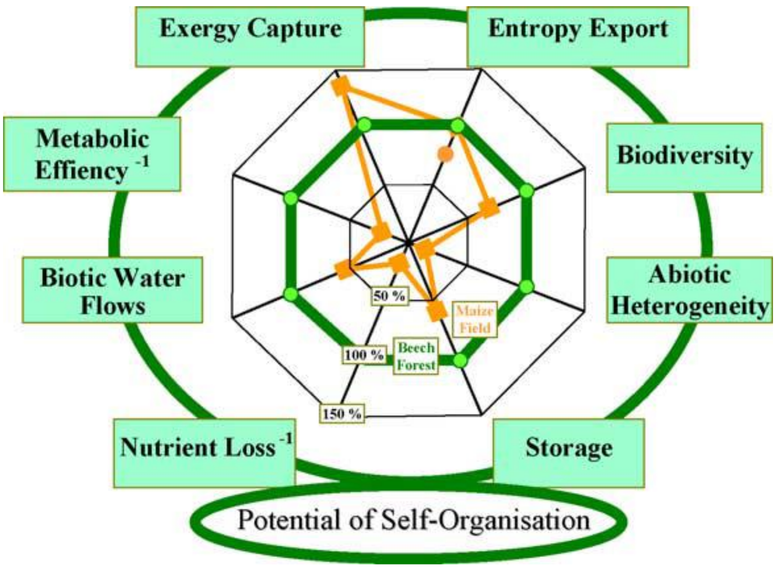


Figure 6.14. Synopsis of the ecological integrity indicator values for the two compared ecosystems (Source: Müller 2005).

Table 6.4. Ecological integrity (ecosystem conditions) as basis for ES provision (Source: Müller & Burkhard 2007).

		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

Recommendations

- Indicators for the ecosystem condition assessment should be selected according to their relevance for the targeted ecosystem services.
- Integrating different data sources and results from different methods increases the explanatory power of the ecosystem condition assessment.
- Applying the ecosystem condition assessment in different case study areas for a long term perspective allows for validation of the assessment and increases the validity of the results.

6.3.5. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

A simple model of habitat condition is being developed for mapping ecosystem condition, using naturalness values assigned to ecosystem types and a single modification factor based on the number of protected vascular plant species present in each patch. The method follows the one used in the mapping and evaluation of ecosystem services of Luxembourg by Becerra-Jurado et al. (2015). **The naturalness map will be used as input data for the ES map**s. The model has the following main components. In the first step, all the ecosystem types are assigned a general naturalness value. Following, this categorisation is further refined on the basis of the number of protected species found in each polygon. Modification factors are defined according to the number of protected species present in the polygon: a polygon with 0 or 1 protected species gets 0 as a modification factor, 2-7 species +1 and more than 8 species +2. The scores and the modification values are then added up, and the resulting values reclassified from 1 to 5.

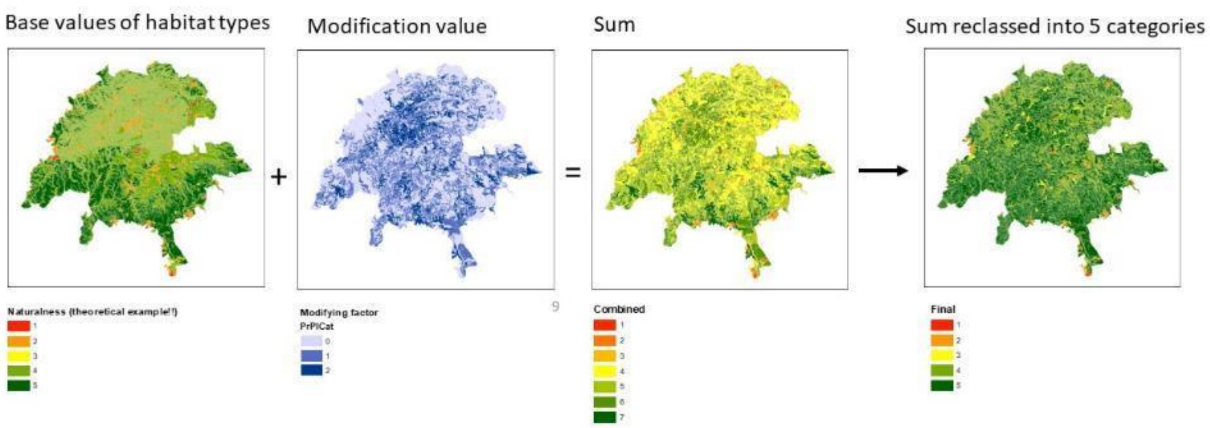


Figure 6.15. Components of habitat condition map of the Bükk National Park.

Recommendations

- A crucial and central question of all ES assessments is how ecosystem condition relates to service provision. With the rule-based matrix model, integration of EC aspects happens at the individual ES level (development of rule-based models) as specific rules.
- Ecosystem condition is crucial for the assessment of trade-offs, synergies and questions related to sustainability.

6.3.6. ITALY: ES mapping and assessment for urban planning in Trento

Ecosystem condition, i.e. the effective capacity of an ecosystem to provide services relative to its potential capacity (MA, 2005), was assessed rather indirectly within this case-study. Information about ecosystem conditions relevant for the case study were mostly related to two aspects: the structural analysis of urban green infrastructure components, and their management. More specifically, the structural analysis involved a preliminary assessment of soil cover and tree canopy coverage across the whole study area. Information about management that were collected concern the property of green areas (public vs. private), their opening to the public, and the presence of infrastructures and facilities. This could indeed be considered as first step towards assessing ecosystem condition.

6.3.7. LATVIA: Mapping marine ES in Latvia

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). 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. 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.

	Applied method	**Example of indicators**
Environmental status of marine waters	MSFD Initial assessment for the following descriptors: D1 “Biodiversity” D3 “Population of commercial fish and shellfish” D4 “Elements of marine food webs” D5 “Eutrophication” D6 “Sea floor integrity”	D1: Benthic Quality Index D3: Spawning stock biomass D4: Zooplankton mean size vs. total stock D5: Summer chlorophyll a concentration; Depth distribution of Fucus vesiculosus and Furcellaria lumbricalis. D6: Population structure of Macoma balthica
Benthic habitat condition	Habitats Directive reporting according to Art. 17 requirements	Conservation status of reef habitats
Ecological value of marine ecosystem	A map of ecological values, which combines available spatial data sets on distribution of benthic habitats, algae, birds and fish species.	Ecological value per grid cell defined as sum of the following criteria: biodiversity, aggregation (areas important for birds and fish species), rarity, naturalness, proportional significance (coverage of benthic habitats)

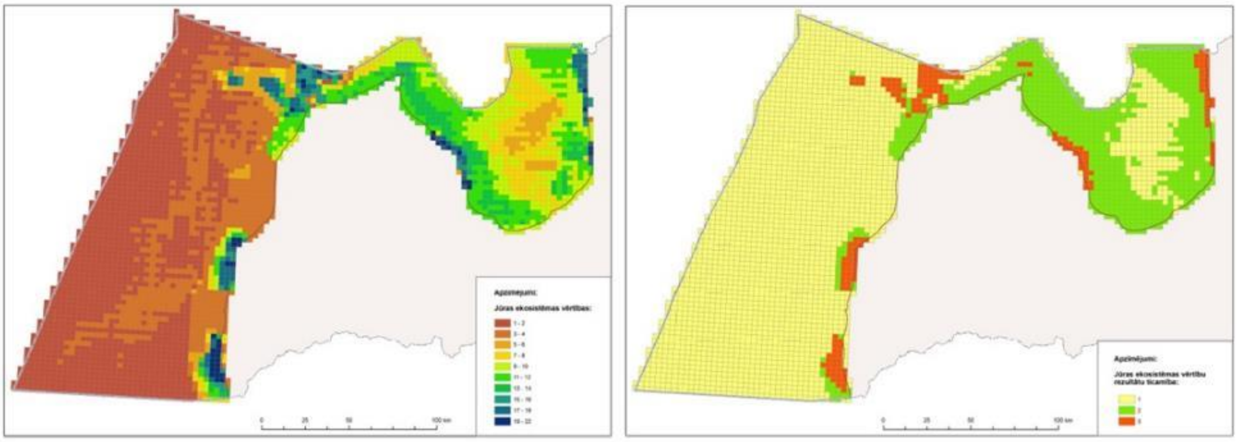


Figure 6.16. (LEFT) Sum of ecosystem values estimated by different criteria. Legend: ecosystem value from low (red) to very high (dark blue). Source: LIAE, 2015. (RIGHT) Estimation of certainty of the results. Legend: level of certainty - low (yellow); medium (green); high (red). Source: LIAE, 2015.

Recommendations

- Monitoring network frequency and density shall be improved to allow spatially explicit assessment of marine ecosystem condition; however, the marine monitoring is very costly. Therefore, development of new, cost-efficient methods and tool shall be promoted.

6.3.8. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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), pollinator diversity in key habitats, and area of irrigated agricultural land.

Recommendations

- Existing baseline data demonstrates that ecosystem condition varies significantly between different sites, affecting ES delivery, and therefore should be considered in the preparation of assessments of ES for Malta.

6.3.9. NETHERLANDS: ES-based coastal defence

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.

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 that include (i) Nature restoration; (ii) Shellfish banks; (iii) European sturgeon; (iv) Fishery; (v) Recreation, and (vi) Monitoring (see www.haringvliet.nu).

6.3.10. POLAND: ES in Polish urban areas

There was no direct research conducted on ecosystem conditions. The structure of green infrastructure was used as the indicator of the ecosystems quality. The analysis was based on landscape indicators delivered by Fragstats software. Some considerations were made also with respect to, for example, air quality and contribution of green infrastructure for flood control, but only in the context of ES demand.

Recommendations

- If the direct analysis is impossible due to the area size, landscape indicators based on the composition and configuration of patches can be very helpful in the assessment of ecosystem conditions.
- Size and configuration of GI patches has important insight into GI potential to deliver regulating ES.
- Analysis of fragmentation is useful to compare the structure of green infrastructure among cities. It shows which structural aspects needs more attention from planning perspective.

6.3.11. AZORES, PORTUGAL: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

The Terceira island ecosystem evaluation was performed in several studies comparing the quality of native forests and the quality of natural forest in comparison with semi-natural pastures, exotic pastures and Cryptomeria japonica plantations, including also the importance of non-natural areas for species conservation. 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 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. Based on land use provided by (DROTRH 2008) and previous fieldwork on native forests and on the proportion of endemic, native and exotic species typical to each land use type present in the island, 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”.

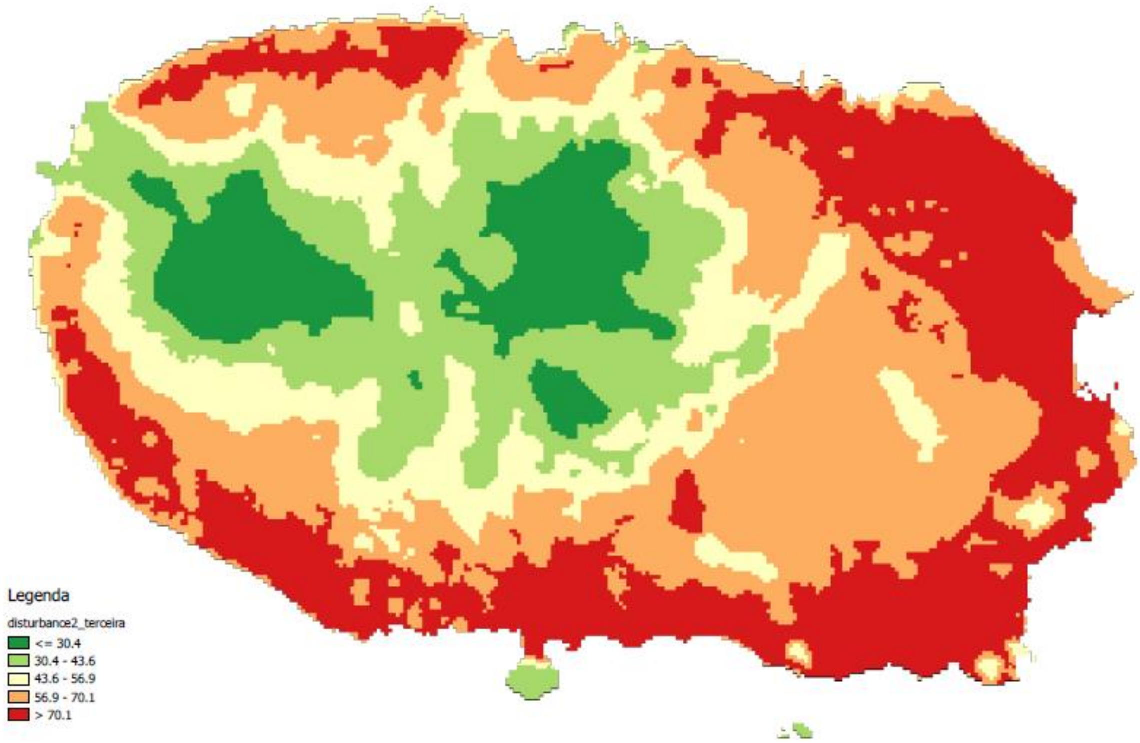


Figure 6.17. Maps of Terceira Island with value of landscape disturbance according to Cardoso et al. (2013). Values of landscape disturbance are represented in a gradient from green for lowest values to red for highest values.

Recommendations

- Inference of ES based on only land-uses may be erroneous. There is the need to have real indicators of the status of the quality of the habitats based on individual species assessments or species diversity indicators.
- In islands the quality of habitats should be measured using standardized sampling of indicator species
- There is the need to measure disservices to understand their impacts in different land-uses.

6.3.12. SPAIN: Spanish National Ecosystem Assessment

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 condition. 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.

We used the Driver-Pressure-State-Impact-Response (DPSIR) framework to analyse the complex relationships established between ecosystems and human systems in Spain from a holistic point of view. The DPSIR framework is a common approach for exploring the relationships of human and natural systems because it provides an organized structure to analyse the causes and consequences of and responses to changes.

Recommendations

- For the assessment of ecosystem condition it is needed it to use multiple indicators. The criteria for the selection of indicators should include: (1) being understandable and widely accepted among the multiple types of stakeholders; (2) having the ability to express information (being unambiguous and sensitive to changes); (3) being temporally explicit (trends can be measured over time).
- Approaches based on the evaluation of ecosystem conditions are becoming a common reference and integration tool for the development of conservation policies at global, national and local scales. It is need an integrated framework for comparable reasons among all these approaches.
- One of the main challenges addressed is the integration of results obtained at different scales with the same conceptual approximation but using different assessment methodologies.

6.3.13. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

Ecosystems conditions have been assessed by using public data governed by the County Administration Board and Municipality Boards, statistics in public databases and from sector authorities, expert knowledge by researchers that have experience from the area and by stakeholders, biophysical national monitoring data, and local knowledge with reindeer herders. For the biophysical data the main sources are the Swedish National Forest Inventory (NFI; Fridman et al. 2014) and the National Inventory of Landscapes in Sweden (NILS; Ståhl et al. 2011). Both these program collect a large set of variables that can be used as indicators or other type of ES measures, in particular if combined with wall-to-wall remote sensing-based data (cf. Mononen 2017). No final indicators for continued assessment and evaluation have been defined at this stage. However, earlier studies by, e.g., Geijzendorffer & Roche (2013), Hansen and Malmeus (2016), Svensson et al. (2016) and Naturvårdsverket (2017) – the two latter in Swedish – indicate substantial ES assessment opportunities in particular with the NILS data. Currently, work is ongoing on testing cultural ES-based amenity value assessment for mountain environment by biophysical NILS variables (Hedblom et al. in prep).

Recommendations

- Models based on systematic monitoring data
- Available public databases
- Local expert knowledge and data on key ES issues

6.4. Recommendations for assessing ecosystem conditions

The assessment of ecosystem types is the starting point for the assessment of the conditions of each single ecosystem in the study area and provides additional information useful in the assessment of the services provided by the ecosystem. E.g. it allows the identification of ecosystems with potential shortages in the delivery of ecosystem services and is therefore an important part of the process of mapping and assessment of ecosystem services. Based on the ESMERALDA case studies, the following general recommendations can be stated.

The identification of multiple and concise indicators on ecosystem conditions for different ecosystem types is a critical step. They must be (1) relevant for the targeted ecosystems, (2) understandable and widely accepted among the involved stakeholder, (3) have the ability to express information and (4) be temporally explicit to allow the analysis of trends in time. The process of indicator identification should harness local expert knowledge and incorporate relevant stakeholders of the study area.

The ESMERALDA case studies show that the identification and availability of relevant data sources is important for the development of a robust assessment. The 2nd MAES report (2014) and the 5th MAES report (2018) list additional indicators and Europe-wide data sources that could be taken into account. E.g. it can build on existing data sources like the Habitats Directive reporting data (Article 17 reporting) or data obtained for the Birds directive (Article 12 reporting). Additionally, indirect methods for the assessment can incorporate the structural analysis of soil cover, tree coverage, information on management and an analysis of landscape indicators based on the composition and configuration of patches. The urban ESMERALDA case studies show that pollution, noise and also flood risk data is useful assessments on small scale.

In order to allow time-series analysis, data recorded in systematic monitoring schemes should be used. If not existing, long-term monitoring schemes on parameters needed for the assessment of ecosystem conditions should be developed.

6.5. Selecting Ecosystem Services

Table 6.5 shows an overview of the process of identification and selection of the ES to be mapped and assessed. It specifies whether the process has been mainly scientist-driven or it included an active involvement of the stakeholders. Following, for each case study, a detailed account of the process of ES identification is provided.

Most ESMERALDA case studies emphasise the benefits from a strong and active stakeholder involvement. In studies contributing to the MAES process the stakeholder involvement is mandatory and should be related to capacity building. The recommendations highlight the need of the selection of ES from the common categories (provisioning, regulating, cultural) to enable the analysis of trade-offs and synergies. Selected ES must be relevant for the study area and definitions should match the CICES classification. Critical is the selection of suitable indicators and the acquisition of appropriate data on these.

Table 6.5: On overview of the process of the selection of ES to be assessed in the ESMERALDA case studies.

Case Study	Scientist-driven	Stakeholders' driven	ES Classification type
Belgium	Yes	Yes	CICES V4.3
Bulgaria	Yes		CISES 4.3
Czech Republic	Yes		MA (2005)
Finland	Yes	(Yes)	CICES V4.3
Germany	Yes		"Kiel" classification system
Hungary	Yes	Yes	CICES v5.1
Italy	Yes	Discussed with stakeholders	
Latvia	Yes		CICES v4.3
Malta	Yes		CICES v4.3
Netherlands	Yes	Yes	MA (2005)
Poland	Yes		
Portugal, Azores	Yes		CICES v4.3
Spain	Yes	Discussed with stakeholders	MA (2005)
Sweden	Yes	Yes	CICES v4.3

6.5.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

The ES were selected based on expert knowledge and relevance for the city authorities. The selected ES are classified using the CICES v4.3 (2013) classification. This was done on the basis of discussions between stakeholders and experts. The relevance for the city was also assessed on the basis of the existing pressures on the city. E.g. high concentrations of PM10; NOx etc. led to the inclusion of the ecosystem services related to the capture of air pollutants.

Recommendations

- It is a plus to select the ecosystem services based on relevance and pressures together with the stakeholders.

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

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. 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. 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 at local scale using hydrological modelling tool. The same service was assessed at national level using spatially related statistical data. Similarly, flood regulation was assessed using both hydrologic modelling and statistical data.

Recommendations

- The stakeholders need capacity building to be actively involved in the process of ES selection.
- Ecosystem services prioritization is a useful tool in selecting relevant services in particular area.

6.5.3. CZECH REPUBLIC: Pilot National Assessment 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. 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.

Recommendations

- Ecosystem services were selected based on the systematic review of existing studies
- Selection of ecosystem services should reflect the needs of stakeholders
- Various aspects of ES (biophysical, economic and social) should be taken into consideration in ES assessment

6.5.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

For the identification of relevant ES, we used the knowledge from previous mapping and assessment studies that were validated through a joint discussion with city planners. The objective of maintaining good opportunities for urban recreation and maintaining citizens' well-being by recognising other cultural ecosystem service values supported the selection of all cultural ES according to CICES 4.3 to be mapped whereas provisioning and regulating and maintenance services consisted only the most relevant services in the area. **Original CICES 4.3 was slightly modified** by combining categories to fit better to the city needs.

Recommendations

- If it is appropriate, identify only the most relevant ES to be mapped in the study area.
- Involve also experts and practitioners in this phase and encourage them to use their local knowledge.
- Do not choose ecosystem services for which you do not have data.

6.5.5. GERMANY: Mapping ES dynamics in an agricultural landscape

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 related to biomass energy production, 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).

Recommendations

- Selection of ecosystem services should be based on specific characteristics of study area.
- Selection of ecosystem services needs to be context dependent and aligned to political relevance.
- Covering ecosystem services from all three categories (regulating, provisioning and cultural) results in a comprehensive assessment and visualizes interactions.

6.5.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

As a first step, semi-structured interviews with experts of the pilot area were carried out to collect preliminary information on the dominant natural characteristics and land use. An initial list of ES was derived corresponding to the CICES, v5.1 (later converted in v4.3 to allow comparison with the other case studies). This list was slightly customized (some ES split or merged) to a list of 15 ES as subject of prioritization. To enable a comparable, comprehensive and documented ES prioritization which takes several aspects into consideration, **a list of selection criteria was drawn**. The adjusted list of ES was assessed one by one against the selection criteria, estimating whether a certain ES is relevant or not (scoring 1 or 0) considering each criteria. This resulted in an aggregated score of 'relevance' for each service. Based on these aggregated scores, ES could be ranked according to their relevance in the area.

Recommendations

- When selecting and prioritizing ES, it is important to consider criteria for (1) representation of ecosystem types, (2) benefits for local people, (3) local relevance and (4) relation to other ES (trade-offs, bundles).

6.5.7. ITALY: ES mapping and assessment for urban planning in Trento

The identification of key urban ES was based on the knowledge of the local context and validated though a joint discussion with stakeholders. The selected ES cover pressing environmental issues for the city, as well as priority themes that the plan aims to address. The plan objective of providing all citizens with equal opportunities for nature-based recreation supported the identification of "Physical use of landscape" as one of the main urban ES. At the same time, the increasing intensity and frequency of heatwaves with growing negative consequences for citizens' health and wellbeing, particularly in the valley floor, led to the selection of "Micro-climate regulation" as another key urban ES.

Recommendations

- For the MAES process to produce relevant results, the selection of ecosystem services must follow the identification of the policy questions and be discussed with stakeholders.

6.5.8. LATVIA: Mapping marine ES in Latvia

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. 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.

Recommendations

- In data scarce areas, e.g. marine ecosystems selection of ES is limited to availability of spatially explicit data sets as well as expert knowledge on linking ES supply potential to particular features of marine ecosystem.

6.5.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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.

Recommendations

- A wide participation by experts is strongly suggested in order to select key ES that have a strong impact on policy and decision-making, and finally affecting human well-being.
- Through a wider participation, the promotion of research that assesses the contribution of ecosystem to ES delivery would be favoured.

6.5.10. NETHERLANDS: ES-based coastal defence

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.

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, as reported in the case study booklet) 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”.

6.5.11. POLAND: ES in Polish urban areas

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

Recommendations

- The choice of ES for analysis should be preceded by interviews with the city's dwellers. The MAES must fit preferences of inhabitants, considering place of residence, age, types of activity, wealth, etc.

6.5.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

We selected two ES for which data was available based on macro-ecological studies. These ES are relatively easy to assess based on simple protocols for field work using standardized techniques to sample epigean soil arthropods (CICES class 2.3.1.2) and pollinators (CICES class 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. 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 and thus are more pristine and adequate to maintain nursery populations and habitats.

Recommendations

- The relevance of indirect macroecological indicators must be evaluated in order to find sound ecological measures that are reliable indicators of ES.
- ES intensities are characterized by proxies, typically abundance or diversity changes in one or several ES providers, or geographical proxies. There is the need for direct measurement of service levels or process intensities.
- There is the need of enforce direct and quantitative tools for monitoring agro-biodiversity ecosystem services (ES) such as natural pest control by predation, pollination, decomposition, herbivory on invasive plants.
- There is the need of enforce direct and quantitative tools for monitoring agro-biodiversity ecosystem disservices (ED) such as predation on beneficial arthropods, herbivory on native and crop plants, and evaluating the relative importance of native and non-native organisms as ES/ED providers on Islands as ecological laboratory

6.5.13. SPAIN: Spanish National Ecosystem Assessment (55 words)

Under the Spanish NEA, 22 services were selected 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.

Recommendations

- To detect general patterns in the trends and possible trade-offs of ES it is need it to classify five types of ES: (i) traditional provisioning ES (i.e., extensive agricultural production systems, such as organic agriculture, transhumant systems); (ii) technology-based provisioning ES (i.e., intensive agricultural systems, such as greenhouses or fish farms); (iii) regulating ES; (iv) rural cultural ES (i.e., local ecological knowledge, cultural identity); and (v) urban cultural services (i.e., recreational activities, scientific knowledge).
- Selected indicators should be scalable (can be aggregated to different scale levels) and quantifiable (the information obtained can be easily compared); and.
- Sources of indicators should be available from official open sources databases to show credibility (being obtained from official statistical datasets).

6.5.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

In the context of ESMERALDA, the focus is on ES associated with forests, forest management and forests in a landscape context, and with Sami community reindeer husbandry. Forests constitute the predominant land cover, and forest industry is a key business in the area as well as regionally and nationally. Forest ecosystems are also key biodiversity entities, alongside with open or semi-open habitats in the forest landscape. Reindeer husbandry represents an indigenous culture and sustainable, traditional land use that substantially contribute to the natural and cultural values of northern Sweden. The annual migration of reindeers from the mountain to the coast and back is a distinct feature that, ultimately, require large-distance connectivity and functional green infrastructure across different land cover types, land ownership situations and land used simultaneously for other land use. Under the frame of sustainable development the ES identification has benefitted from the long-term process of participation and networking forming the UNESCO MAB candidacy, as well as from previous ES-oriented projects and processes

Recommendations

- ES that are relevant to local stakeholders
- ES that are relevant to natural-resource-based business sectors
- Expand and improve already known and explored ES information

6.6. Recommendation for selecting ecosystem services

The selection of ecosystem services is the third step after the identification of ecosystem types and their conditions. Following the MAES protocol, the selection of ecosystem services must follow the identified policy questions relevant for the study area.

The ESMERALDA case studies underpin the relevance of the involvement of stakeholders and local expert in the selecting process. This ensures the relevance of the selected ES for stakeholders, politics and the study area. Generally, stakeholders need capacity building to be actively involved in the ES selection.

The selected ecosystem services must cover the various aspects of ecosystem services. Therefore services from the common categories (provisioning, regulating, cultural) should be selected in order to enable the analysis of trade-offs, synergies and interactions between the different ecosystem services. The Spain national assessment distinguish between five different ES categories to facilitate further analysis. A complementary aspect of the selection process is the relevance of the services for the specific study area and target of the study. Therefore a context-specific selection of ES that are e.g. sensitive to identified pressures is needed.

The specific ecosystem services selected should match with the definition of an ES in a common ES classification. Most ESMERALDA case studies utilised the CICES v4.3 classification, less the classification developed in the Millennium Assessment (MA 2005). Studies carried out under the MAES framework should utilise the newest CICES classification (CICES v5.1 2018).

The last step in the selection of ES is the definition and acquisition of appropriate indicators. It is hardly recommended to select only ES that are assessable by available data / indicators. These should be scalable and quantifiable. The use of official open source data increases the credibility of the assessment.

7. Mapping and assessment: Methods

As illustrated by the ESMERALDA Method Explorer and related Methods Database (see introduction), there is a range of different approaches and methods for mapping and assessment of ES which can be applied at different levels of detail and complexity. There are basically three different types of methods to map and/or assess ecosystem and the services they provide: biophysical, economic and social. Biophysical methods are based on quantification of different parameters of biotic and abiotic structure which determine the provision of ecosystem services (Vihervaara et al., 2018). Social methods principally involve measure of individual and collective preferences to support the operationalization and further development of the ES concept (Deliverable 3.1 by Santos-Martin et al., 2018). Economic methods involve measuring the economic value of ES, including its spatial variation, and structuring this information to support decision making and the design of policy instruments (Brander et al., 2018).

Biophysical methods describe how ecosystems contribute to the supply of services to society and operate on the left side of the ES cascade (Potschin & Haines-Young, 2010), while economic and social methods both reflect on the relative importance of ecosystem services to people, thus revealing the demand side corresponding to the right side of the ES cascade. On the other side, social methods are distinguished from economic ones by their non-monetary evaluation and because they demonstrate the multi-dimensional nature of human well-being (see Deliverable 3.1 by Santos-Martin et al., 2018).

There is not always clear distinction between methods and the borders between them are blurry. For example, outputs from social methods can be used as inputs for economic or biophysical. Furthermore, no method alone can aspire to assess with precision all ecosystem services. Instead, an integrated spirit that mixes different methods that belong to different categories, might have the potential to do so. Such integration can be achieved in practice if the is a list of example applications organized in a proper manner to show who and how are using different methods into their mapping and assessment studies. The methods interlinkage is one of the main functionality of the ESMERALDA online method explorer (see section 2.1.2). By considering existing data and expectations of stakeholders a multi-tiered flexible methodology for mapping ES was developed. It incorporates social, economic and biophysical value domains at different spatial and temporal scales. The multi-tiered approach allows working different levels of information, time and resources.

7.1. Socio-cultural ES mapping and assessment methods

Social methods in ESMERALDA are used as an umbrella term for those approaches that aim to analyse human preferences towards nature in non-monetary terms. It includes terms such as 'socio-cultural valuation', 'social valuation', ´non-monetary valuation´, 'deliberative valuation', 'qualitative valuation' and 'subjective assessment' (Santos-Martín, et al., 2018). Social methods include quantitative and qualitative research techniques (i.e. surveys, interviews, models), participatory and deliberative tools (focus groups, citizens juries, participatory or rapid rural appraisal, Delphi panels, etc.), as well as ways of measuring in quantifiable terms (i.e. preference assessment, time use studies). There are several attempts to classify these methods including the FP7 project OpenNESS classification of Non-Monetary Valuation (NMV) methods, the decision trees to structure and guide the process of methods selection foe socio-cultural processes (Harrison et al., 2018), the framework for the potential determination of socio-cultural values (Scholte et al., 2015) and the frameworks that classify of social methods in relation to ecosystem services relating them three axes (Santos-Martín et al., 2018).

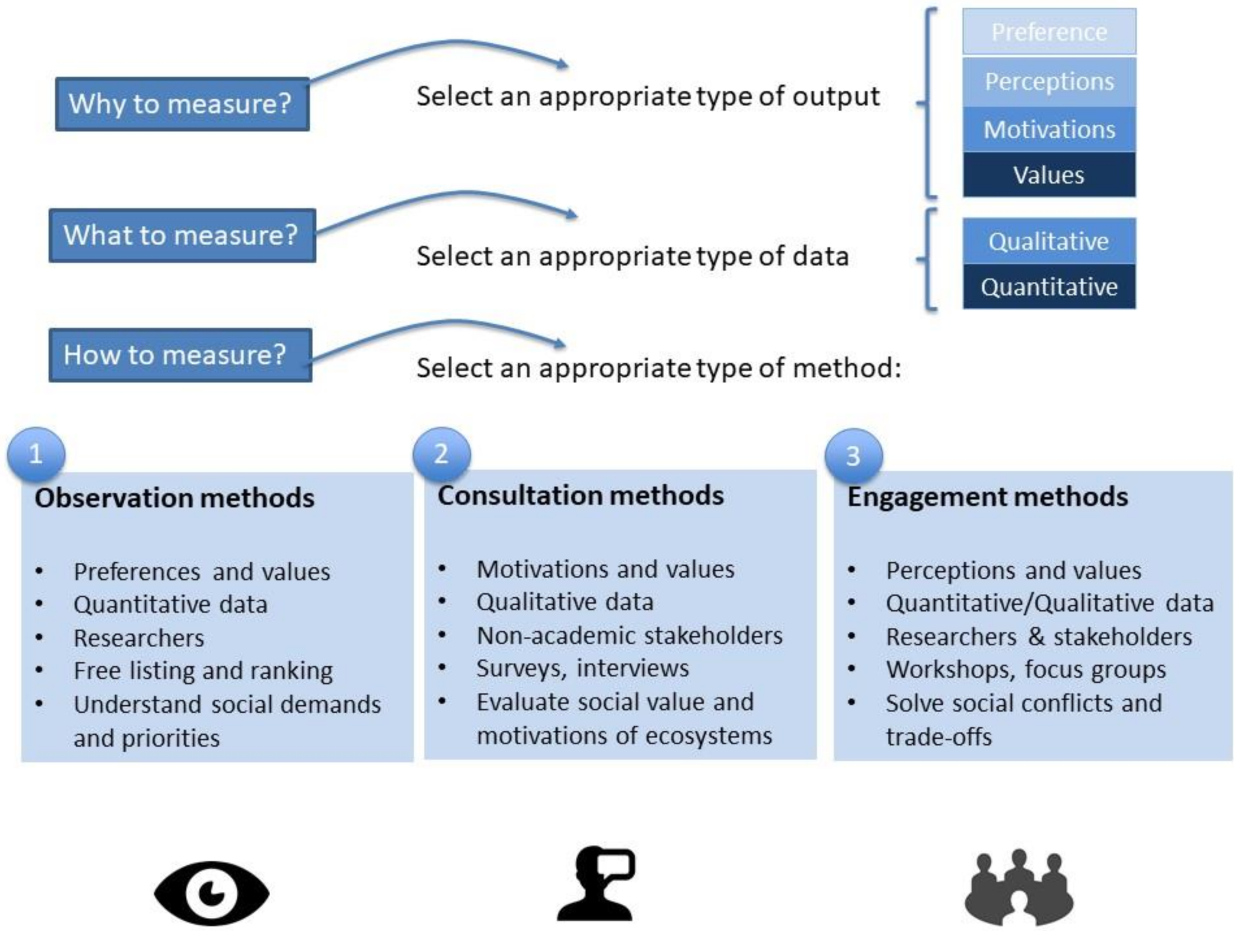


Figure 7.1. ESMERALDA broad classification of social methods to map and assess ecosystems and their services based on the contacting approach (Icons by Freepik). (after Santos-Martin et al., 2018).

Building on these works, for the needs of ESMERALDA social methods were divided into the three broad groups: (1) **Observations methods** which require multiple observations as they elicit quantitative data and they are directed to demonstrate the social importance of ecosystem services by analysing social preferences and associated values of ecosystem services; (2) **Consultation methods** which are based on qualitative data that are usually applied in collaboration with non-academic stakeholders (i.e. narratives, Q-methodology); (3) **Engagement methods** which gather qualitative and quantitative data by collaborating with researchers and non-academic stakeholders (i.e. Public Participatory GIS, participatory scenario planning and deliberative assessment). Each group includes several individual methods which can be linked to the main research questions in order to select the appropriate method for particular study (Figure 7.1). For comprehensive review of individual socio-cultural methods see section 5 in Santos-Martin et al. (2018). As shown in Table 7.1, the broad classification of social methods described is determined by different methodological requirements (see Deliverable 3.1 by Santos-Martin et al., 2018).

Accordingly, social methods were characterized according to 9 key aspects whether they have the capacity to: (1) provide spatial outputs for different geographical areas (mapping) or estimating representative social values of ES without spatial explicit information (assessment); (2) elicit collective and shared values of ecosystem services that go beyond the aggregation of individual preferences; (3) to engage, observe or consult participants and collect their preferences/answers; (4) to provide results that are applied at local, regional, national or even broader spatial scales; (5) to provide appropriate and explicative results at tiers I, II and II ; (6) to work with different types and amount of quantitative and/or qualitative data; (7) elicit diverse or single range of values associated with nature; (8) to integrate results with other biophysical and economic methods; (9) to be applied in collaboration with researchers from different fields in collaboration with non-academic stakeholders; and (10) to be implemented using different levels of time and monetary resources.

Table 7.1. Social methods classification based on key variability aspects according to their suitability to map and assess ecosystems and their services. Methods are classified according to their suitability to map and assess ES based on qualitative aspects: (🟢) highly appropriate, (🟡) less suitable, (🔴) not appropriate; and according to the level of requirements in terms of quantitative aspects: high degree, medium degree, and low degree. (After Santos-Martin et al., 2018).

SOCIO-CULTURAL METHODS	Approach		Preference		Procedure			Scale			Tier			Data			Values		Integration		Collaboration		Resources	
	Mapping	Assessment	Individual	Social	Observation	Consultation	Engagement	Local	Regional	National	Tier I	Tier II	Tier III	Amount	Qualitative	Quantitative	Diverse	Single	Biophysical	Economic	Researcher	Stakeholder	Time	Monetary
Observation methods																								
Time use assessment	🟡	🟢	🟢	🔴	🟢	🟡	🔴	🟢	🟢	🔴	🟢	🟡	🔴	●	🔴	🟢	🟢	🟡	🔴	🟢	●	◔	◑	◑
Photo-elicitation	🟡	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🟡	🔴	●	🟡	🟢	🟢	🟡	🟡	🔴	●	◔	◑	◑
Geo-tagged photographs	🟢	🟡	🔴	🟢	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	🔴	●	🟡	🟢	🟢	🟡	🟢	🟢	●	◔	◑	◔
Consultation methods																								
Preference assessment	🟡	🟢	🟢	🟡	🟢	🔴	🔴	🟢	🟢	🔴	🟢	🟢	🔴	●	🟡	🟢	🟢	🟡	🟡	🟢	●	◔	◑	◑
Narratives assessment	🟡	🟢	🟢	🟢	🟡	🟢	🔴	🟢	🟢	🔴	🔴	🟢	🟢	●	🟢	🟡	🟢	🔴	🟢	🟡	◔	●	◑	◑
Q-methodology	🔴	🟢	🟡	🟢	🟡	🟢	🔴	🟢	🟢	🟡	🟢	🟢	🔴	◑	🟢	🟡	🟢	🟡	🟢	🟡	◔	●	◑	◔
Engagement methods																								
Participatory GIS	🟢	🟡	🟡	🟢	🟡	🔴	🟢	🟢	🟢	🟢	🟡	🟢	🟢	◑	🟢	🟢	🟢	🔴	🟢	🟢	◑	●	◑	◑
Scenarios planning	🔴	🟢	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🔴	🟡	🟢	◑	🟢	🟢	🟢	🔴	🟢	🔴	◑	●	◔	◑
Deliberative assessment	🟡	🟢	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🔴	🟡	🟢	◑	🟢	🟢	🟢	🔴	🟡	🟢	◑	●	◑	◑
Multicriteria analysis	🔴	🟢	🔴	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟢	●	🟢	🟢	🟢	🔴	🟢	🟢	●	◔	◑	◑

In addition, social methods were classified based the framework as shown in Figure 7.2 *adapted* from the conceptual classification of the tiered approach developed by Grêtegamey et al. (2015, 2017). Social methods are thus classified into three tiers levels based on information about reliability, accuracy and precision of social methods to map and assess ES. In particular, they differ in the level of engagement of participants ranging from observations (Tier 1) to consultations (Tier 2) and finally engagement (Tier 3). This additional classification is important for users to determine their suitability in a specific context and can help them to select the appropriate type of method. In general, a tier 1 approach is suitable for a rough overview for example of hot- and cold spots of ES provision and demand. If the ES study is used to evaluate management measures or the suitability of different locations for an intended use, then a tier 2 approach is suitable. A tier 3 approach should be applied if explicit measures are implemented that affect not only the service itself but also other components of the system, which was defined in the first step. In case data and other resources are severely limited, it is possible to choose a lower tier yet efforts should be made to achieve the originally identified tier to best support decision-making. Approaches assigned to higher tier levels require a higher level of detail of input and output data as they should inform specific management questions. This high level information can either be estimated through rather complex models combining different datasets, through the extrapolation of primary data or through a combination of both. One very precise field survey might therefore substitute several other datasets that would have been used to estimate the survey values. Thus, the amount of datasets is also not a criterion to distinguish the different tiers but rather the level of detail. Most methods can be implemented at different levels of detail: An assessment based on geo-tagged photographs can simply present the amount of pictures taken at specific locations to get a first impression which would be suitable at a tier 1 level. However, the pictures can be further categorized and analysed according to their content which would be an appropriate approach for higher tier levels. Surveys as a typical method of social assessments can be relatively simple including few questions and/ or choices but can also become very detailed and complex. Similarly, scenarios can be very sophisticated interlinking several aspects or can be simple storylines of possible future development.

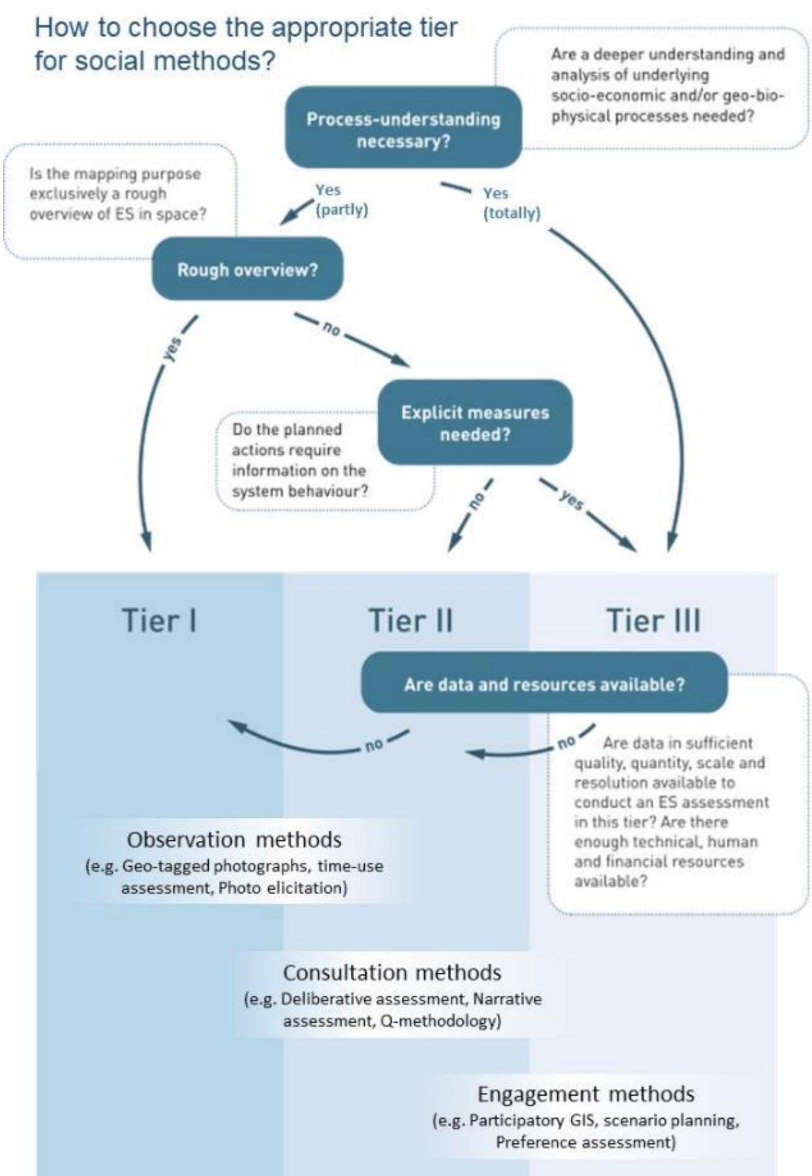


Figure 7.2. Classification of social methods based on a tier approach (Adapted from Grêt-Regamey et al. 2017).

7.2. Economic ES mapping and assessment Methods

Economic methods for mapping and assessing ES include methods such as primary valuation and value transfer which are based on spatial extrapolation or transfer of value information as well as different analytical methods such as cost-benefit analysis, multi-criteria analysis and ES accounting (Brander et al., 2018). These methods are based on key concepts such as economic value, total economic value, and exchange value. In the ESMERALDA Deliverable 3.2 by Brander et al., (2018), these methods are explained together with an evaluation of their strengths, weaknesses and applicability to ES assessment. They can be divided into three main groups: 1. Methods for estimating economic values for ES; 2. Methods for mapping economic values on maps; 3. Economic assessment methods.

The methods for estimating economic values are designed to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment. They are grouped into two categories: primary valuation methods and value transfer methods. Primary valuation methods can be divided into three categories: 1. Cost-based approaches that use some measure of the costs associated with an ES as a proxy for the value of the service; 2. Methods that estimate the value of ESs as inputs into production; and 3. Methods that use consumer behaviour to measure the value of ESs. The last one can be further divided into revealed preference methods and stated preference methods.

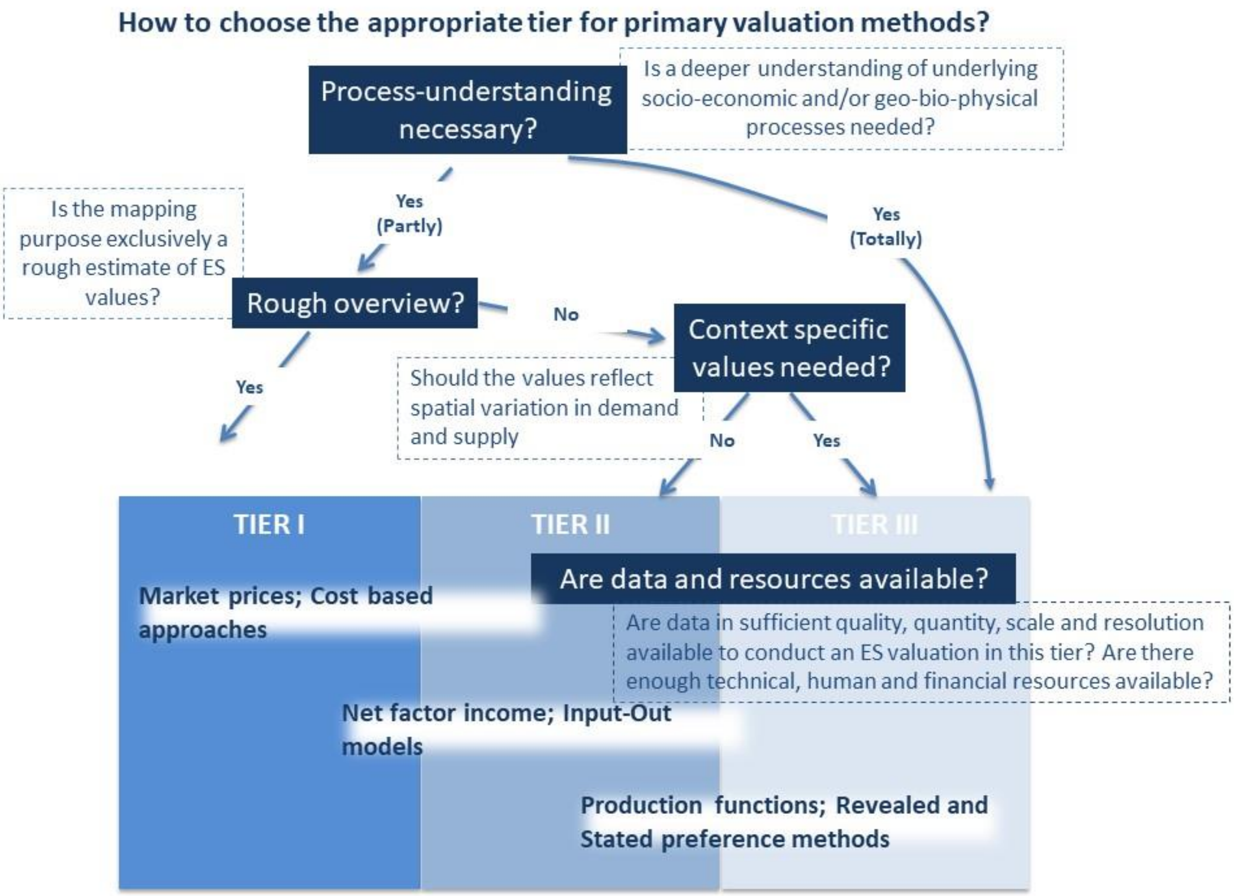


Figure 7.3. Classification of primary valuation methods based on a tier approach (Adapted from Grêt-Regamey et al. 2017).

The value transfer methods are based on transfer of value information from existing primary valuation studies to other areas. There are several methods including: 1. Value transfer which is the use of research results from existing primary studies at one or more sites or policy contexts to predict welfare estimates or related information for other sites or policy; 2. Unit value transfer which uses values for ESs at a study site, expressed as a value per unit, combined with information on the quantity of units at the policy site to estimate policy site values; 3. Value function transfer which uses a value function estimated for an individual study site in conjunction with information on parameter values for the policy site to calculate the value of an ES at the policy site; 4. Meta-analytic function transfer which uses a value function estimated from the results of multiple primary studies representing multiple study sites in conjunction with information on parameter values for the policy site to calculate the value of an ES at the policy site.

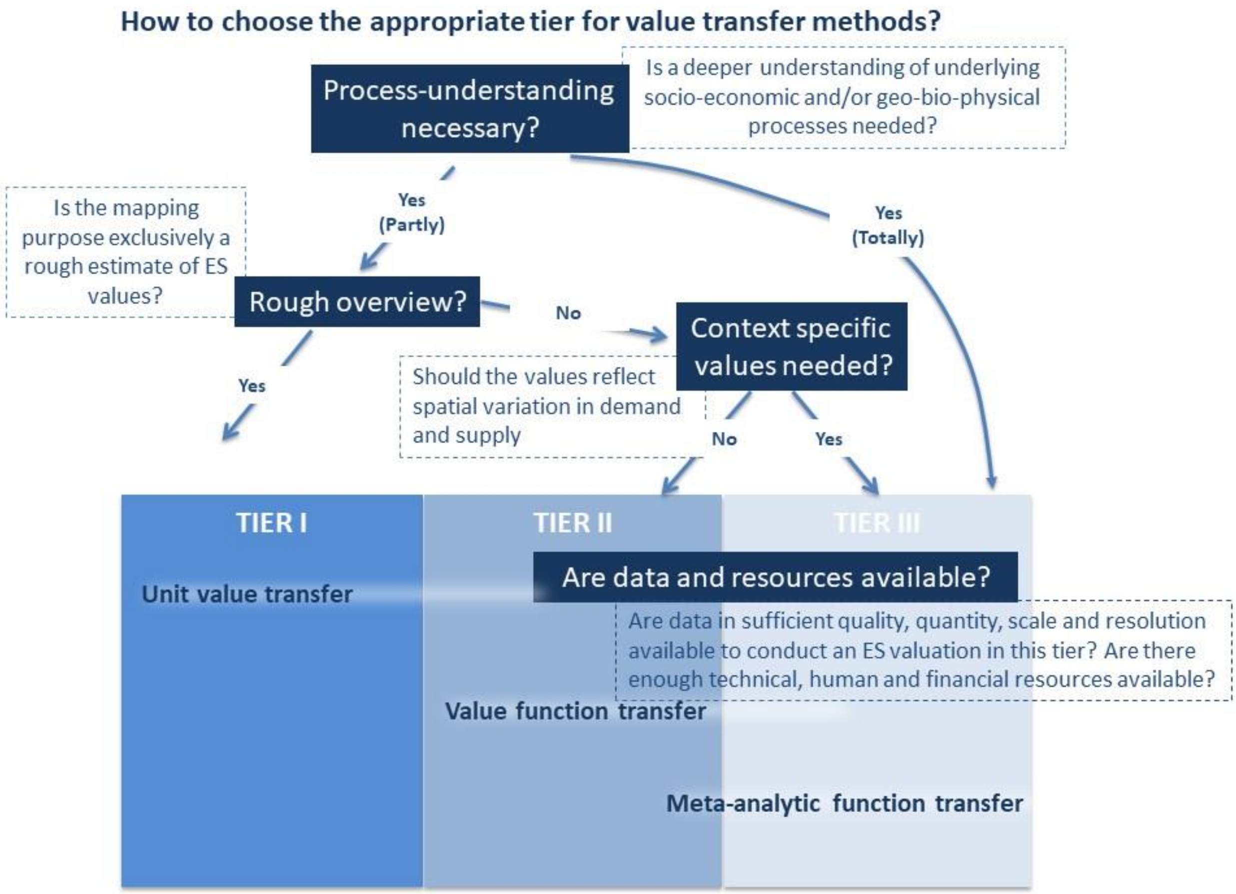


Figure 7.4. Classification of value transfer methods based on a tier approach (Adapted from Grêt-Regamey et al. 2017).

The methods for mapping economic values for ESs are based on estimation of accurate values for ESs requires that account is taken of spatial heterogeneity in biophysical and socioeconomic conditions. There are two main approaches for mapping economic values: 1. representing economic values on maps; 2. scaling up economic values. The representation of economic values on maps involves estimating variable combinations of supply and demand across spatial units and plotting the resulting values. The scaling up of economic values describes the transfer and aggregation of values that have been estimated for localised changes in individual ecosystem sites to assess the value of simultaneous changes in multiple ecosystem sites within a large geographic area.

Economic assessment methods are used for structuring information on the value of ESs into decision making, often in combination with other forms of information. There are a number of economic assessment methods available to help decision makers to structure the information and factors that are relevant to a decision and to select between alternative investments, projects or policies. The choice of which assessment method to use will largely be determined by the type of decision problem and the availability and nature of information related to each potential option. To understand the differences between economic assessment methods, in D3.2 the procedural steps of each approach are described. There are five main economic assessment methods: 1. Cost-effective analysis; 2 cost-benefit analysis; 3. Multi-criteria analysis; 4. ESs accounting; 5. Corporate ESs review.

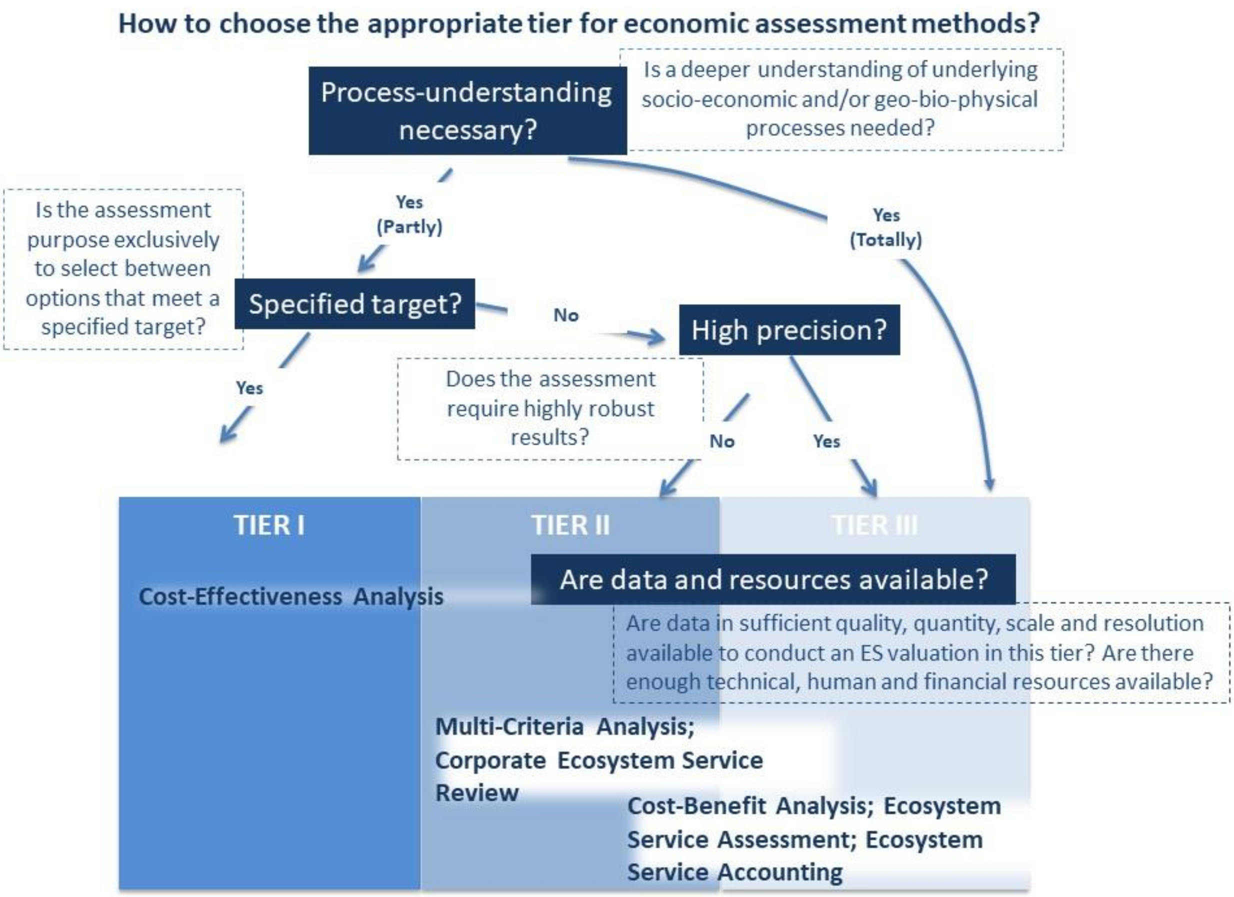


Figure 7.5. Classification of economic assessment methods based on a tier approach (Adapted from Grêt-Regamey et al. 2017).

7.3. Biophysical ES mapping and assessment methods

Biophysical methods for mapping ecosystem services are used to quantify ecosystems' capacity to deliver ecosystem services and the amount of harvested yield of such capacity for human benefit (see Deliverable 3.3 by Vihervaara et al., 2018). Biophysical methods are from terminological point of view are closely related with biophysical quantification, biophysical valuation and biophysical assessment. Biophysical quantification is built on spatial and temporal measures of ecosystem processes. Biophysical valuation derives values from measurements of the physical costs (e.g., in terms of labour, surface requirements, energy and material inputs) of producing a given good or service (MAES et al., 2014). There were several attempts to classify some aspects of biophysical methods including OPERAs project grouping of biophysical models (Lavorel et al. 2014) and OpenNESS project catalog of methods and case studies. The categories from these projects and additional components defined during the ESMERALDA workshops were used to structure an extensive review process which included analysis of scientific papers, case studies and reports. As a results of this process a comprehensive database methods was created and further analyses led to development of a three level classification of biophysical methods. At the first level the methods are grouped into three main categories in relation to the character of the measurements and how the necessary information is extracted: (1) Direct measurement methods, (2) Indirect measurement methods, and (3) Modelling methods (Figure 7.6). At the second level each first level category is divided into method groups which include individual methods at level 3.

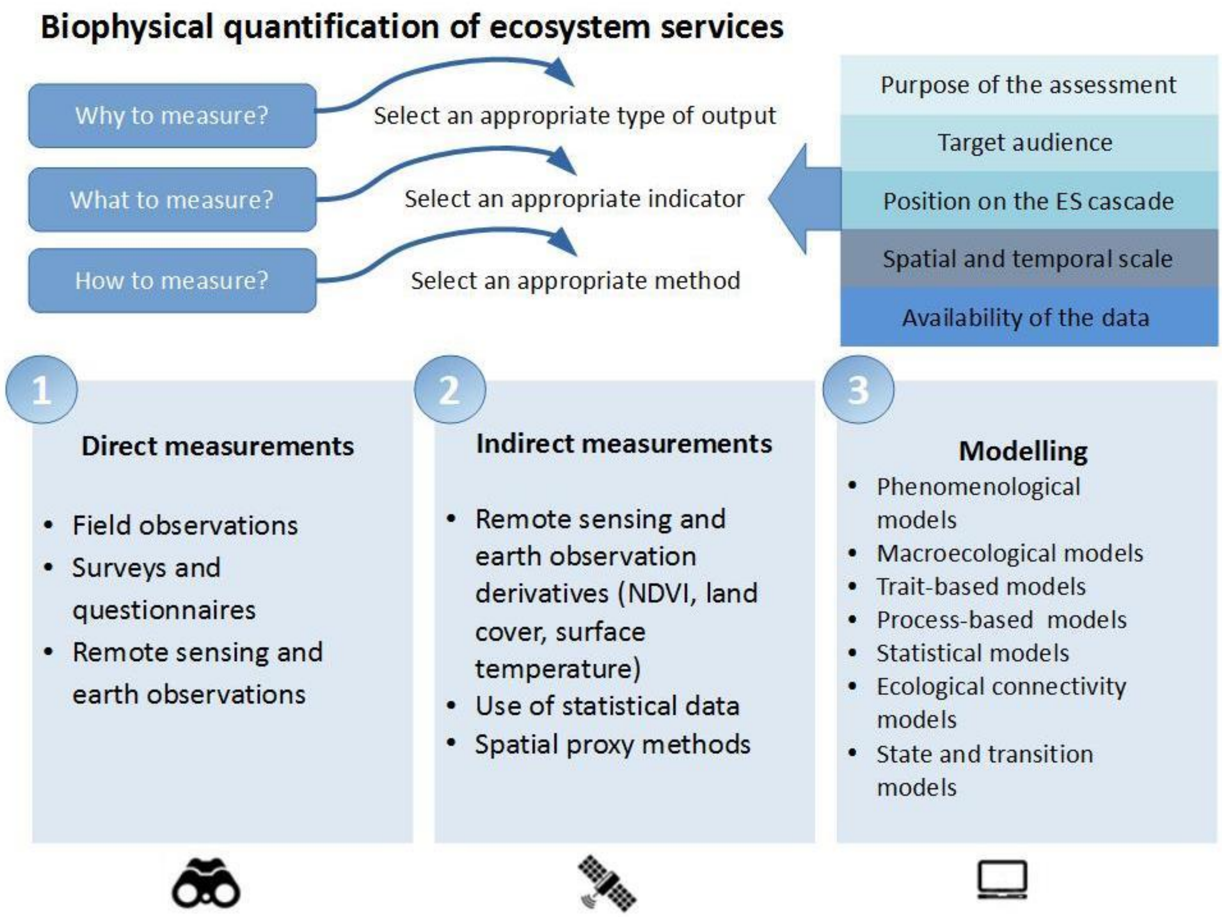


Figure 7.6. Classification of biophysical methods (modified from: Vihervaara et al. 2017a).

Direct measurement methods (1) (Table 7.2) of ES are the measurements of a state, a quantity, or a process from ecosystem observations, monitoring, surveys, questionnaires, or data from remote sensing and earth observations, which cover the entire study area in a representative manner (Vihervaara et al., 2018). They are also used as primary data to other methods, as they are one of the most accurate ways to quantify ES. However, they are often impractical and expensive beyond the site level, and therefore are usually used as an input for a different biophysical mapping method or to validate certain mapping and assessment elements.

Table 7.2. Direct measurement methods (after Vihervaara et al. 2018)

Class	**Description**
Field observations	A primary approach to data collection in the natural sciences based on making observations in the field, and taking direct measurements of physical units.
Surveys and questionnaires	Method often used to get a quick overview of the study, and assist in selecting which other models can be used in mapping and assessment.
Remote sensing and earth observations	An increasingly important method in environmental monitoring, both for biodiversity, and for ES, which have huge potential to improve quantification, mapping, and assessment of ES. Can also be used for direct measurements, or to gather information that feeds into the models.

Indirect measurement methods (2) (Table 7.3) are based on the use of different data sources which rely on biophysical value in physical units, but this value needs further interpretation, certain assumptions, or data processing before it can be used. They can be based on remote sensing and Earth observation derivatives such as land cover, Normalised Difference Vegetation Index (NDVI), surface temperature, or soil moisture which are extracted from the original sources by specific procedures.

Table 7.3. Indirect measurement methods (after Vihervaara et al. 2018)

Class	**Description**
Remote sensing and earth observation derivatives	Can be used indirectly to get derivatives for ES. Examples of such measurements are NDVI, land cover, and surface temperature.
Use of statistical and socioeconomic data	Data from national and regional institutions responsible for environmental monitoring and statistics (such as air and water quality) can also be used as proxy data for ES.
Spatial proxy methods	Derived from indirect measurements delivering a biophysical value in physical units, but these values need further interpretation or data processing, rely upon certain assumptions, or need to be combined in a model with other sources of environmental information before they can be used to measure ES.

Modelling methods (3) (Table 7.4) are based on biophysical models that deliver information on the relationship of biophysical characteristics and ES. They include several groups of modelling approaches from ecology (phenomenological, macro-ecological, and trait-based), statistics, or other earth sciences fields such as hydrology, climatology, soil science etc. Conceptual models and integrated modelling frameworks are also considered under this class. Integrated modelling frameworks are common also for socio-cultural and economic methods.

Table 7.4. Modelling methods (after Vihervaara et al. 2018)

Class	Description
Phenomenological models	The phenomenological models describe empirical relationships between biodiversity or ecosystem components and ES. They are based on the understanding that biological mechanisms underpin ES supply, for instance, vegetation effect to hinder snow slides in mountainous areas
Macro-ecological models	Models that assess ES supply, based on the presence (or abundance) of specific components of biodiversity, are referred to as Ecosystem Service Providers (ESP) or Service Providing Units (SPU), depending on their geographic distribution.
Trait-based models	Functional traits are associated with ecosystem functioning, and thus with the delivery of ES. There is increasing evidence for relationships between traits of organisms and ES supply (e.g. Lavorel 2013). Trait-based models can organize ecosystem functioning by species response to environment. Trait-based models can quantify ES supply based on relationships between functional traits of ESPs and ecosystem properties.
Process-based models	Process-based models rely on the explicit representation of ecological and physical processes, such as carbon sequestration or nutrient cycling, that determine the functioning of ecosystems. These models provide functional means of ecosystem processes that are universal rather than specific to one biome or region.
Statistical models	They are mathematical models that measure the attributes of certain populations or a representative sample of the population. The use of statistical models to map ES are usually based to the estimation of the relationship between the response variable (i.e. ES) and explanatory variables (e.g. biophysical functions), such as soils, climate, etc.
Ecological connectivity models	Ecological connectivity models are used to evaluate the structural and/or functional degree to which the landscape facilitates or impedes movement of different ecological processes.
State and transition models	State and transition models (STM) assume there are a number of states in which a system can exist, but there are specific conditions that can drive the system between states. The main focus of these models is the threshold point that separates one state from another and marks the transition between them. STMs are developed using information from a combination of sources including expert knowledge, historical observations, monitoring, and controlled experiments
Conceptual models	
Integrated modelling frameworks	This group includes tools designed specifically for ecosystem services modelling and mapping that can assess tradeoffs and scenarios for multiple services. They integrate various biophysical, but also social and economic methods, to assess and map different services. The methods are usually organized in modules, where each of them is designed for assessment of particular service

The vast variety of biophysical mapping methods complicate the selection of an appropriate approach for a particular set of services, and given particular data availability options. The tiered approach for ES mapping suggested by Grêt-Regamey et al. (2017) provides an appropriate basis for identification of appropriate method according to particular cases of data availability, level of complexity and policy needs. The different tier levels are distinguished according to the purpose and the level of detail of the ES analysis that is required. This allows the resulting maps to provide relevant information to decision makers, and avoid the application of over-complex or over-simplified methods. The process starts with identification of the goal of the assessment and the different components of the analyzed human-environment system.

Then, components of the assessment such as the ecosystems, the services they provide, beneficiaries of these services should be identified and analyzed. Finally, the tier level and associated method can be selected, guided by a decision tree (see **Error! Reference source not found.**)

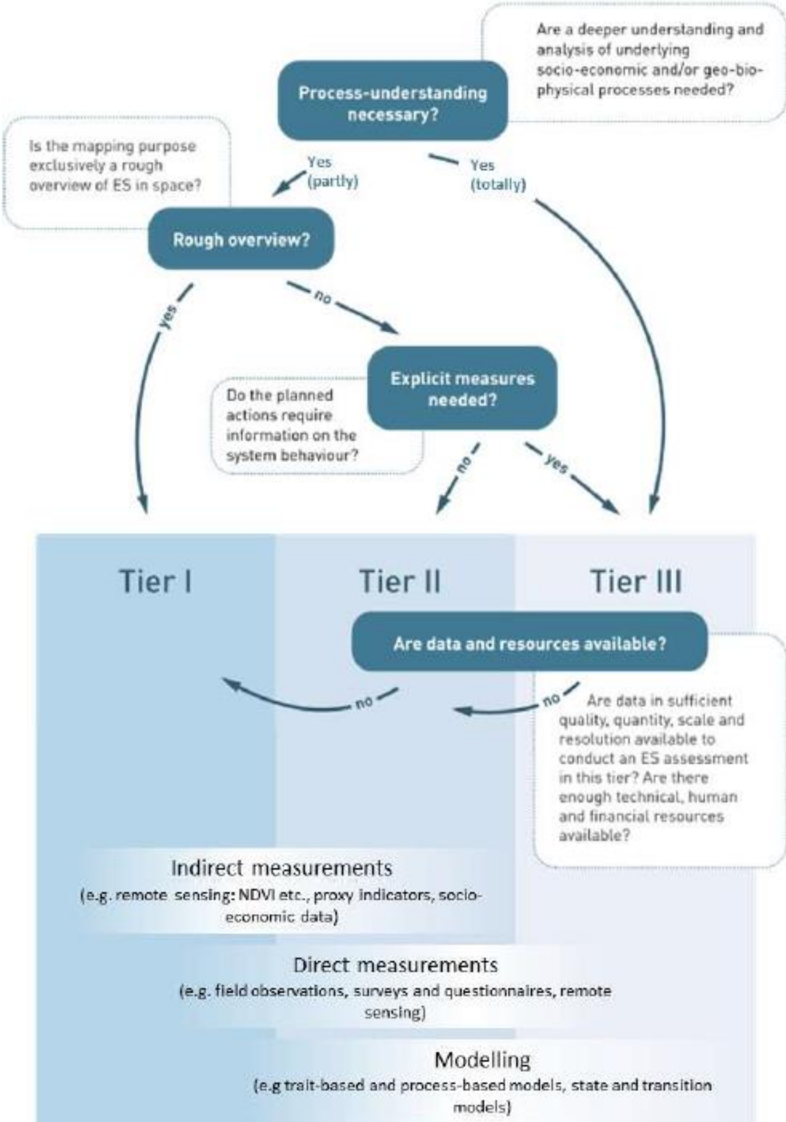


Figure 7.7. Decision tree guiding the selection of tiers for ES mapping (methods are not strictly assigned to a single tier but usually have a focus at a certain tier level).

7.4. Methods applied in the ESMERALDA case studies

Table 7.5 provides an overview of the different methods applied for some selected ES mapped and assessed in the ESMERALDA case studies. Particularly, the listed ES are those that were discussed in detail during the ESMERALDA workshops to test the different versions of the methodology. For these selected ES, a "Method Application Card" was prepared synthesizing the main characteristics in terms of data, expertise, and resource requirement as well as applicability to different spatial scales, and a list of relevant policy questions, among others.

The ESMERALDA case studies include 31 different cases of ES mapping and each of them represents particular method application. The mapped ES are almost equally distributed between three main CISES categories provisioning (9), regulating (10) and cultural (11). The methods presented in the case studies are mainly biophysical (20) followed by social (5) and economical (2). However, the integrated modelling framework methods (presented in 8 case studies), which are counted in biophysical group, contain also elements from social and economic methods. In addition, there are 12 alternative methods presented by supporting experts during the workshops, which are mainly economic (6) and biophysical (5). The case studies represent different scales and tiers. Some of them are fixed at particular scale and tier (e.g. local, tier 1) while other cover more than one (e.g. local/regional, tier 1-3). The scale of the case studies varies from local (24) to regional (8) and national (6). There are 21 methods applicable at tier 2 presented at all three levels of scale. The examples at tier 1 are at local (5) and national (3), while the methods applicable at tier 3 are presented at local and regional scale. There is no single example of tier 3 methods at national scale as they need much detailed data which are usually not available for whole country.

In the following pages, we include an example of "Method Application Card" to show its structure and content. All the Method Application Cards are appended to their respective Case Study Booklet.

Table 7.5 An overview of selected ecosystem services analysed in the ESMERALDA case studies and containing links to the relevant Method Application Cards

COUNTRY	ECOSYSTEM SERVICES (CICES CLASS)	APPLIED METHOD		ALTERNATIVE METHOD	
Belgium	Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)	SPATIAL PROXY METHOD (EXPERT SCORING)			
	Physical use of land- /seascapes in different environmental settings (3.1.1.2)	SPATIAL PROXY METHOD (EXPERT SCORING)			
Bulgaria	Surface water for drinking (1.1.2.1)	PROCESS-BASED MODELS (SWAT)			
	Aesthetics (3.1.2.5)	PHOTO ELICITATION SURVEYS			
Czech Republic	Surface water for drinking (1.1.2.1)	VALUE (BENEFIT) TRANSFER		NETFACTORE INCOME	
	Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	INTEGRATED MODELING FRAMEWORKS (INVEST)		VALUE (BENEFIT) TRANSFER	
	Entertainment (3.1.2.4)	INTEGRATED MODELING FRAMEWORKS (ESTIMAP)		HEDONIC PRICING METHOD	
Finland	Educational (3.1.2.2)	PARTICIPATORY GIS			
	Multiple ES	INTEGRATED MODELLING FRAMEWORK (SPATIAL MULTI-CRITERIA DECISION ANALYSIS)			
Germany	Plant-based [energy] resources (1.3.1.1)	SPATIAL PROXY METHODS		REPLACEMENT COST	
	Buffering and attenuation of mass flows (2.2.1.2)	INTEGRATED MODELING FRAMEWORKS (GISCAME)		BAYESIAN BELIEF NETWORK	
	Educational (3.1.2.2)	NARRATIVE ASSESSMENT			
Hungary	Animals reared to provide nutrition, fibres and other materials (1.1.1.2, 1.2.1.2)	SPATIAL PROXY METHODS (RULE-BASED MATRIX MODEL)			
	Touristic attractiveness of nature (3.1.1.1, 3.1.1.2)	SPATIAL PROXY METHODS (RULE-BASED MATRIX MODEL)			
Italy	Micro and regional climate regulation (2.3.5.2)	PROCESS-BASED MODELS			
	Physical use of land- /seascapes in different environmental settings (3.1.1.2)	INTEGRATED MODELING FRAMEWORKS (ESTIMAP RECREATION MODEL)			
Latvia	Wild plants, algae and their outputs (1.1.1.3)	SPATIAL PROXY METHODS			

	Maintaining nursery populations and habitats (2.3.1.2)	SPATIAL PROXY METHODS (SPREADSHEET METHOD)		STATE AND TRANSITION MODEL	
	Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)	INTEGRATED MODELING FRAMEWORKS (MULTI-CRITERIA ES ASSESSMENT MODEL)		INTEGRATED MODELING FRAMEWORKS (INVEST)	
Malta	Reared animals and their outputs (1.1.1.2)	PREFERENCE ASSESSMENT		SPATIAL PROXY METHODS (SPREADSHEET METHOD)	
	Pollination and seed dispersal (2.3.1.1)	SPATIAL PROXY METHODS + FIELD DATA			
Netherlands	Flood protection (2.2.2.2)	-		PROCESS BASED MODELLING (KINEROS FLOOD MODELLING)	
	Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)	-		SPATIAL PROXY METHOD (RECREATION BASED ON GREEN TYPOLOGY)	
Poland	Filtration/sequestration/ storage/accumulation by ecosystems (2.1.2.1)	SPATIAL PROXY METHODS		REPLACEMENT COST (MARGINAL ABATEMENT COSTS)	
	Physical use of land / seascapes in different environmental settings (3.1.1.2)	SPATIAL PROXY METHODS		CHOICE MODELLING	
Portugal, Azores	Pollination and seed dispersal (2.3.1.1)	MACRO-ECOLOGICAL MODELS			
	Maintaining nursery populations and habitats (2.3.1.2)	MACRO-ECOLOGICAL MODELS			
Spain	Cultivated crop (1.1.1.1)	MARKET PRICE METHODS			
	Surface water for drinking (1.1.2.1)	INTEGRATED MODELING FRAMEWORKS (INVEST)			
Sweden	Reared animals and their outputs (1.1.1.2)	PARTICIPATORY GIS			
	Experiential (physical) use of plants, animals and landscapes (3.1.1.1 & 3.1.1.2)	INTEGRATED MODELLING FRAMEWORK (INTEGRATED MONITORING DATA GAM-MODELLING FRAMEWORK)			

Table 7.6. Structure and content of the Method Application Card.

METHOD APPLICATON CARD: NAME OF THE METHOD ACCORDING TO THE ESMERALDA CLASSIFICATION Applied to: Ecosystem service according to the CICES class (x.x.x.x)	
CASE STUDY	
SCALE	
TYPE	
TIER	
DESCRIPTION	
Brief description of the applied method.	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	•
2. RESOURCES REQUIREMENT	
Time	•
Cost	•
Expertise	•
Tools & equipment	•
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	•
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	•
Non-academic stakeholders	•
5. SPATIAL SCALE OF APPLICATION[1]	
Local	•
Regional	•
National	•
Pan European	•
6. EXAMPLES OF POLICY QUESTION	
	• •
Suggested Citation: **Disclaimer**:	

7.5. Integration of ES mapping and assessment results

The ES domain as such is an integrative, multi-, inter- and trans-disciplinary field of study. This fact already emphasizes the dependency of ES mapping and assessments on integrative approaches. In addition to that, mapping and assessing all ES with only one single method will not lead to precise results. The application of different methods and tools belonging to the different categories (biophysical, economic and social) has the potential to do so. The combination of methods can be differentiated into two different techniques: Linking and integrating. As linked approach we defined, when the output of one method is used as input for another method. Along the mapping and assessment process, multiple linkages might be involved. When the separate outputs of biophysical, economic and social mapping and assessment applications addressing different aspects of the assessed ES are combined in order to produce policy relevant information it is called integration.

In the following section integration is discussed referring to social, economic and biophysical methods separately. As outlined in Deliverable 3.1 (Santos-Martín, et al., 2018), social methods for ES mapping and assessments have the potential to capture multiple values that other methods are not capable of, as they can identify how different stakeholders hold different preferences/perceptions/motivations/values toward ecosystem services and offer insights into values that are frequently invisible in other valuations approaches (e.g. economic or biophysical). Nevertheless, the prevalent social ES mapping and assessment methods are fundamentally complementary with outputs from economic or biophysical measurement or modelling approaches. Frequently, social and economic methods are incorporated into an integrated assessment. In many cases social methods have been identified as precursor of economic evaluation approaches. However, also the inverted flow of information can be encountered.

As elaborated in Deliverable 3.2 (Brander, et al., 2018), economic methods for mapping and assessing ES primarily focus on measuring changes in human welfare following changes in the availability of ES. Thus, biophysical changes in ecosystem extent, condition and functioning can often be defined driving forces. Therefore, economic mapping and assessment of ES fundamentally relies on inputs from biophysical measurement or modelling approaches. Moreover, economic mapping and assessment methods frequently incorporate inputs derived from socio-cultural methods, for example to define the scope of an assessment (e.g. participatory GIS, narrative assessment, Q-methodology) or develop scenario storylines (e.g. participatory scenario planning). However, the flow of information from can also travel in the other direction, feeding results from economic methods into biophysical and socio-cultural mapping and assessment applications.

Finally, the Deliverable 3.3 (Vihervaara et al., 2018) deals with biophysical ES mapping and assessment methods. Within the deliverable it is outlined that biophysical methods are based on quantification of different parameters of biotic and abiotic structures which determine the provision of ES. Biophysical quantification is built on spatial and temporal measures of ecosystem processes. Concerning the aspect of integration, biophysical quantification and representation of the ES data on maps is fundamental for social and economic mapping and assessment. Reliable biophysical data is required for sustainable use and management of ecosystems, ES and natural capital accounting at country and EU level.

Overall, it can be highlighted that methods defined by disciplinary boundaries are to a large extent complements rather than substitutes in the context of ecosystem service mapping and assessments. The ESMERALDA online method explorer allows for searching for integrative approaches by means of a method interlinkage filter, which searches for most common combination of methods used in the registered literature.

7.6. Integration in the ESMERALDA case studies

An overview of the integration of the ES mapping and assessment results in the ESMERALDA case studies is shown in Table 6.5. It specifies whether the results were somehow linked (i.e. outputs of one of the applied methods were used as input for another) or they are actually integrated (i.e. methods were applied in a combined fashion). Following, for each case study, a detailed account of the process of ES identification is provided. In order to optimize the knowledge transfer from the ESMERALDA case studies, from each case study key aspects which are of high relevance and which should be emphasised are extracted in the form of recommendations.

Across the 14 ESMERALDA case studies, both linking and integration of results is very common. Around ¾ of the ESMERALDA case studies employed at least one of the two techniques. However, the scope of application of the different forms of integration varied across the case studies. Amongst others, integration was used to combine the individual results for different ES. In addition to that integration and linkage of results was found to be essential in order to incorporate aspects from the three research domains; social, biophysical and economic.

Table 7.7: On overview of how integration was performed in the ES mapping and assessment exercises.

Case Study	Results linked	Results integrated	Note
Belgium	No	Yes	We combine the different scores of the different ES in a web-tool.
Bulgaria	Yes	Yes	Results from the assessment of ecosystem condition were used in ES assessment. The spreadsheet method was used to integrate the results from different ES by normalization to common qualitative scale.
Czech Republic	Yes		Integrated initial assessment based mainly on value transfer. Other approaches complementing the main results.
Finland	Yes		Mapping and assessment results derived from spatial proxy methods and Participatory GIS methods were used as an input for SMCDA
Germany	Yes (spreadsheet matrix)	Yes (quantifying erosion regulation: Lower resolution data on erosion from a state-wide assessment was combined with high resolution erosion modelling results)	
Hungary	Yes	Yes	Integration stakeholder perspectives is a strong element. Integration and uptake of results is increased by participatory action planning and using ES assessment results for the identification of pro-biodiversity business opportunities.
Italy	No	Yes (Multi-Criteria Analysis)	
Latvia	No	No	Due to lack of time and resources only selected biophysical mapping methods were applied
Malta	No	Yes	Statistical analysis of the generated ES maps, using multivariate and environmental modelling technique
Netherlands			
Poland	No	No	
Portugal, Azores	Yes	Yes	
Spain	To cover a wide spectrum of techniques, ES and values we conducted a systematic review and a meta-analysis of the previous studies published regarding ecosystem services valuation, market methods, and choice models.	Our results show that the methods used to assess the services from a biophysical dimension are very different to the results given by the processes of and socio-cultural and economic valuation which are more associated with human preferences.	Regarding the integration of the different dimensions that were made since 2011, one of the most notable ideas that came from this project was that the value associated with ES should be based on the results of three dimensions: (A) biophysical assessment, (B) sociocultural preferences, and (C) economic value.
Sweden	All assessed ES are linked by nature type, ecosystem or land-use	Results can be extracted for integration across ES-categories and types	

7.6.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

The Antwerp Greentool was specifically designed to perform integrated, and spatially-explicit assessments. Particularly, to allow an easy overview on the condition (land use distribution, pressures), the Greentool allows users to select an area and get a quick overview (star diagram) of all the pressures. An expert based scoring table is applied to map the impact of measures (tier 1). This was combined with outcomes from process based models for modelling pressures to identify interesting locations for green infrastructure. This information, in combination with other data such as the presence of buildings, street canyons, open spaces to assess the suitability of the area to implement specific measures, allows to assess the impact of specific types of measures.

Operationally, applying the Greentool consists of three main steps: (i) selecting an urban area in an interactive map; (ii) analyse current situation for selected area; and (iii) assess the suitability and impact to install specific types of green infrastructure in this area. The tool can be applied to benchmark sites owned by city authorities, support management plans and can be made mandatory for urban development plans to ensure spatial planners take into account environmental challenges and liveability.

Recommendations

- Assessment of the suitability and impact of specific green types is inspiring for planners
- It is of interest to create example streets and assess the impact of these combinations of measures. It is clear that it is not necessarily just adding up impacts of the different types but there is not much literature available on effect of combinations.
- Use a simple illustration e.g. a star diagram to demonstrate the integrated impact of the specific measure on different topics.

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

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.

Recommendations

- The condition of ecosystems is very important for the provision of ecosystem services. Some condition indicators could be used directly in ES assessment.
- The spreadsheet method can be effectively used to integrate the results from different ES by normalization to common qualitative scale.

7.6.3. CZECH REPUBLIC: Pilot National Assessment of ES

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 Global Change Research Institute of the Czech Academy of Sciences (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.

Recommendations

- ES mapping and assessment should start with a concrete product, which is of direct interest for stakeholders
- Flagship results can support integration and extension of ES mapping and assessment process (e.g. National Assessment)
- Production of integrated results is not possible in one step

7.6.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

The mapping and assessment of ES in Järvenpää generated important information that helped to address the policy question on the better and more sustainable integration of GI and infill development. From a planning perspective, spatially explicit analysis results provided a way to compare potential ES supply, demand and connectivity between the planned infill development sites. Thus, the construction could be directed to areas not decreasing the quality of green and blue structure in the area.

Although each category of the ES was included, the main focus was in cultural ES. Provision potential combined to citizen preferences and values related to cultural benefits is directly linked to the wellbeing of the citizens, hence a useful tool to inform planning decisions in a way required in the Finnish land use and building act. The Spatial Multicriteria Analysis (SMCA) mapping and assessment exercise allowed better engagement of the practitioners to the planning process. The decision tree was seen useful tool to structure the factors having impact to the infill development and provide a visual way to understand the challenge to weight different factors against each other. It provided also a way to include experts' knowledge and perceptions in equal manners.

7.6.5. GERMANY: Mapping ES dynamics in an agricultural landscape

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. 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.

Recommendations

- The linkage and integration of different methods leads to more elaborated results.
- It is very important to identify appropriate resolutions and physical units when integrating results from different methods.
- The integration of results from different methods might be useful for validation.

7.6.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

One of the main objectives of the project is to integrate the results of ES mapping and assessment in exploring and verifying pro-biodiversity business (PBB) potentials and creating a local action plan for new PBB development. This planning process is carried out with the active participation of stakeholders, integrating their perception. A pro-biodiversity business (PBB) is dependent on biodiversity for its core business and through that, business effects contributes to biodiversity conservation. ES maps and valuation provides crucial information to ensure that the resulting action plans are indeed sustainable and support biodiversity. The below path is followed in order to effectively influence business decisions.

1) A gap analysis will explore the current situation and form the basis for identifying new and innovative biodiversity-based business opportunities.
2) Three workshops will be organized with the relevant business-related stakeholders to verify the feasibility of PBB ideas suggested by the gap analysis, and to examine new business models that use existing ES more sustainably and secure local livelihoods.

Recommendations

- The role of the stakeholders is crucial for the integration of results.
- Working with stakeholders, however, has to start already at the scoping phase of the assessment to be able to reflect to their needs.
- Applying the Integrated Assessment Framework developed in ESMERALDA (D4.8) can help achieve better results by putting emphasis on each key elements of integration especially at the synthesis phase.

7.6.7. ITALY: ES mapping and assessment for urban planning in Trento

The ES mapping and assessment in the case study generated credible and relevant information that can help to address the starting policy question on how ecosystem service knowledge can be applied to design and assess specific planning actions. The illustrative application concerned 13 brownfields identified in the urban plan as areas for future re-development. Alternative greening scenarios considering the conversion of brownfields to new urban green areas were investigated based on their potential provision of two illustrative and crucial ES for the city of Trento and resulting benefits for the surrounding residents: microclimate regulation and recreation. In the case of microclimate regulation, the biophysical analysis was combined with the quantification of the beneficiaries of the cooling effect, considering both the surrounding residents in general and specific vulnerable groups among them. In the case of recreation, the spatially-explicit assessment of the recreation potential and of the opportunities for nature-based recreation based on expert evaluation allowed comparing the current condition with the greening scenario. The quantification of beneficiaries was done by considering the number of people (total and for specific age groups) with increased availability of areas in the highest class of recreation opportunity within walking distance from home.

From a planning perspective, although each analysis provided useful information, especially on the current needs of the city, the integration of the results of the two mapping and assessment exercises was far more interesting. The integration, carried out in a multi-criteria fashion, allowed exploring trade-offs between the ES in the specific context, considering their combined impact of the potential beneficiaries of the transformation. This beneficiary-based assessment proved to be consistent with the administration objective of increasing the wellbeing of the citizens, hence a useful tool to inform planning decisions.

Recommendations

- Indicators based on ES beneficiaries and benefits can be used to measure advancements towards socially-oriented planning objectives, hence to inform planning decisions.
- Indicators based on ES beneficiaries and benefits are useful to communicate the value of ES to multiple stakeholders.
- Multi-Criteria Analysis techniques are suitable tools to integrate results of different MAES processes and to combine multiple ES values (e.g., of regulating and cultural ES).

7.6.8. LATVIA: Mapping marine ES 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.

Recommendations

- Results of the provisioning services assessment (e.g. total fish landing) could be directly used for economic valuation, e.g. by using Market Price Analysis
- Results of cultural service assessment on tourism potential (estimated based on empiric data) can be used for developing spatial proxy models on contribution of ecosystem features to the particular service supply as well as to design study on social preferences.

7.6.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands (175 words)

Operationally, the integration was carried out through a statistical analysis of the generated ES maps, using multivariate and environmental modelling techniques. The results demonstrate how Malta's rural landscapes, characterized by patches of semi-natural and agricultural areas, are important for the delivery of these key ES. Specifically, 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. NO2 deposition velocity and NO2 removal flux). Thus, this study provides 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.

Recommendations

- Studies that investigate how cultural, provisioning and regulating services co-vary, and the role of ecosystems in the delivery of these services, are important to identify management practices maximising the potential of landscapes to deliver ES bundles, whilst reducing trade-offs and negative impacts on ecosystems.
- An assessment of the different components of the ES delivery chain, including the biophysical structure of ecosystems, condition and spatial variability, capacity to provide ES, demand for and actual flow of ES, is considered as being important. Results obtained during the ESMERALDA Malta case-study demonstrate a strong link between green infrastructure and ES capacity but the ES demand and flow may be higher in urban (and peri-urban) areas. Hence through the identification of centres of ES capacity, demand and flow, it is possible to assess whether mismatches between these occur and to correct these through policy and landscape and urban planning measures.

7.6.10. NETHERLANDS: ES-based coastal defence

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.

7.6.11. POLAND: ES in Polish urban areas

The study aimed to show the ES in urban areas and compare Polish cities in terms of the level of services. It was considered that at this stage the use of only a biophysical method is sufficient. Although social and economic methods have not been included, the demand of services has been taken into account, esp. in the context of accessibility of green infrastructure.

7.6.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

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.

We applied the index of landscape disturbance (D) metric based on the attributes of the landscape matrix (Cardoso et al. 2013 – see case study booklet). 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 - see case study booklet) with the land use and the disturbance index D. We've 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 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. 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.

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.

Recommendations

- There is the need to relate maps of human disturbance to ES indicators

7.6.13. SPAIN: Spanish National Ecosystem Assessment

In principle, 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. 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.

Recommendations

- To carry out the process of economic valuation of ES it is needed to first support it by a rigorous analysis of the biophysical dimension and applying mixed methodologies that include social and cultural aspects of the valuation.
- It is important to spatially represent the results avoiding the simplification of values expressed in economic units and include methodologies that can complement this information in terms of social importance.

7.6.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

The ES mapping and assessment has been put in the context of planning and implementing sustainable development. The Vindelälven-Juhtatdahka river valley area is in the candidacy process for the UNESCO Man and Biosphere Program. With the overarching aim to support sustainable development following the Sustainable Development Goals and Agenda 2030, the UNESCO MAB approach to landscape planning includes a zonation of the area into core areas, buffer zones and development areas. The different zones reflect the natural, social and economic aspects of improved human livelihoods and equitable sharing of services, goods and benefits of natural and managed ecosystems. Hence, ES are outlined, described, mapped and assessed, and indicators and other measures are proposed, developed and tested, for developing, supporting and conserving the natural and cultural identity and values. The foci in the ESMERALDA ES mapping and assessment was on forest habitats, forest management and forests in a landscape context, and on the indigenous Sami culture reindeer husbandry. These foci are key ingredients in the MAB zoning approach to sustainable development and will assist in balancing different and sometimes conflicting interest and views on multiple geographical scales.

Recommendations

- A zoning (triad) approach to ES-assessment
- ES linked to sustainable development
- ES as components in land-use planning on landscape and holistic scales

7.7. Recommendations for integration of ES mapping and assessment

From the 14 ESMERALDA case studies a lot can be learned concerning integration in the context of ES mapping and assessments. The preparation of recommendations for each ESMERALDA case study aimed to emphasize the most important aspects and lessons learned from the conduced studies. These recommendations can be differentiated into three main categories, referring to methods, results and general remarks, respectively. In order to further optimize the knowledge transfer the main findings from the recommendations are summarized.

In general it is found, that the integration of methods and results is essential for providing a comprehensive overview from different perspective (e.g. social, economic). The development of a simple illustration (e.g. in the form of a star diagram) presenting the implemented form of integration and its effects in the ES mapping and assessment process is recommendable in order to ensure transparency and to increase replicability. Furthermore, it is found very important to identify appropriate resolutions and physical units when integrating results from different methods. Both the spreadsheet method and Multi-Criteria Analysis have been emphasized as suitable methods/techniques for matters of integration. A great share of studies aiming for economic evaluation (e.g. market price analysis) require data on social and biophysical aspects. Thus, in these cases an integration of results is mandatory for the implementation. Generally speaking, the integration of different methods has the potential to increase the accuracy and integrity of the results. In addition to that the integration can be used for the purpose of validation. In that sense also the preparation and evaluation of flagship results can be extremely valuable as these results can serve to support and improve the process of integration within ES mapping and assessment projects.

8. Dissemination and Communication

The interface between science and policy making is crucial for environmental governance. An appropriate and efficient dissemination and communication of (often complex) scientific findings to potential users from policy and decision making is at the core of a successful science-policy-society interface. Connecting ES mapping and assessment related research and relevant, competent authorities is thus key to ensure effective use of science in policy making. This dialogue is needed, as policymakers do not always effectively inform scientists about their needs for scientific knowledge, especially in the spatial planning and land use realm.

8.1. Application in ESMERALDA case studies

The case studies have employed different strategies. *Table 6.5*Table 8.1 provides an overview of how the ES mapping and assessment results have been disseminated and communicated to different categories of stakeholders. It specifies whether they were published in a scientific articles, disseminated and communicated to competent authorities (e.g. decision-makers, people working in agencies etc.) and to the general public.

Table 8.1: On overview of the Dissemination and Communication activities in the selected ESMERALDA case studies.

	Targeted audience		
	Scientific publication	Competent Authorities	General Public
Belgium			
Bulgaria			
Czech Republic			
Finland			
Germany			
Hungary			
Italy			
Latvia			
Malta			
Netherlands			
Poland			
Portugal, Azores			
Spain			
Sweden			

Generally, the 14 ESMERALDA case studies show different degrees of Dissemination and Communication levels. Close collaboration with competent authorities takes place in almost all cases. In ten cases, scientific publications were used to communicate the MAES efforts. While only seven cases state that Dissemination and Communication to general public took place.

Following, for each case study, a detailed account of the process of ES identification is provided.

8.1.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp

Recommendations

- Pay attention to the way results are presented. Use strong visualization and inspiring examples
- SDG's and especially health are a strong argument to include into the communication on ES.
- You need 'champions' within the administration, neighbourhood who are defending and promoting the use of the tool.

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

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.

Recommendations

- The results ES assessment are still not enough comprehensible for the general public. There is need to "translate" the results in a way that more people could understand them.

8.1.3. CZECH REPUBLIC: Pilot National Assessment of ES

Dissemination and communication 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 of the Czech Republic 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.

Recommendations

- Communication to competent authorities should be important part of the process

- ES concept is often misunderstood by policy-makers and practitioners. Communication is required to get the concept right.
- Scientists should not suppose that everyone knows and understands ES.

8.1.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

Communication and collaboration between planners and researcher were ongoing during the process through regular meetings and planners participation to the process. Analysis results including GIS-datasets and report (Kopperoinen et al. 2016 [in Finnish]) have been shared with municipal planners. The involvement of citizens, schools and kindergartens provided a way for a more effective policy-science-society interface and enhanced the knowledge exchange between participants in terms of cultural ES. The continuous collaboration along the entire process of mapping and assessment is expected to facilitate the introduction of the results into the ongoing urban planning process. From an academic perspective, results obtained in this case study concerning the engagement of practitioners aiming to enhance the integration of urban greenspaces and residential infill development will be disseminated through scientific publications (Tiitu et al. 2018). In addition, case study has been presented in international and various national conferences.

Recommendations

- Make sure that the results of the mapping and assessment are understandable to everyone who will be using them.
- Organize feedback workshop with practitioners and stakeholders
- If possible, publish the results as open datasets

8.1.5. GERMANY: Mapping ES dynamics in an agricultural landscape

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.

Recommendations

- Scientific publications are crucial as instrument for a comprehensive knowledge exchange between scientists, supporting the reproduction of the assessment in other study areas.
- Dissemination and communication to the general public is highly advisable for politically relevant management and assessments on the local scale.
- In the ideal case D&C to the general public should be informative and at the same time attractive and easily understandable.

8.1.6. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

The project has a strong communication activity targeting a large range of external stakeholders (local authorities, agencies, higher education, research, SMEs and NGOs) and aiming to achieve a change in at least one of the following three characteristics: knowledge, attitude and practice. For that, a number of communication channels are used from scientific publications and conferences to press releases, social media, at levels from local to international. In particular, all the participating stakeholders from the pilot areas will at the end of this activity receive a PBB Development Guide.

Recommendations

- Awareness of stakeholders about the project and its results requires visibility from the beginning. Ask for feedback about the usefulness of the project for them.
- When disseminating results, technical terms and details should be avoided and the main messages put in focus.
- It is useful to publish the results in sectoral journals, e.g. agriculture, beekeeping, forestry etc.

8.1.7. ITALY: ES mapping and assessment for urban planning in Trento (155 words)

From an academic perspective, the results obtained have been disseminated through scientific publications, and communications in international and national conferences. In addition, the involvement of the city of Trento in the MAES Urban Pilot and EnRoute projects was the occasion to communicate and disseminate the results in the respective networks through publications (the MAES report) and project websites (https://oppla.eu/enroute). Above all, results have been shared with municipal officers responsible for planning and managing urban green infrastructures in the city of Trento, through regular meetings and their direct participation to the project activities. Moreover, the involvement as experts of officers from other municipal and provincial departments and from other institutions with an interest in nature-based recreation provided a table for discussion and paved the way for a more effective policy-science-society interface and closer cross-sectoral collaboration.

8.1.8. LATVIA: Mapping marine ES in Latvia (180 words)

The dissemination and 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 defence, 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.

Recommendations

- To communicate the ES mapping and assessment results to wider audience targeted dissemination materials and appropriate language shall be developed
- The main challenge for dissemination and communication on ES is how to bring across the message on the very complex phenomena in understandable way
- Wider stakeholder involvement in the MAES through participatory approach could increase acceptance of results and support their further dissemination.

8.1.9. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

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.

Recommendations

- A wide participation by experts is strongly suggested in order to select key ES and to contribute to ecosystem and ES assessments. The development of a network that brings together scientists, researchers and policy-makers is considered as being important to favour knowledge exchange and to lead to the co-production of an adapted approach for ES assessment.
- Dissemination to the public and education are important steps for sharing information about the importance of ecosystems for ES delivery and to promote individual choices favouring the sustainable use of ecosystems.

8.1.10. NETHERLANDS: ES-based coastal defence

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.

8.1.11. POLAND: ES in Polish urban areas

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: (i) Mapping and Assessment of Ecosystems and their Services, EEA Grants/European Conference, Trondheim/Norway, May 2015; (ii) ECOSERV 2016, 4th Polish National Symposium on ES in transdisciplinary approach, Poznań/Poland, September 2016; (iii) European ES Conference, Antwerp/Belgium, 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, 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.

Recommendations

- Informing stakeholders about ES potential on the background of the land use provides new perspective on their activities.
- Stakeholders are often aware of environmental issues in spatial planning; however, they rarely use ES approach.

8.1.12. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

The data used for current studies were published by Gaspar et al. (2011) and Picanço et al. (2017a). Moreover, 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 traps. The same data was influential in the development of Ecosystem Assessment Profiles within BEST III project for Macaronesia and the creation of Key Biodiversity Areas (KBAs) for Azores.

Recommendations

- There is the need of training technicians and civil servants – a tailored program, with different levels of complexity (e.g. starting, advanced), for different stakeholders, aiming to build institutional capacity

8.1.13. SPAIN: Spanish National Ecosystem Assessment

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.

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:

- Generic public communication elements: (i) Website: www.ecomilenio.es, (ii) Facebook: Ecomilenio España; (iii) Quarterly Newsletters: quarterly newsletters mailing; (iv) Ecosystem videos (available on web site and SNEA YouTube channel); (v) Brochures and other materials such as postcards, notebooks, etc.
- Specific public communication elements: (i) SNEA Reports: Results and Synthesis, (ii) Teaching materials; (iii) Slide presentation; (iv) Posters: one general poster identifies the ES associated with different types of ecosystems and another poster is specific to urban ecosystems; (v);Stakeholder surveys: providing basis for a participatory process to build future scenarios..

Recommendations

- 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.
- To bring 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 in different social spheres, e.g. the media, school communities, NGOs and social movements.

8.1.14. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

For academic purposes, the approach and results presented here will be used for the continuing building of know-how on ES applications within the Swedish EPA ES research and communication programs. With the direct anchorage with the County Administrative Board of Västerbotten and the Municipality Boards involved in the UNESCO MAB-process, this will also contribute to regional and local ES understanding and use as input data in spatial planning. Furthermore, through the MAB-program and the following steps towards formal MAB reserve membership for the Vindelälven-Juhtatdahka site, this also supports ES applications as a key ingredient in the global MAB-network with the Sustainable Development Goals and Agenda 2030 as a main framework. At site, for exploring and solving the conflict risks but also for elucidating integration and synergy opportunities between reindeer husbandry and other land uses as well as among other land uses, appropriate ES mapping and assessment is needed for stakeholder-informed and sustainable operational landscape planning.

Recommendations

- Building of know-how
- Input to continuing processes, i.e. UNESCO MAB reserve and network
- Input to regional and local landscape planning strategies

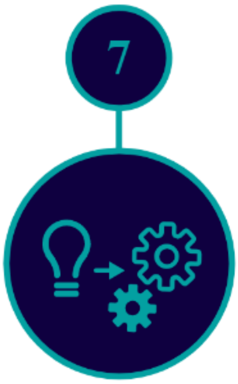
8.2. Recommendations for dissemination and communication

TAILORING YOUR MESSAGE TO THE NEED OF THE AUDIENCE is a crucial element for a successful dissemination and communication. Thus, it essential to develop a communication strategy designed to meet the needs of different target audiences or stakeholders, including innovative formats and channels for the dissemination in different social spheres, e.g. the media, school communities, NGOs and social movements. Accordingly, in the case of **scientist,** the results of the ES mapping and assessment should possibly be made available as (open access) publications, the main instrument for a comprehensive exchange of knowledge, in order to supports the reproduction of the assessment in other study areas. When it comes to **competent authorities**, it is important to provide a strong arguments by using strong visualization and inspiring examples, including references to Sustainable Development Goals (SDGs) and especially health issues. For example, informing stakeholders about ES potential on the background of the land use provides new perspective on their activities. Generally, it is important to tailor the final message as a possible input for regional and local landscape planning strategies or other relevant ongoing processes. Finally, for the **general public,** dissemination and communication should be informative and at the same time attractive and easily understandable with an appropriate language. This is especially important for politically relevant management and assessments on the local scale in which dissemination and communication should serve to share information about the importance of ecosystems for ES delivery and to promote individual choices favouring the sustainable use of ecosystems.

INVOLVEMENT OF STAKEHOLDER SHOULD BE AN IMPORTANT PART OF THE OF THE D&C PROCESS. A wide participation by experts is strongly suggested in order to select key ES and to contribute to the assessment of ecosystems and their services. The development of a network that brings together scientists, researchers and policy-makers is in fact considered as being important to favour knowledge exchange and to lead to the co-production of an adapted approach for ES assessment, which ultimately increases acceptance of the results and support their further dissemination and implementation. Particularly, it is important to bring 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. However, the involvement of stakeholder should not be limited only to the initial stages of the MAES process, rather it is crucial to keep the involvement throughout the process, for example, organizing feedback workshop with practitioners and stakeholders.

CHALLENGES IN COMMUNICATING A COMPLEX CONCEPT OF ECOSYSTEM SERVICES. The main challenge for dissemination and communication on ES is how to bring across the message on the very complex phenomena in understandable way. To this end, scientists should not suppose that everyone knows and understands ES. Quite often the ES concept is misunderstood by policy-makers and practitioners, thus the need of a targeted communication to “get the concept right” in the first place. Following, the results of an ES assessment may not be comprehensible enough for the general public; there is thus a need to “translate” the results in a way that more people could understand them. As a general rule, make sure that the results of the MAES are understandable to everyone who will be using them.

NEED FOR CAPACITY BUILDING. A crucial step towards getting the MAES message across is to build know-how. Quite often, stakeholders are aware of environmental issues in their activities (e.g. spatial planning or other decision-making processes), however they rarely use ES approach. Therefore, there is the need of training technicians and civil servants – a tailored program, with different levels of complexity (e.g. starting, advanced), for different stakeholders, aiming to build institutional capacity. Finally, there is an urgent need of 'champions' within the administration, neighbourhood who are defending and promoting the use of the MAES approach.



9. Implementation

With regards to implementation in policy and decision making, the ESMERALDA case studies cover various policy areas relevant at EU level: nature conservation; climate, water and energy, marine policy, natural risk, urban and spatial planning, green infrastructures, agriculture and forestry, business, industry and tourism, and health (see also Section 3 and 4 of this report).

Table 9.1 provides an overview of the level impact on policy and decisions in the selected ESMERALDA case studies. Here, the assumption is that level of impact is somehow indicative of the level of implementation of the ES mapping and assessment process and its results. Operationally, the level of impact has been here evaluated ex-post by the case study coordinators using a scale adapted from Ruckelshaus et al., (2015). Accordingly, the level of impact ranges from one in which stakeholders are aware of, understand and discuss ES to a level in which new policy and finance mechanisms are established.

Particularly, some of the ESMERALDA case studies represent good working examples of the implementation of ES mapping and assessment in different policy and decision-making contexts. As illustrated in detail in Cortinovis and Geneletti (2018), the Italian case study dealing with ES mapping and assessment for urban planning in Trento in an example. Initially scientifically driven, the aim of the study gradually shifted towards producing relevant knowledge to support the local administration in drafting the new Urban Plan for the city of Trento. Among other issues, the study produced a spatial analysis of key urban ecosystem services, and tested the use of this information to priorities brownfields redevelopment, by comparing the benefits of alternative greening scenarios. The continuous interaction with stakeholders in the public administration during the process of ES mapping and assessment facilitated the consideration of the results into the ongoing urban planning process.

Another example is the Latvian case study - Mapping marine ecosystem services in Latvia. It was performed within the development of the national Maritime Spatial Plan (MSP) for Latvian territorial waters and EEZ, described in detail in Veidemane et al. (2017). The 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.

Table 9.1: On overview of the impact on policy and decisions of the MAES exercise in the ESMERALDA case studies (based on the evaluation of the coordinators).

Increasing level of Impact

	People aware of, understand and discuss ES	Stakeholders focus on ES and articulate different positions	Alternative choices based on ES mapping and assessment	Plans & policies considers ES mapping and assessment	New policy and finance mechanism established
Belgium	■	■	■	■	■
Bulgaria		■	■		■
Czech Republic				■	
Finland	■	■		■	
Germany					
Hungary					
Italy	■	■	■	■	
Latvia			■	■	
Malta					
Netherlands					
Poland				■	
Portugal, Azores		■		■	
Spain			■	■	
Sweden			■	■	

Similarly, the Polish case study - ES in Polish urban areas, which was commissioned by the Ministry of the Environment, had the main purpose of identifying the spatial structures of ecosystems in the 10 largest urbanized areas in Poland and compare them in terms of their potential for providing services. The results of the study served to draw recommendations for spatial planning on local and sub-regional levels.

Finally, a good example is also the Swedish case study - ES mapping and assessment in the Vindelälven-Juhtatdahka river valley. Here, the mapping and assessment of ES has been put in the context of planning and implementing sustainable development across a large-scale biotic transition. The focus is on reindeer husbandry-related businesses aiming to integrate natural and cultural values in territorial planning. With the direct anchorage with the County Administrative Board of Västerbotten and the Municipality Boards involved in the UNESCO MAB-process, the study contributes to regional and local ES understanding and use as input data in territorial planning. This is crucial for exploring and solving conflicts, and understanding potential synergies between reindeer husbandry and other land uses.

In the following, we provide a brief account of the implementation of the MAES results in some of the case studies.

9.1.1. BELGIUM: Mapping green infrastructures and their ES in Antwerp (166 words)

The tool is inspirational for local green management plans. The idea is to supply easily available information (it should not take more than 1 hour), to non-expert users. The tool was used in several projects in the city of Antwerp to do a quick scan of the existing problems and needs in a particular area. It was for example used as inspiration for the reconstruction of a public square (Groenplaats), to support judgement of deviations on permits for impermeable surfaces and to support decisions on greening public buildings. It was also used as a co-creation tool in the development of climate-robust neighbourhoods. General feedback of users given on the existing methodologies is that a quick feedback on identification of the pressures in the selected area is very relevant and of high added value. The general challenge remains on improving the usability of maps and assessments for selecting suitable building blocks for local green plans.

Recommendations

- Quick feedback on identification of the pressures in the selected area is very relevant and of high added value.
- Supply easily available information for non-expert users

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

The flood regulation ES as a part of nature based solution was proposed as an alternative choice to the traditional measures that include building or reinforcing existing dykes and dams. It was included in the preparation of the Karlovo municipality management plan. Ecosystem services provided by forests are already part of the legislation in forestry sector. The management plans at regional level should have maps of 9 ecosystem services provided by forests.

Recommendations

- Nature-based solutions in disaster management should be prior to traditional measures because they are cost effective and environmentally friendly.
- Flood risk measures should include not only the flood plain areas but also the ecosystems in the whole river basin. The forest ecosystems in the basin have higher prevention function than those in the floodplain.

9.1.3. CZECH REPUBLIC: Pilot National Assessment of ES

The pilot national assessment supported incorporation of ES into national strategies (Climate Change Adaptation, Biodiversity Strategy). The assessment provided a basis for preparation and testing of Experimental Ecosystem Accounting (a still ongoing process).

Recommendations

- National mapping and assessment of ecosystem services is prerequisite for the effective implementation of ES
- ES mapping and assessment can form basis for implementation of ES, e.g. in ecosystem accounting.

9.1.4. FINLAND: Green infrastructure and urban planning in the City of Järvenpää

The Järvenpää spatial planners employed the ES concept to value urban greenery in context of new infill development. A novelty, as active stakeholder involvement was ensured at each stage of the planning process, using PGIS methods in schools/kindergardens, an online survey and a citizen workshop, making sure that urban green stayed accessible by stakeholders. Combining municipal planning and research, also enabling citizens to co-shape new development plans enhanced the acceptance of new infill development and proves that the MAES, as applied in this case, bears great potential for upscaling, informing spatial urban developments at higher, regional levels

Recommendations

- Implementing local case-studies can demonstrate the effectiveness of MAES for sustainable spatial planning and prove its potential for upscaling to regional or national level
- PGIS methods can help raise awareness and strengthen understanding of the ES concept amongst the public
- Bringing together scientists, decision makers and stakeholders is crucial to co-produce sustainable development plans

9.1.5. HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

All participating stakeholders from the pilot areas will receive a PBB Development Guide at the end of this activity. This Guide will inform on factors of success of existing best practice examples (cross-sectoral/ sector specific), relevant steps for developing a PBB, and legal requirements to be considered. The guidance will also be applicable for businesses outside the pilot areas. A 'Best PBB idea' title is awarded across the seven pilot areas of the project. Owners of this idea will be given professional help for its realization.

Recommendations

- Use ES to highlight opportunities for combining nature conservation and local economic development to generate a win-win situation.
- A key factor contributing to the success of an ES assessment – the uptake of its results - is the cooperation of local residents and managers, entrepreneurs, NGOs and authorities.

9.1.6. ITALY: ES mapping and assessment for urban planning in Trento

The continuous interaction along the entire process of mapping and assessment is expected to facilitate the introduction of the results into the ongoing urban planning process.

Recommendations

- Integrating MAES results in formal decision-making processes (e.g., planning) requires understanding the (highly regulated) procedures of the administration.
- Land ownership may limit the implementation of planning actions based on MAES results.

- MAES results can promote innovation in planning processes (e.g., new forms of implementation tools, innovative approaches to the use and management of green areas).

9.1.7. LATVIA: Mapping marine ES in Latvia

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.

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.

Recommendations

- Researchers should be open and proactive for co-operation with decision makers and promoting of ecosystem service approach to ensure uptake of MAES results in decision making
- Lack of data and research-based evidence should not be an obstacle for introducing ecosystem service approach in spatial planning and decision making. Solution can be tiered approach and iterative process, updating the assessment results when better knowledge and data becomes available.

9.1.8. MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands

Recommendations

- The development of a network that brings together scientists, researchers and policy-makers is considered as being important to favour knowledge exchange and to lead to the co-production of an adapted approach for ES assessment.
- The development of a more effective science-policy interface that involves a wider community of researchers and decision-makers from various fields is considered as being critical for the co-production of new approaches that are suitable for ES assessments. It is also important for the development of a continuous cycle of innovation and improvement rather than the implementation of ES assessments that are static and carried out only at one point in time.

9.1.9. POLAND: ES in Polish urban areas

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.

Recommendations

- Planning activities in Polish cities are based on minimizing the pressure on ecosystems, less frequently on the improvement of ecosystems' condition. MAES for cities is aimed at making the authorities aware on increasing the level of ES, and firstly on improving the accessibility to ES.
- Awareness of consequences of spatial planning decisions on ES potential may contribute to creation of more efficient spatial structure.

9.1.10. PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores

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. The results obtained for Maintaining nursery populations and habitats, published by Gaspar et al. (2011) and Picanço et al. (2017a), were already used to implement an 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 traps. Similarly, the results obtained for Pollination and seed dispersal can be used to identify key ES for Azorean agro-ecosystems.

Recommendations

- There is the need to use ES assessments to inform local governments on islands on where to create new protected areas.

9.1.11. SPAIN: Spanish National Ecosystem Assessment

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 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.

Recommendations

- Make a special effort to represent the results in a spatially explicit way;
- Only use economic methods that can be contextualized by biophysical and social characteristics.
- Develop initiatives to promote knowledge and understanding of the importance of biodiversity, including its effects on human well-being, to promote changes in attitudes toward it.

9.1.12. SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley

With the direct anchorage with the County Administrative Board of Västerbotten and the Municipality Boards involved in the UNESCO MAB-process, the ES mapping and assessment will also contribute to regional and local ES understanding and use as input data in territorial planning. Furthermore, through the MAB-program and the following steps towards formal reserve membership for the Vindelälven-Juhtatdahka site, this also supports ES applications as a key ingredient in the global MAB-network with the Sustainable Development Goals and Agenda 2030 as a main framework. At site, for exploring and solving the conflict risks but also for elucidating integration and synergy opportunities between reindeer husbandry and other land uses as well as among other land uses, appropriate ES mapping and assessment is needed for stakeholder-informed and sustainable operational landscape planning.

Recommendations

- Input to continuing processes, i.e. UNESCO MAB reserve and network
- Input to regional and local landscape planning strategies
- Step-wise inclusion of ES into existing decision-making frameworks

9.2. Recommendation for implementation

THE RELEVANCE AND POTENTIAL OF MAES RESULTS TO SUPPORT DECISION-MAKING. To this end, researchers should be open and proactive for co-operation with decision makers and promoting of ES approach to ensure uptake of MAES results in decision making. In involving decision makers, it is important to showcase how MAES results have potential to raise awareness of consequences of decisions on ES potential, and to promote innovation in decision making processes. In addition, MAES results should be tailored to be informative for specific decision-making processes, for example, supplying easily available information for non-expert users, and addressing relevant current issues. To this end, a stepwise approach for the inclusion of ES into existing decision-making frameworks and ongoing processes is thus crucial. For example, implementing local case-studies can demonstrate the effectiveness of MAES for sustainable policy and decision-making at the local level can prove its potential for upscaling to regional or national level.

THE PROCESS IS AS MUCH AS IMPORTANT AS THE CONTENT: NETWORK TO MAINSTREAM. Bringing together scientists, decision makers and stakeholders is crucial to co-produce credible and relevant MAES results that support policies and decisions for sustainable development. Content wise, among others, bear in mind to develop initiatives to promote knowledge and understanding of the importance of biodiversity, including its effects on human well-being, to promote changes in attitudes toward it. Process wise, the development of a network that brings together scientists, researchers and policy-makers is as equally important to favour knowledge exchange and to lead to the co-production of an adapted approach for ES assessment. In fact, the development of a more effective science-policy interface that involves a wider community of researchers and decision-makers from various fields is critical for the co-production of new approaches that are suitable for ES assessments. It is also important for the development of a continuous cycle of innovation and improvement rather than the implementation of ES assessments that are static and carried out only at one point in time.

Some operational steps that could promote an effective networking and mainstreaming include making a special effort to represent the results in a spatially explicit way, to apply participatory GIS methods that can help raise awareness and strengthen understanding of the ES concept amongst the public, to include quick feedback on identification of the pressures in the selected area, and last to use only use economic methods that can be contextualized by biophysical and social characteristics, among others.

BARRIERS FOR IMPLEMENTATION CAN BE BEYOND THE SCIENTIFIC MAES PROCESS. Lack of data and research-based evidence, often mentioned as key barriers mainly by scientists, should however not be an obstacle for introducing ES approach in policy and decision making. Ways forward include applying a tiered approach and an iterative process, updating the assessment results when better knowledge and data becomes available. On the other hand, land ownership is a key real-life hindrance which may limit the implementation of planning actions based on MAES results in a real-life context. Similarly, integrating MAES results in formal decision-making processes (e.g., planning) requires understanding the (highly regulated) procedures of the administration.

BOX 5.1 An example from urban planning (By Chiara Cortinovis - UNITN)

As demonstrated by the ESMERALDA case studies, mapping and assessment of ecosystem services can answer a variety of policy questions related to a number of different themes (see Section 4). Hence, the results of the assessment can serve as input in various policy- and decision-making processes, from spatial planning to the definition of business plans for industries. Within these processes, ecosystem service knowledge assumes different roles, corresponding to different purposes of the mapping and assessment exercise (e.g., exploratory, informative, decisive, design), and to different desired or expected impacts, from awareness raising to policy design (see Table 9.1) (Posner et al., 2016; Barton et al., 2018).Therefore, 'implementation' refers to a variety of tasks that, depending on the context, are accomplished by the mapping and assessment results within policy- and decision-making processes.

A successful uptake, hence implementation, of mapping and assessment results in the different processes depends not only on their credibility in terms of scientific soundness, but also on their salience, i.e. their relevance and adequacy to the issue at hand, and on their legitimacy, i.e. the extent to which they are perceived as fair and unbiased by stakeholders (Cash et al., 2003; Clark et al., 2016). These characteristics depend on how the interface between the mapping and assessment process and the policy- or decision-making process it aims to support is conducted. In fact, any policy- or decision-making process can be seen as a sequence of phases, each one characterised by different purposes that determine the possible roles for ecosystem service knowledge, and related requirements in terms of saliency and legitimacy.

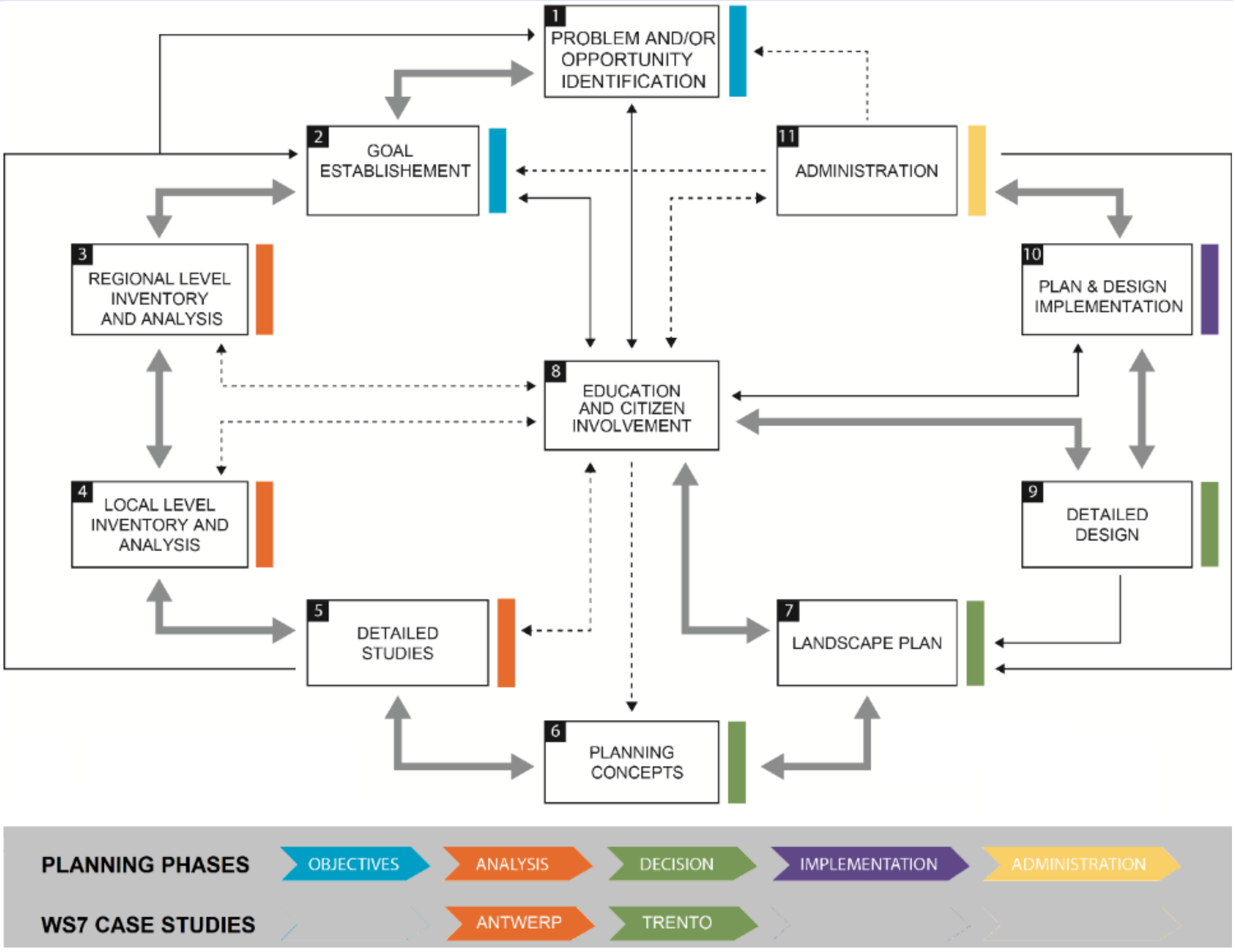


Figure 9.1: Ecological planning model (Source: Steiner, 2000) and the Antwerp and Trento case studies to investigate the analysis and decision phases.

An example of this can be done on urban planning, based on the two ESMERALDA case studies of Antwerp and Trento discussed during workshop 7. The urban planning process follows a quite consolidated sequence of phases, which have been described – among others – in the Ecological Planning Model proposed by Frederick Steiner and shown in Figure 9.1Figure X. The author himself summarizes the model as a process that “involves setting goals, assessing the environment, analysing suitability, exploring options, selecting a course of action, testing those actions through design, and implementing a plan. In a democracy, the public is involved throughout the process.” (Steiner, 2016). By further generalizing, the main stages of objectives, analysis, decision, implementation, and administration can be identified.

Within this framework, the two case studies of mapping and assessment of urban ecosystem services refer to two different phases of the process, i.e. the analysis phase in the case of Antwerp, and the decision phase in the case of Trento. In the case of Antwerp, the purpose of the assessment is mostly informative, aiming to provide some basic knowledge on the spatial distribution of green infrastructure and related conditions and ecosystem services across the city. From a planning perspective, the results produced by the mapping and assessment activity allow investigating the current conditions and widen the knowledge base of the urban plan. In the case of Trento, the purpose of the assessment is mostly decisive, aiming to support decision-makers in the assessment of planning actions. The results produced by the mapping and assessment activity are used as criteria to compare alternative options for the new urban plan.

According to the different purposes, the mapping and assessment of ecosystem services is carried out in different ways. The number of ecosystem services assessed is different: higher in the case of Antwerp, where a comprehensive overview of urban ecosystem services is provided, lower in the case of Trento, where two key ecosystem services are assessed, based on the most relevant issues and policy goals identified by local stakeholders. The type of output and result integration are also different. In the case of Antwerp, the Greentool is a highly interactive web-based tool that can be queried by all citizens, providing an overview, in the form of a star diagram, of the relative provision of ecosystem services in the analysed area. In the case of Trento, multi-criteria analysis is used to combine the results of the assessments considering different perspectives, thus supporting a negotiation process where representative stakeholders are involved in reaching an agreed solution (i.e., the best planning scenario under the defined priorities) in a transparent way.

While the two ESMERALDA case studies can be considered representative for the two phases of analysis and decision, other phases of the schematized urban planning process can benefit from mapping and assessment of ecosystem services results. In the implementation phase, for example, ecosystem service knowledge can support the design of specific implementation tools, including regulations (e.g., the designation of protected zones), financial mechanisms (e.g., payments for ecosystem services or incentives), and compensation measures. At the same time, in the administration phase, a follow-up on ecosystem service mapping and assessment can become an integral part of the monitoring scheme of the urban plan. The purposes and related requirements for the mapping and assessment exercise in these other phases are different from the ones earlier described in terms of specific questions to be answered and potential users of the results, which asks for a careful design of the interface between the mapping and assessment and the policy- and decision-making process it aims to support.

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Note

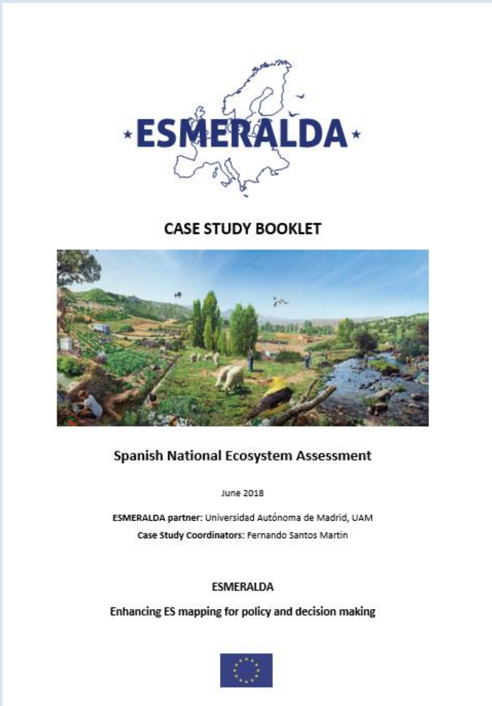
Reference related to the individual case studies can be found in their respective booklets (see Annex).

Annex to Deliverable 5.4

ESMERALDA Case Study Booklets

Drafted during the preparatory phase of each ESMERALDA Workshop by the case study coordinators, **Case study Booklets** represent important support material used during the testing workshops. They illustrate the process of ES mapping and assessment in the case studies, with information about the study area, main questions and themes addressed, ecosystem types and conditions, mapping and assessment of ES, and finally, about the dissemination and communication of the results , and their implementation (see Box 0.1). The final version of the Case Study Booklets, which form a building block of the ESMERALDA flexible methodology, is accessible via the **ESMERALDA MAES Explorer.** http://maes-explorer.eu/page/overview_of_esmeralda_case_studies .

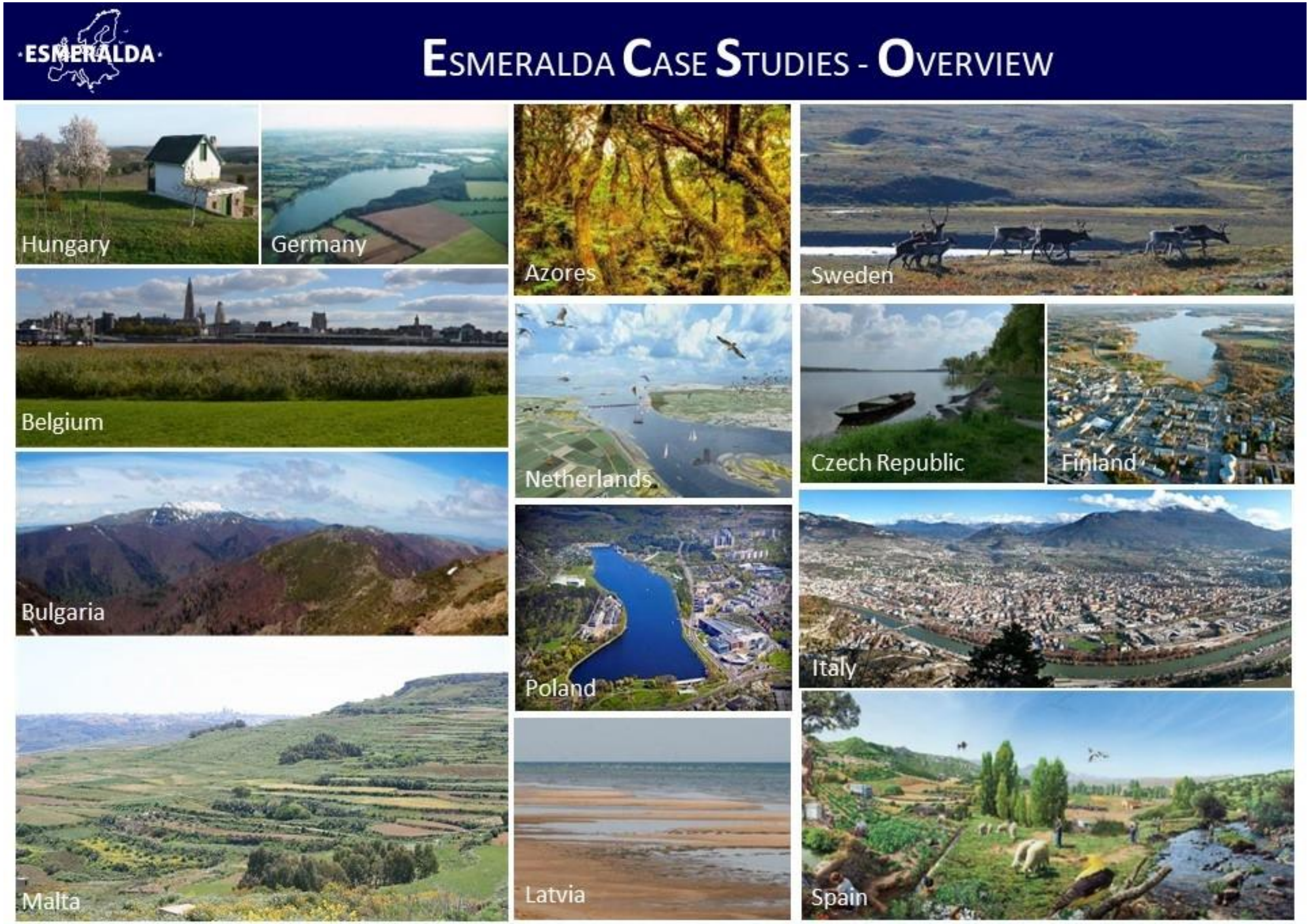
1) **Case study factsheet and overview of the study area**
2) **Questions and Themes**
   a) Objectives of ES mapping and assessment
3) **Stakeholders' Involvement**
4) **Initiating Mapping and Assessment**
   a) Identification and mapping of ecosystem type
   b) Assessment of ecosystem conditions
   c) Selecting Ecosystem Services
5) **Methods for ES mapping and assessment**
   a) Biophysical methods for ES mapping and assessment
   b) Socio-cultural methods for ES mapping and assessment
   c) Economic methods for ES mapping and assessment
   d) Integration of ES mapping and assessment results
6) **Dissemination and Communication**
7) **Implementation**
8) **References & Annexes**



Box 0.1. Content of the booklets illustrating ES mapping and assessment in the ESMERALDA case studies

ESMERALDA Method Application Cards

Drafted during the preparatory phase by the case study coordinators and other ESMERALDA partners acting as supporting experts, the **Method Application Cards** represent a key support material used during the testing workshops. They 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 final version of the Methods Application Cards, which form a building block of the ESMERALDA flexible methodology, is accessible via the **ESMERALDA MAES Explorer:** http://maes-explorer.eu/page/ecosystem_services_and_applied_methods .


ESMERALDA
ESMERALDA CASE STUDIES - OVERVIEW
Hungary
Germany
Azores
Sweden
Belgium
Netherlands
Czech Republic
Finland
Bulgaria
Poland
Italy
Malta
Latvia
Spain

	BELGIUM	BULGARIA	CZECHIA	FINLAND	GERMANY	HUNGARY	ITALY	LATVIA	MALTA	NETHERLANDS	POLAND	AZORES	SPAIN	SWEDEN
WS	_WS7_cs2	_WS5_cs3	_WS3_cs2	_WS8_cs2	_WS3_cs3	_WS8_cs1	_WS7_cs1	_WS3_cs1	_WS4_cs3	_WS4_cs1	_WS4_cs2	_WS5_cs2	_WS5_cs1	_WS8_cs3
Title	Mapping green infrastructures and their ES in Antwerp	Mapping and assessment of ES in Central Balkan area at multiple scales	Pilot National Assessment of Ecosystem Services	Green infrastructure and urban planning in the City of Järvenpää	Mapping ES dynamics in an agricultural landscape in Germany	Fostering pro-biodiversity business in the Bukk National Park	ES mapping and assessment for urban planning in Trento	Mapping marine ecosystem services in Latvia	Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.	ES-based coastal defense.	ES in Polish urban areas.	BALA - Biodiversity of Arthropods from the Laurisilva of Azores.	Spanish National Ecosystem Assessment	ES mapping and assessment in the Vindelälven-Juhtatdahka river valley
MAES status	Stage 1	Stage 2	Stage 2	Stage 1	Stage 3	Stage 2	Stage 2	Stage 1	Stage 2	Stage 3	Stage 2	Stage 1	Stage 1	Stage 2
Scale	Local	Regional	National	Local	Local/Regional	Local	Local	National	Local-regional	Local	Local-(regional)	Local	National (Local)	Sub-national
Case Study coordinator	Liekens, I.; Broekx, S. (VITO)	Nedkov, S; Borisova, B. (NIGGG-BAS)	Vačkář, D. (CVGZ)	Kopperoinen, L.; Viinikka, A. (SYKE)	Burkhard, B (LUH); Kruse, M.; Muller, F, (CAU)	Arany, I.; Kuslits, B. (MTA ÖK), Kallay, T. (REC),	Geneletti, D.; Cortinovis, C.; Zardo, L.; Adem Esmail, B. (UNITN)	Ruskule, A.; Veidemane, K. (BEF)	Balzan, M. (MCAST)	van Beukering, P. (VU)	Mizgajski, A; Łowicki, D. (UPOZ)	Borges, Paulo A.V.; Picanço, A.; Gil, A. (GBA-cE3c)	Santos, Martin F. (UAM)	Svensson, J. (SLU), Östergård, H.; Inghe, O. (SEPA)
Supporting experts	Adem Esmail, B.; Geneletti, D.	Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Liekens, I.; Broekx, S.; Łowicki, D.; Brander, L..; Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Adem Esmail, B.; Geneletti, D.	Adamescu, M.; Balzan, M.; Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Adem Esmail, B.; Geneletti, D.		Nedkov, S.; Adem Esmail, B.; Geneletti, D.	Ostergard, H.; Inghe, O.; Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Weibel, B.; Nedkov, S.; Viinikka, A.; Pitkanen, K., Adem Esmail, B., Geneletti, D.	Liekens, I.; Broekx, S.; Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Viinikka, A.; Pitkanen, K..; Adem Esmail, B.; Geneletti, D.	Adem Esmail, B.; Geneletti, D.
Ecosystem Service 1	Filtration/(sequestration/storage/)accumulation by ecosystems (Capture of fine particles) (2.1.2.1)	Surface water for drinking (1.1.2.1)	Surface water for drinking (1.1.2.1)	Educational (3.1.2.2)	Plant-based [energy] resources (1.3.1.1)	Animals reared to provide nutrition, fibers and other materials (1.1.1.2, 1.2.1.2)	Microclimate (and regional) regulation (2.3.5.2)	Wild plants, algae and their outputs (1.1.1.3)	Reared animals and their outputs (1.1.1.2)	Flood protection (2.2.2.2)	Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)	Pollination and seed dispersal (2.3.1.1)	Cultivated crop (1.1.1.1)	Reared animals and their outputs (CICES classes 1.1.1.2)
Applied METHOD 1	Spatial proxy methods	Process-based models / SWAT	Value (benefit) transfer	Participatory GIS	Spatial proxy methods	Spatial proxy methods (rule-based matrix)	Process-based models	Spatial proxy methods	Preference Assessment	Missing	Spatial proxy methods	Macro-ecological models	Market-based methods	Participatory GIS
Alternative METHOD 1			Netfactore income		Replacement cost				Spreadsheet method	Process based modelling / KINEROS	Replacement cost			

	BELGIUM	BULGARIA	CZECHIA	FINLAND	GERMANY	HUNGARY	ITALY	LATVIA	MALTA	NETHERLANDS	POLAND	AZORES	SPAIN	SWEDEN
WS	**_WS7_cs2**	**_WS5_cs3**	**_WS3_cs2**	**_WS8_cs2**	**_WS3_cs3**	**_WS8_cs1**	**_WS7_cs1**	**_WS3_cs1**	**_WS4_cs3**	**_WS4_cs1**	**_WS4_cs2**	**_WS5_cs2**	**_WS5_cs1**	**_WS8_cs3**
Title	Mapping green infrastructures and their ES in Antwerp	Mapping and assessment of ES in Central Balkan area at multiple scales	Pilot National Assessment of Ecosystem Services	Green infrastructure and urban planning in the City of Järvenpää	Mapping ES dynamics in an agricultural landscape in Germany	Fostering pro-biodiversity business in the Bukk National Park	ES mapping and assessment for urban planning in Trento	Mapping marine ecosystem services in Latvia	Assessing and mapping ES in the mosaic landscapes of the Maltese Islands.	ES-based coastal defense.	ES in Polish urban areas.	BALA - Biodiversity of Arthropods from the Laurisilva of Azores.	Spanish National Ecosystem Assessment	ES mapping and assessment in the Vindelälven-Juhtatdahka river valley
Ecosystem Service 2	Physical and intellectual interactions with environmental settings (3.1.1.2)	Aesthetics (3.1.2.5)	Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)	Integration of GI and ES for infill development	Buffering and attenuation of mass flows (2.2.1.2)	Touristic attractiveness of nature (3.1.1.1, 3.1.1.2)	Physical use of landscapes in different environmental settings (Recreation) (3.1.1.2)	Maintaining nursery populations and habitats (2.3.1.2)	Pollination and seed dispersal (2.3.1.1)	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)	Maintaining nursery populations and habitats (2.3.1.2)	Surface water for drinking (1.1.2.1)	Experiential (physical) use of plants, animals and landscapes (3.1.1.1 and 3.1.1.2)
Applied METHOD 2	Spatial proxy methods	Photo Elicitation Surveys	Integrated modeling frameworks	Integrated modelling framework	Integrated modeling frameworks	Spatial proxy methods (rule-based matrix)	Integrated modeling frameworks	Spatial proxy methods	Spatial proxy methods + Field data		Spatial proxy methods	Macro-ecological Models	Integrated modeling frameworks	Integrated modeling framework
Alternative METHOD 2			Value (benefit) transfer		Bayesian Belief Network			State and Transition model		Recreation based on green typology	Choice modelling			
Ecosystem Service 3			Entertainment (3.1.2.4)		Educational (3.1.2.2)			Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)						
Applied METHOD 3			Integrated modeling frameworks		Narrative assessment			Integrated modeling frameworks						
Alternative METHOD 3			Hedonic pricing method					Integrated modeling frameworks						

CASE STUDY BOOKLET

Source: groenplan antwerpen www.antwerpen.be

Mapping green infrastructures and their ES in Antwerp

June 2018

ESMERALDA partner: Vlaamse Instelling Voor Technologisch Onderzoek N.V. (VITO)

Case Study Coordinators: Inge Liekens & Steven Broekx

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Liekens, I., Broekx, S., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: MAPPING GREEN INFRASTRUCTURES AND THEIR ES IN ANTWERP prepared for “WS 7 - Testing the final methods in policy- and decision-making (I)” held in Trento, Italy, 22-25 January 2018. ESMERALDA EC H2020 Grant Agreement no. 642007.

Acknowledgement: The Greentool was developed with support of the City of Antwerp. Preparation of the booklet was supported by EU H2020 project ESMERALDA (Enhancing Ecosystem Services Mapping for Policy and Decision Making), grant agreement No 642007.

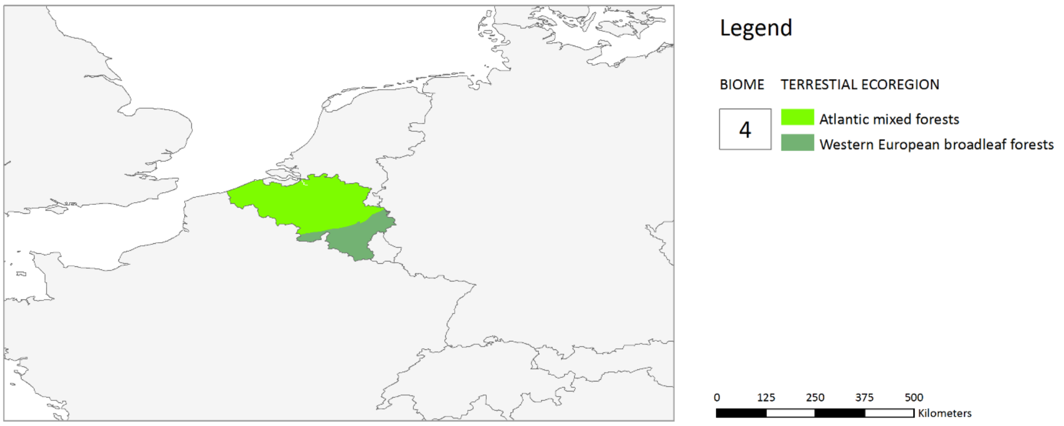
CASE STUDY FACTSHEET

Mapping green infrastructures and their ES in Antwerp WS7_cs2a

NAME AND LOCATION OF STUDY AREA	City of Antwerp
COUNTRY	Belgium

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. 200 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

1. Overview of the study area

Antwerp is the second largest city in Belgium. It has 517 000 inhabitants and a surface of 204.5 km². The city is a mix of a highly urbanized central area, with a clear shortage of available green space, some larger important conservation areas at the borders of the city, and an industrial harbour area. The tidal river Scheldt, which runs through the city, and neighbouring wetlands are also important ecosystems.

The city has the ambition to become more green (see Figure 3.4.). To achieve this purpose, a masterplan on green and blue infrastructure was developed, focusing on five "park-regions". The master plan includes large-scale restoration projects (e.g. *parkspoor Noord*: transform former railway station to urban park; *park groot Schijn*: restore a green-blue corridor and connect a large nature area to the city) and small-scale initiatives such as garden streets, green facades and urban farming. Beside this citywide strategic plan, nine local green plans at district level and one for the harbour area are currently under development or planned.

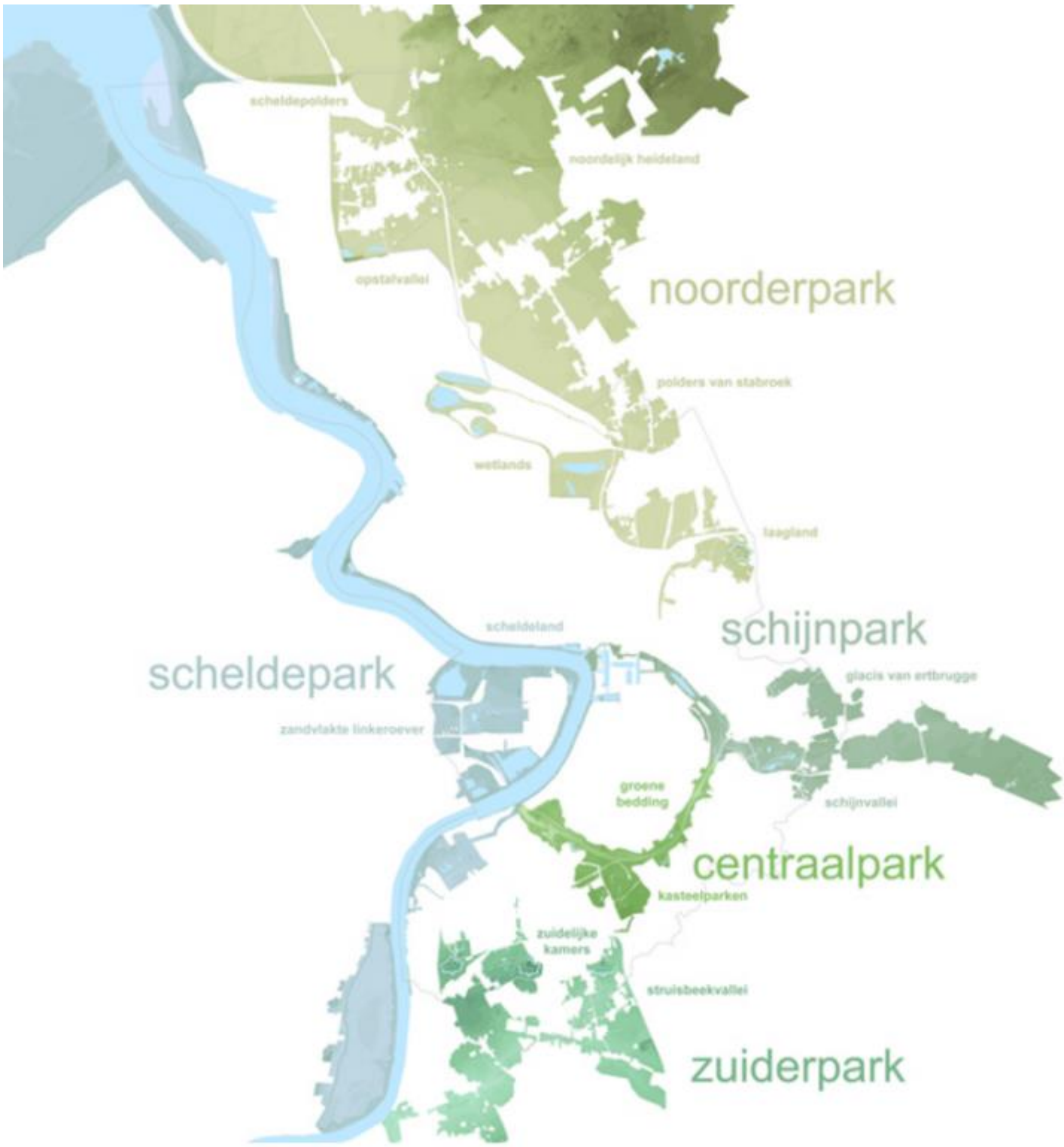


Figure 2: Key park regions and corridors in the Antwerp green masterplan

2. Questions and Themes

Establishing win-win situations for different topics simultaneously with green and blue infrastructure is a key ambition of the city and its strategy. Mapping and assessing the impacts of green infrastructure will help to achieve this. For this purpose, the city developed the ***Antwerp Greentool***, which contains different ES maps and integrated assessment tools (see https://groentool.antwerpen.be/). It is only available in Dutch but "gebiedsanalyse" is self-explanatory.

The objective of the *Greentool* is to inspire spatial planners and city officials to take smart and green measures when developing urban locations. For this purpose, it provides different sorts of information:

1) General Insights into the advantages of including vegetation and water bodies in urban developments (literature review). The degree of positive impact of various 'smart' measures can be seen on the following environmental factors:
    - Air quality
    - Heat Stress
    - Noise
    - Water management
    - Nature and Biodiversity
    - CO2-capture
    - Recreation
    - …

2) An overview of the existing environmental quality is provided allowing the existing environmental challenges to be identified (pressure maps).
- The effects of a large database of green and blue measures can be performed for each topic (expert based evaluations).
- Suggestions of interesting measures to users for locations of their interest
- The measures are applicable on different scales: street level up to city wide
- Analysis is based on cartographic information:

3) Maps presenting the impact of possible measures

The tool can be applied to benchmark sites owned by city authorities, support management plans and can be made mandatory for urban development plans to ensure spatial planners take into account environmental challenges and liveability.

The tool is inspirational. The idea is to supply easily available information (it should not take more than 1 hour), to non-expert users.

3. Stakeholders' Involvement

The development of the tool and all maps was done in close cooperation with the city authorities (department sustainable city, with focus on energy and environment). During the project, other departments such as the biodiversity department and the spatial planning department were consulted. Generally, the tool supports the development of local green plans, which involves the consultation of local citizens.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

The major ecosystem type is “Urban”. Other important habitats include forests, wetlands and grasslands. A lot of effort was invested in setting up a suitable typology of urban green infrastructure and developing a map of the current situation (see Table 2). This is based on existing morphological classifications of land use maps, green management, green infrastructure (example categories are green roofs intensive, extensive; semi-hardened surface; tree rows; SUDs; grassfield; hedges and shrubs; coniferous – broadleaved forest. We also provide 12 inspirational street images from Antwerp or other cities to roughly estimate the impact of combined measures (see examples in Figure *6.1*).

Table 2: Typology of urban green infrastructure applied for Antwerp

Level 1	**Level 2**	**Level 3**
Green roofs	Extensive Green roofs	
	Semi intensive green roof	
	Intensive green roof	
Pavements	Closed pavements	
	Semi-hardened pavement	
	Open pavements (soil, woodchips, broken fractions)	
Water and Humid Vegetation	Water	
	Humid vegetation	
	Suds	
Open vegetation	Bare soil	
	Flower meadow and herbaceous vegetation	
	Grass field, lawn	
	Heathland	
	Private gardens (low vegetation)	
	Agricultural landuse	Community gardens/kitchen garden
		Other agricultural landuse
Bushes, hedges and woodsides		
Forest	Deciduous forest	Tree height <6m; 6-12m; >12m
	Coniferous forest	Tree height <6m; 6-12m; >12m
	Mixed forest	Tree height <6m; 6-12m; >12m
	Forest edge vegetation	Tree height <6m; 6-12m; >12m
City trees	Deciduous trees	Tree height <6m; 6-12m; >12m
	Coniferous trees	Tree height <6m; 6-12m; >12m
	Mixed trees	Tree height <6m; 6-12m; >12m
	Orchard	
Facades and walls	Green walls	
Build surface		

Street typology 1: Garden street Antwerp

Street typology 2: Copenhagen water street

Figure 3. Examples of inspirational street typology

4.2. Assessing ecosystem conditions

Condition indicators:

- Land cover map taking into account a tree inventory and the presence of green roofs (proportions of land use)
- Biodiversity: identification of key protected areas and corridors.

Pressure indicators:

- air quality (yearly average concentrations EC, Nox, PM10, PM2,5 in µg/m³)
- noise hindrance (dB)
- urban heat (radiation temperature during a heat event in °C)
- flood risk pluvial flooding (risk: non critical risks < T 20years; low critical T 20 years; highly critical T 5 years; very critical T 2 years)
- areas with shortage local green (m² of green area per inhabitant)

4.3. Selecting Ecosystem Services

The ES were selected based on expert knowledge and relevance for the city authorities. Table 1 lists the selected ES, classified using the CICES v4.3 (2013) classification, and related assessment method categories.

Table 3. Overview of the ES and related mapping and assessment methods in the Antwerp case study

Ecosystem Service selected for mapping and assessment	B	S	E
2.3.5.1 Global climate regulation by reduction of greenhouse gas concentrations	X		
2.3.5.2 Micro and regional climate regulation	X		
2.1.2.3 Mediation of smell/noise/visual impacts	X		
2.1.2.1 Filtration/sequestration/storage/accumulation by ecosystems*	X		
2.2.2.1 Hydrological cycle and water flow maintenance	X		
3.1.1.2. Physical use of land- /seascapes in different environmental settings*	X		

* ES selected for further discussion during ESMERALDA workshops 7 in Trento;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

An expert based scoring table was applied to map the impact of measures (tier 1). This was combined with outcomes from process based models for modelling pressures (tier 3 for noise, urban heat island effect, air quality, risk for pluvial flooding; tier 1 for recreation) to identify interesting locations for green infrastructure.

Impact calculation:

*impact_measures = pressure * (impact_score measure – impact_score existing situation)*

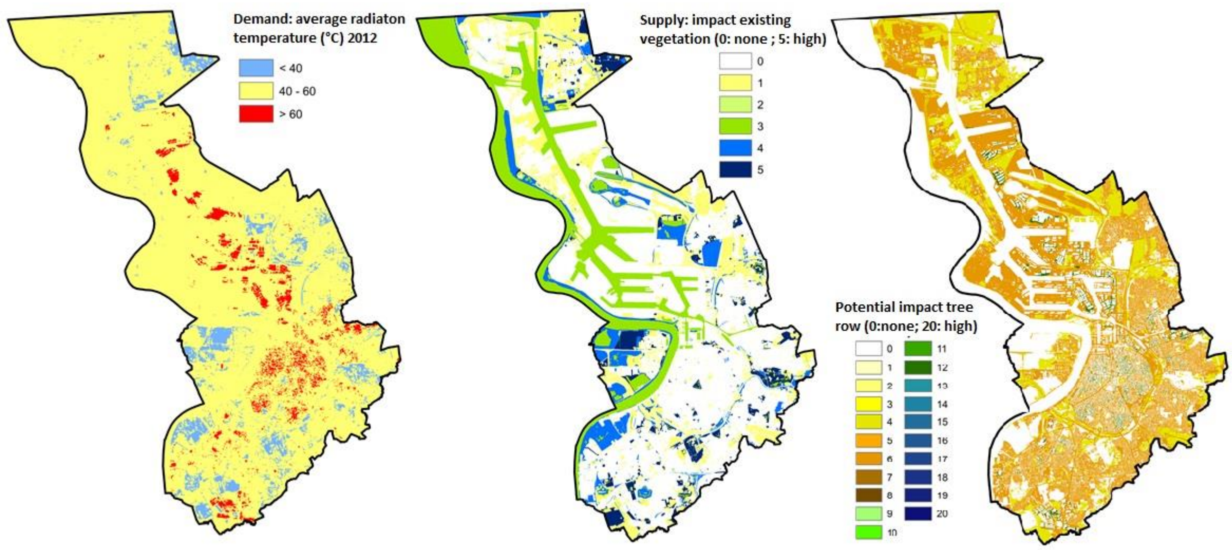


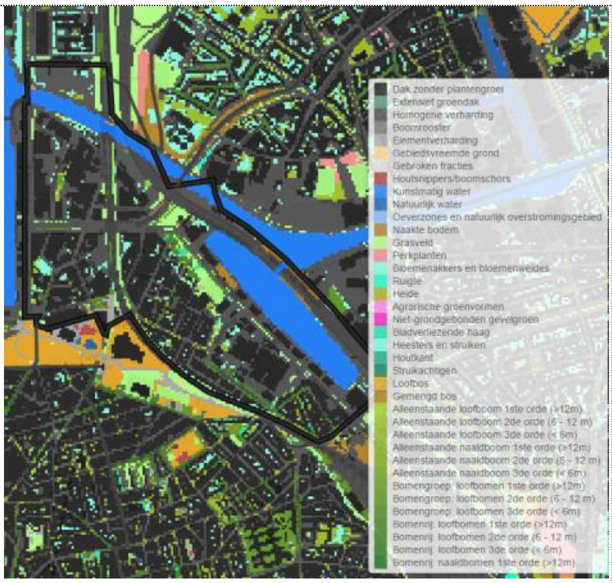
Figure 4: ES maps for heat stress in Antwerp. Supply from existing vegetation and water is scored from none (0) to maximal (5). Based on a heat map of the city and population densities the demand is mapped leading to zones with varying degrees of impact vegetation. Taking into account the current supply and demand, the potential for green measures is calculated, and scored from no potential (0) to maximal potential (20).

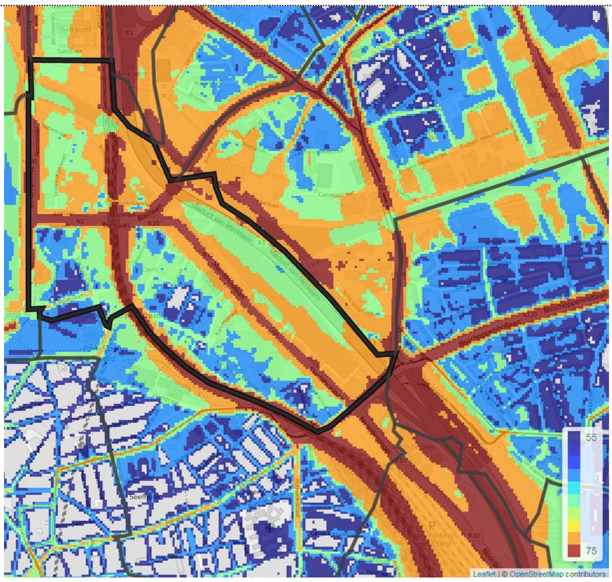
5.2. Integration of ES mapping and assessment results

To allow an easy overview on the condition (land use distribution, pressures)**,** the *Greentool* allows users to select an area and get a quick overview (star diagram) of all the pressures. This information, in combination with other data such as the presence of buildings, **street canyons**, open spaces to assess the suitability of the area to implement specific measures, allows to assess the impact of specific types of measures.

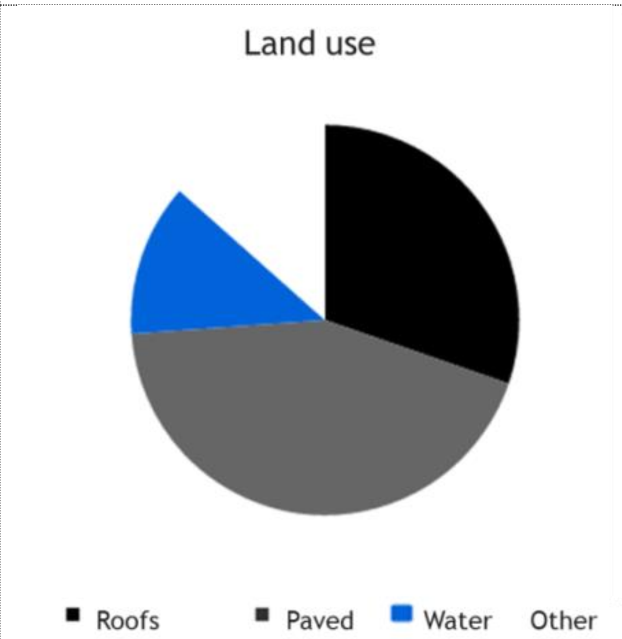
5.2.1. Applying the Greentool

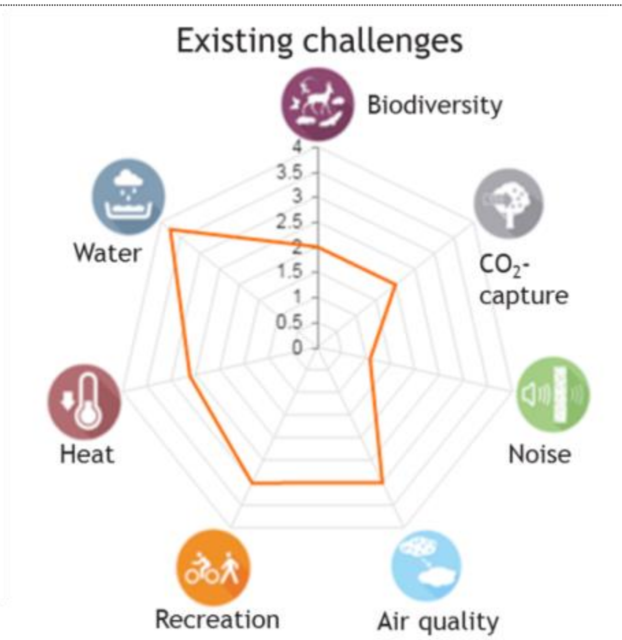
Step 1: Select an urban area in an interactive map: noise map with noise levels in dB and selection of an area (left) and land use - buildings, infrastructure, vegetation, water etc. (right).



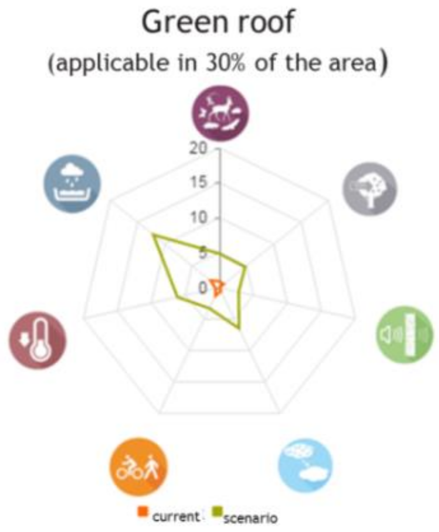


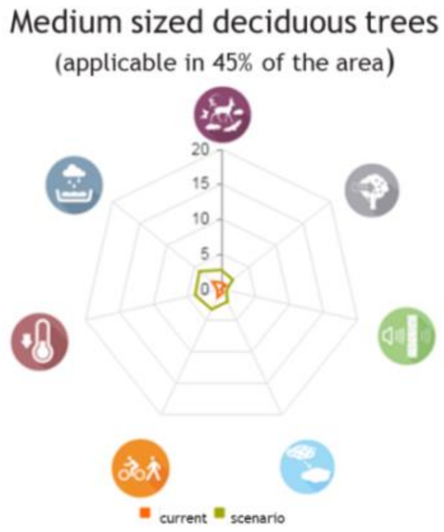
Step 2: Analyse current situation for selected area: land use composition - existing pressures





Step 3: Assess the suitability and impact to install specific types of green infrastructure in this area





6. Implementation

General feedback of users given on the existing methodologies is that a quick feedback on identification of the pressures in the selected area is very relevant and of high added value. Impact calculation of the measures and top five list of most suitable measures could improve.

The general challenge remains on improving the usability of maps and assessments for selecting suitable building blocks for local green plans.

General expert question: Is it sufficiently credible? Yes/no? Where do you see major knowledge gaps and challenges for further improvement? How to bridge the gap with spatial planners?

This general question is split into the following five groups of specific questions found in annex:

- Typology
- Selection of indicators
- Impact calculation
- Integrated assessment
- Communication of results and use

7. References & Annexes

References

https://groentool.antwerpen.be

https://www.natuurwaardeverkenner.be/

Annexes

Table 4: Biophysical ranges as a baseline for expert based evaluation of impact green infrastructure

Score	Heat stress reduction	Air quality improvement	Noise buffer	kg C seq. per year per m²	Recreation & Amenity
5	-2°C	> 15% improvement local air quality	>=10 dBA	0.79 - 1.18	High visibility and a lot of evidence positive impact on amenity, recreation
4	-1.5°C	> 10%	>=5 en <10 dBA	0.74 - 1.08	High visibility and some evidence positive impact
3	-1°C	> 5%	>=3 en <5 dBA	0.45 - 0.79	Average visibility (low vegetation), some evidence positive impact
2	-0.5°C	> 1%	>=1 en <3 dBA	0.40 - 0.74	Low visibility, some evidence positive impact
1	-0.5 tot 0°C	< 1% improvement	>0 en <1 dBA	0.05 - 0.40	Low visibility, very little evidence positive impact
0	no impact	no improvement	0 dBA	< 0.05	No impact
-1		negative	< 0dBA	n.a.	n.a.

Table 5: Impact scores major types green infrastructure elements (expert based)

Green infrastructure element	Heat	Air quality open	Air quality - canyon	Air quality - buffer	Noise	Carbon seq.	Biodiversity	Water	Amenity and recreation
Extensive Green roofs	1	0	0	0	4	1	1	3	0
Semi intensive green roof	2	1	1	1	4	2	2	3	1
Intensive green roof	3	2	2	2	4	3	3	4	1
Closed pavements	0	0	0	0	-1	0	0	0	0
Grass dales	1	0	0	0	2	0	2	2	0
Broken fractions	1	0	0	0	1	0	0	3	0
Wood chips	1	0	0	0	2	0	0	3	0
Water	3	0	0	0	-1	0	4	5	4
Humid vegetation and wetlands	4	0	0	0	1	1	5	4	3
SUDS	2	0	0	0	0	1	3	5	3
Bare soil	1	0	0	0	0	0	1	3	2
Grass field	1	0	0	0	2	1	3	5	3
Flower meadow	1	0	0	0	3	1	5	5	3
Heathland	1	0	0	0	3	1	5	5	3
Agriculture	1	0	0	0	3	1	3	5	3
Green walls	1	1	1	1	3	1	1	1	2
Hedges	2	1	-1	1	3	2	1	4	3
Shrubs	2	1	n.a.	2	2	2	4	5	4
Deciduous forest	5	3	n.a.	5	4	5	4	5	5
Forestedge vegetation	1	1	n.a.	1	2	2	5	5	5
City tree deciduous(>12m)	2	2	-1	2	1	4	4	4	4
City tree deciduous (6 - 12 m)	1	1	-1	2	1	3	4	3	3
City tree deciduous (< 6m)	1	1	-1	2	1	2	3	3	3
Biodiversity friendly building elements	0	0	0	0	0	0	4	0	0

Specific expert questions to be discussed during workshop:

a) Typology of green (land cover map):

Expert questions:

- Do you have suggestions on how we can incorporate tree canopy data and information of private gardens? What are suitable data layers and methodologies?
- How to deal with two-dimensional information? (tree crown versus soil coverage, green walls)
- Scale: what is an appropriate scale for the line of questioning? Is 10x10m sufficiently detailed?

b) Indicator selection

Expert questions:

- Are the applied indicators suitable for the objective of the tool?
- Do you see important topics missing?
- Are the applied indicators good to assess the pressures for the different topics? Do you have alternative suggestions?
- Does including biophysical, social and economic valuation add value to the evidence base for the decision making process? If yes, how and how to approach this?

c) Impact calculation

Large simplification of impact calculation due to lack of knowledge and calculation complexity. Assessment of quantitative impacts of process-based models is not an option (scenarios). Biophysical (e.g. tonnes), social and economic valuation was not expressed as a need by the users.

Expert questions:

- Impact calculation depends heavily on the local pressure in the existing methodology (cell values). Is this problematic? Do you know methodologies to overcome these problems? And do you have good examples? (E.g., distance decay functions)
- Can/should we standardize scores based on the importance of the impact? (e.g. in terms of health)
- Diversity on impact of measures can be large between different species (e.g. tree species). Is credible information available on this? Where can we find this information?
-

d) Prioritization of measures / integrated assessment

The star diagram is used to demonstrate the integrated impact on different topics.

Expert questions:

- What your feeling is about these star diagrams? Does it answer the need of the tool?
- Do you see possible improvements? Do you have inspirational examples?

e) Communication of results and use

The tool is intended to be used on a voluntary basis. As many small projects are happening where it is not feasible to do detailed model calculations/scenario analysis on specific topics, this tool can serve as an explorer to assess small-scale impacts of urban greening. Additionally, it needs to help to identify priority areas on a city scale. Inspiration is an important key word. Not decision.

Target audience: city administrations, consultancies, urban planners, citizen organizations.

Multi-scale application:

- Project level/street level: Design book management of public spaces – can a sustainability check be built in the building code to underpin selection of measures?
- City level: where are the top five locations to install green roofs?
- What is the contribution of projects, specific measures, to sustainable development goals?

Time foreseen for use: the idea is that the user gets feedback within 1 hour.

Expert questions:

- Does the intended use corresponds with the tool set up? Do you see issues?
- Do you see other potential uses to support decision-making?
- Do you have other examples where similar tools are used in a similar context?
- How to improve usability? How to improve the process organization and the inclusion of the tool / maps in this?
- What can we learn from social valuation/participatory techniques in this perspective?

METHOD APPLICATION CARD: SPATIAL PROXY METHOD (EXPERT SCORING) Applied to: Filtration, sequestration/storage/accumulation by ecosystems (2.1.2.1)	
CASE STUDY	BELGIUM: Mapping green infrastructures and their ES in Antwerp
SCALE	Local
TYPE	Biophysical
TIER	1
DESCRIPTION	
A list of possible green measures is assembled. Experts are questioned to give a score on the rate (between 0 and 10) a certain green measure supplies a certain ecosystem service (in this example capturing capacity of fine particles by green). This score is combined with pressure maps (air quality PM10 concentrations) based on process based models	
1. DATA REQUIREMENT	
Qualitative	• Score per green measure
Quantitative	
2. RESOURCES REQUIREMENT	
Time	• Low to medium time (survey set up and literature research). Process based model: very high
Cost	• low
Expertise	• Expert survey
Tools & equipment	• /
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Scores can be linked to biophysical quantification methods (kg of PM10 captured yearly) (multiplication)
Socio-cultural	• Participative approaches: scores can be used in discussions with stakeholders
Economic	• Replacement cost approach or social cost method has been applied in some studies
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	• Air quality experts working particularly on PM emissions and capturing by green
Non-academic stakeholders	
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly appropriate, but more quantitative methods can be used.
Regional	• Appropriate.
National	• Appropriate.
Pan European	/
6. EXAMPLES OF POLICY QUESTION	
	• Which green measures are best to lower the pressure of bad air quality due to fine particles in the city? • At which location in the city these green measures are best taken? • Where is the demand for capturing fine particles the highest? Where is air quality a severe pressure?
Suggested Citation: Liekens, I., Broekx, S., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD (EXPERT SCORING) applied to "Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: SPATIAL PROXY METHOD (EXPERT SCORING) Applied to: Physical and intellectual interactions with environmental settings (3.1.1.2)	
CASE STUDY	BELGIUM: Mapping green infrastructures and their ES in Antwerp
SCALE	Local
TYPE	Biophysical
TIER	1
DESCRIPTION	
A list of possible green measures is assembled. Experts are questioned to give a score (between 0 and 10) on the rate a certain green measure supplies a certain ecosystem service. The score for recreation is the average of 3 expert scores for visibility, naturalness of vegetation and attractiveness for recreation. The visibility score for green infrastructures that are less visible from public places (e.g. green roofs) get a low score, whereas big trees that are visible from a longer distance get the highest score. As naturalness is an important element for the attractiveness of green landscapes, more natural vegetation (wetlands) types get a higher score. The score for attractiveness for zero for non-accessible areas (e.g. green roofs), lawns and low vegetation get a middle score whereas vegetation types that were identified in literature as very attractive, such as forests or natural waters get a high score. Also individual trees get a higher score, as they mitigate visual intrusion. It has to be noted that the score does not account for size of the area or scarcity (e.g. important for parks) and population density. These scores were combined with a pressure map on the availability of green space for recreation. This pressure map was created by clustering the available accessible green within 400m of inhabitants using a national land use map (10x10m), green map and tree map of the city of Antwerp. On this map hot spots and cold areas could be detected. This cold areas could be linked to possible measure to lower the shortage of available green for recreation in a certain neighbourhood	
1. DATA REQUIREMENT	
Qualitative	• Score per green measure based on attractiveness
Quantitative	• Available green space within 400m of home location, based on a detailed LU-map (10x10m).
2. RESOURCES REQUIREMENT	
Time	Low to medium time (survey set up and literature research) Land use map costs time to set up using with small green elements in cities (resolution).
Cost	Low to high (depending on available LU data)
Expertise	Expert surveys (expert score tables for attractiveness green elements) + GIS
Tools & equipment	GIS
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Combined scores (multiplication) based on pressure maps showing the available green within 400m of inhabitants and the attractiveness of urban green elements
Socio-cultural	• Participative approaches: scores can be set up based on discussions with stakeholders
Economic	• Travel cost and contingent valuation studies can be used to monetize this ecosystem service.
4 COLLABORATION LEVEL	
Researchers own field	• Expertise in cultural services/recreation
Researchers other fields	• Experts in GIS;
Non-academic stakeholders	• Possible interaction with non-academic stakeholders on accessibility of green in the neighbourhood.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly appropriate, but the availability can further be translated to number of visits
Regional	• Appropriate.
National	• Appropriate.
Pan European	/

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

Suggested Citation: Liekens, I., Broekx, S., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD applied to “Physical and intellectual interactions with environmental settings (3.1.1.2)”. ESMERALDA EC H2020 Grant Agreement no. 642007.

Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

CASE STUDY BOOKLET

(Picture by Petar Nikolov)

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

June 2018

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

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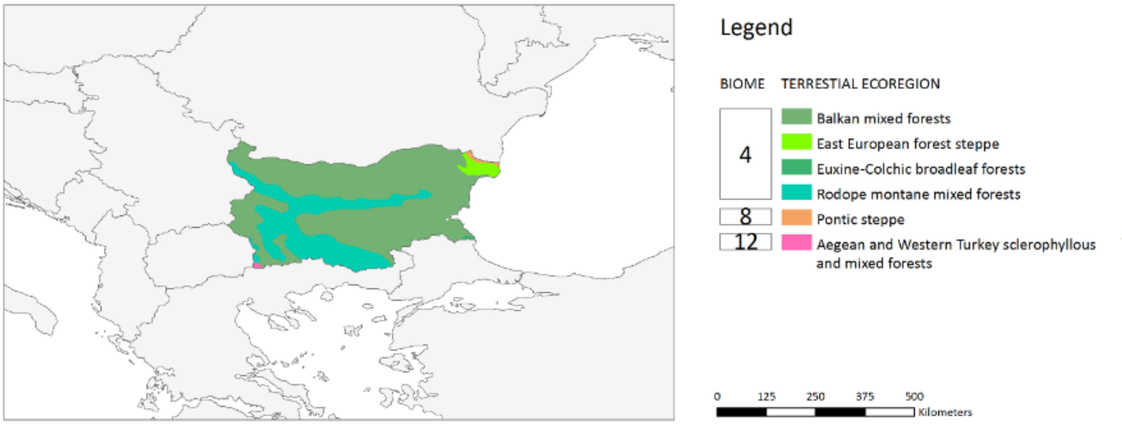
CASE STUDY FACTSHEET

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

1. Overview of the study area

The study area is located in Central Bulgaria and covers the central part of the Balkan Mountains (Stara Planina) and the surrounding areas (Figure 4.1). 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°C to 10.0°C in Troyan and decrease to 0.7°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.

2. Question and Themes

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:

- 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).
- 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).
- 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.
- 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).
- 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.

3. Stakeholders' Involvement

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).

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 4.1) – 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.

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 4.1). 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.

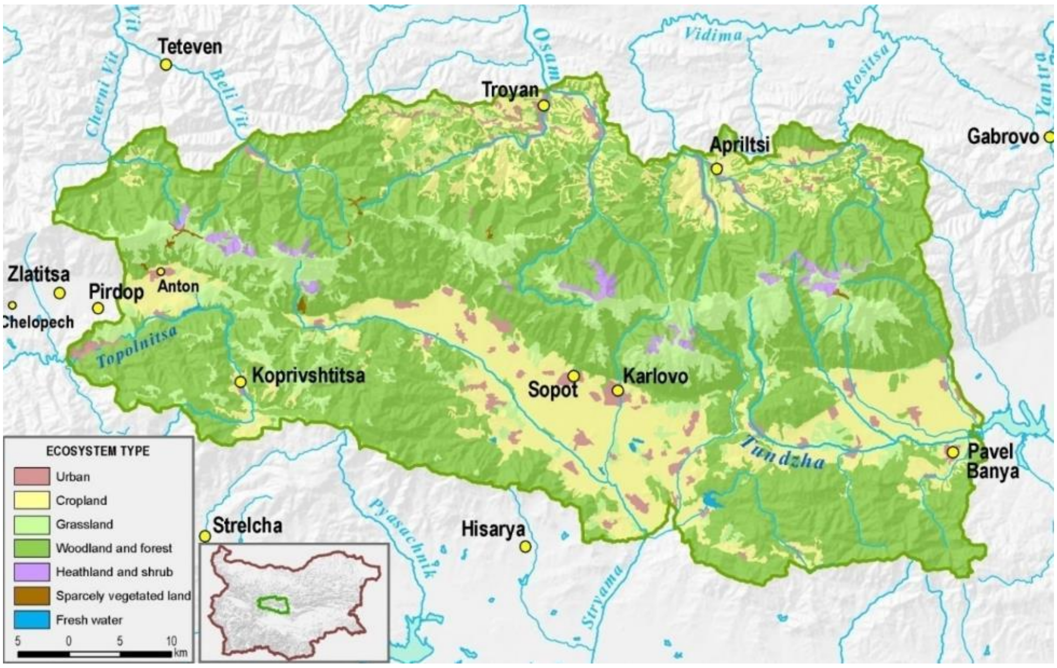


Figure 4.1. *Ecosystem types in Central Balkan case study area*

Table 4.1. 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 4.2).

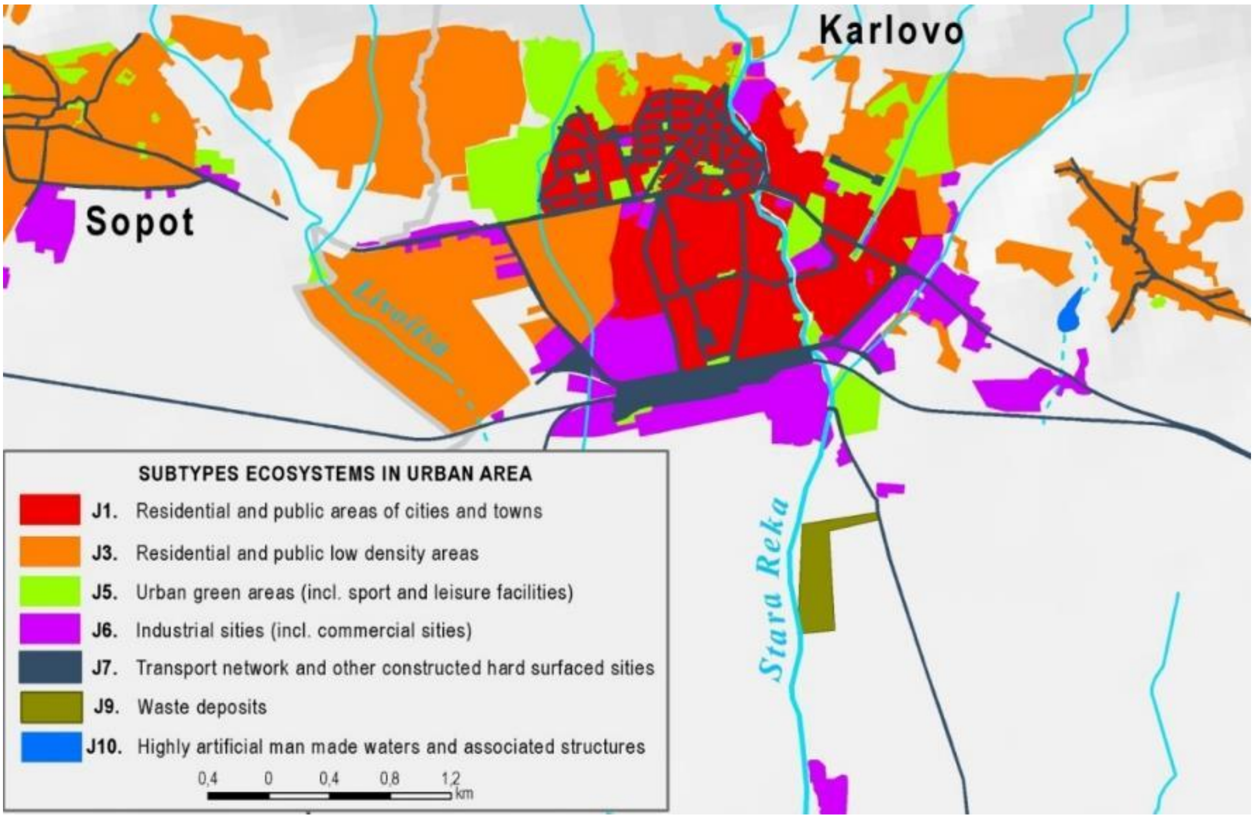


Figure 4.2. Urban ecosystem subtypes in the city of Karlovo.

4.2. 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 6.3.

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 4.3).

Table 4.2. 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

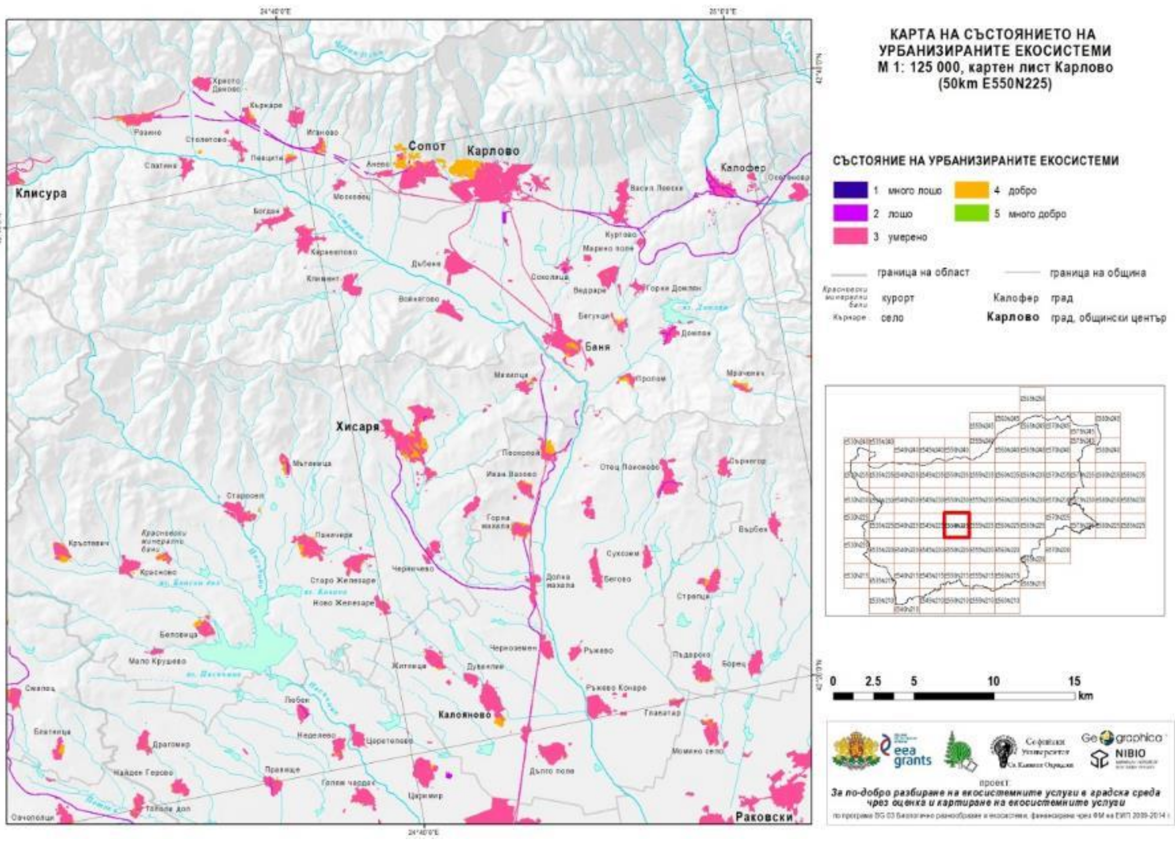


Figure 4.3. Condition of urban ecosystems in Karlovo map sheet (The area of the Central Balkan case study falls within two map sheets – E550N220 and E550N225).

4.3. Selecting Ecosystem Services

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: Annexes

Table 8.1). 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 4.3). 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 4.3. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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.

5.1.1. 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 5.1).

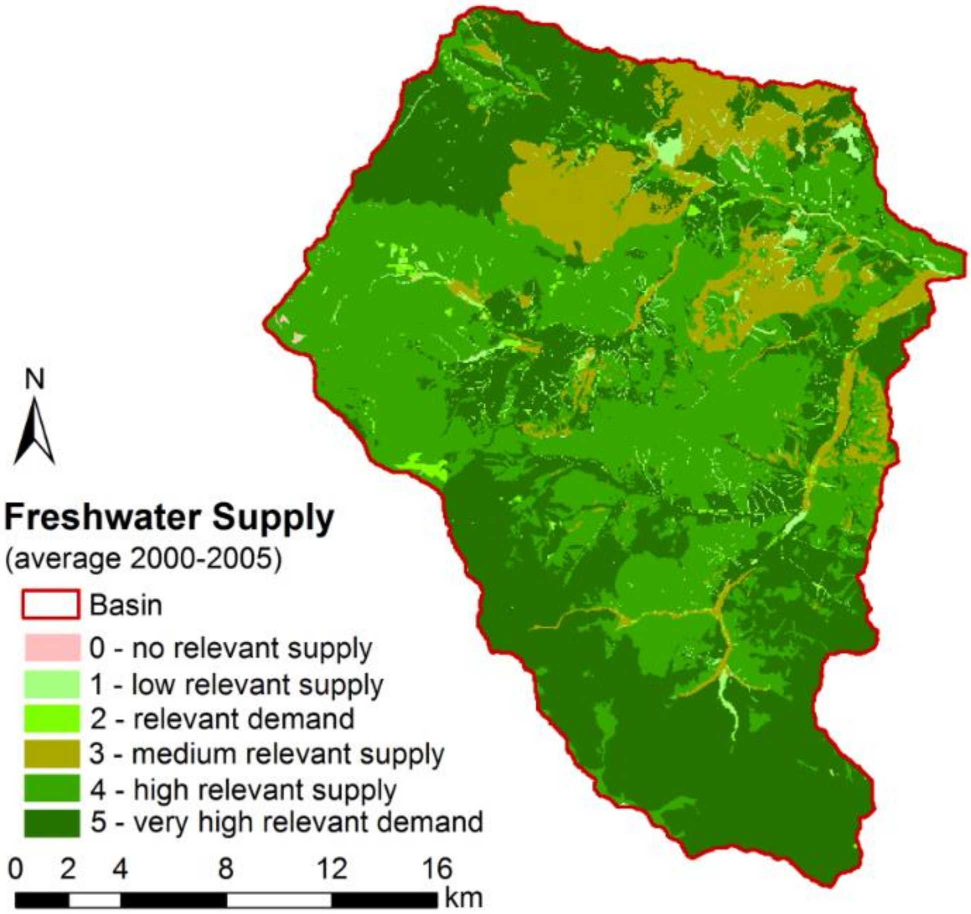


Figure 5.1. Fresh water supply in upper Ogosta river basin.

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).

5.1.2. 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.

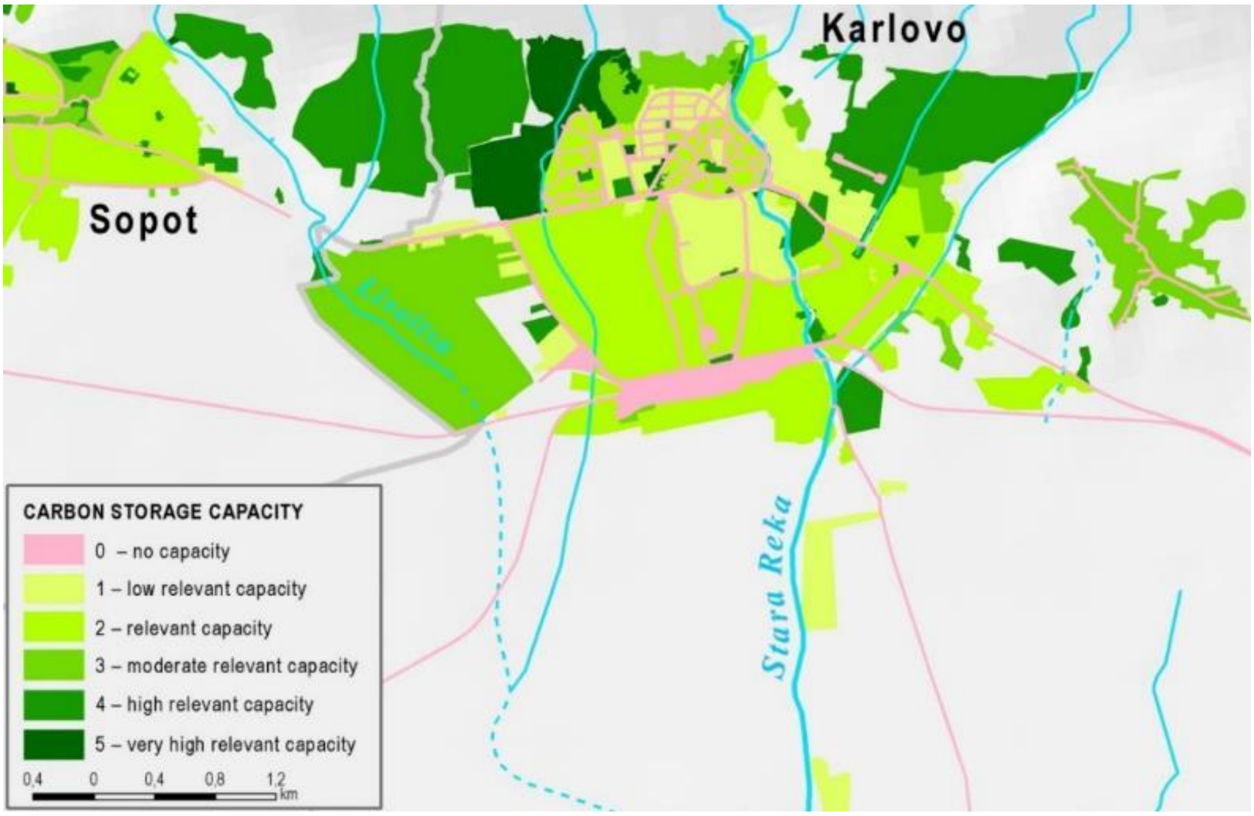


Figure 5.2. Global climate regulation supply capacity of the urban ecosystems in the city of Karlovo.

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).

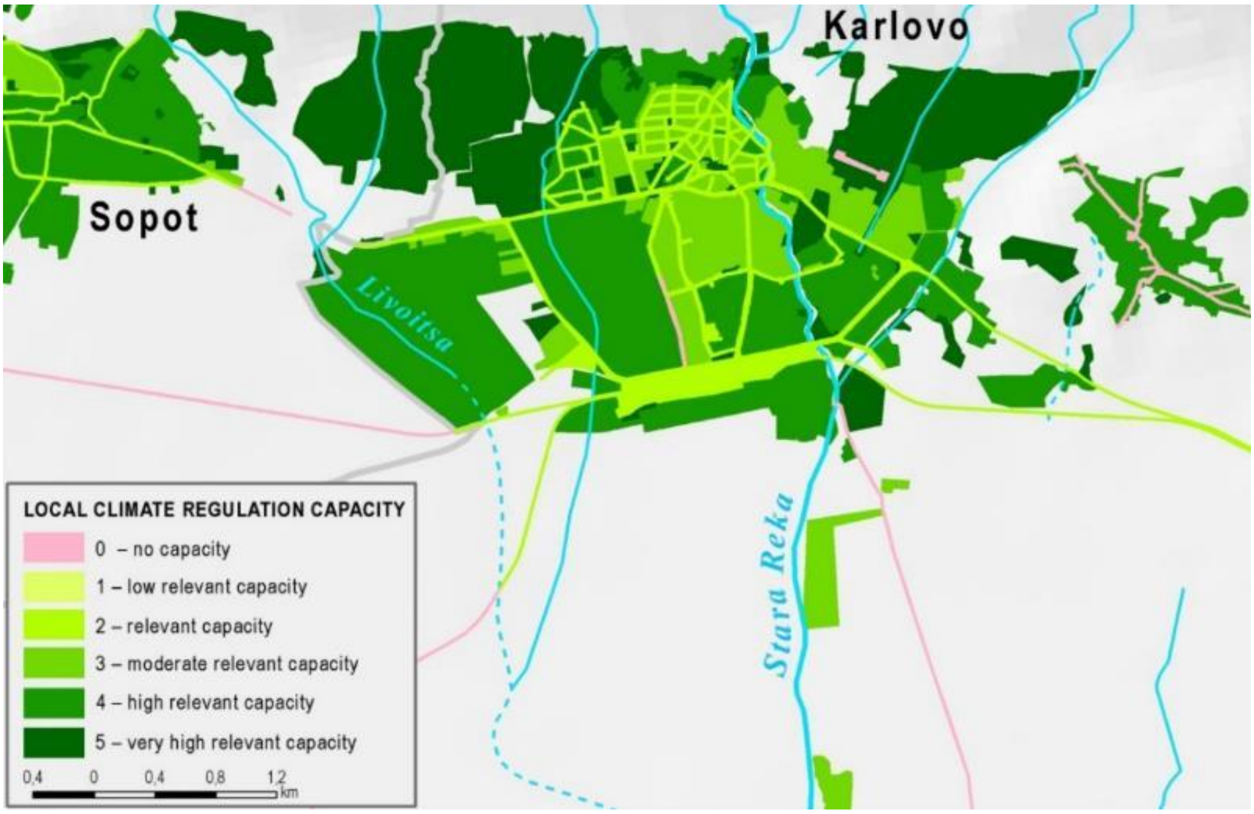


Figure 5.3. Micro and regional climate regulation supply capacity of the urban ecosystems in the city of Karlovo.

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.

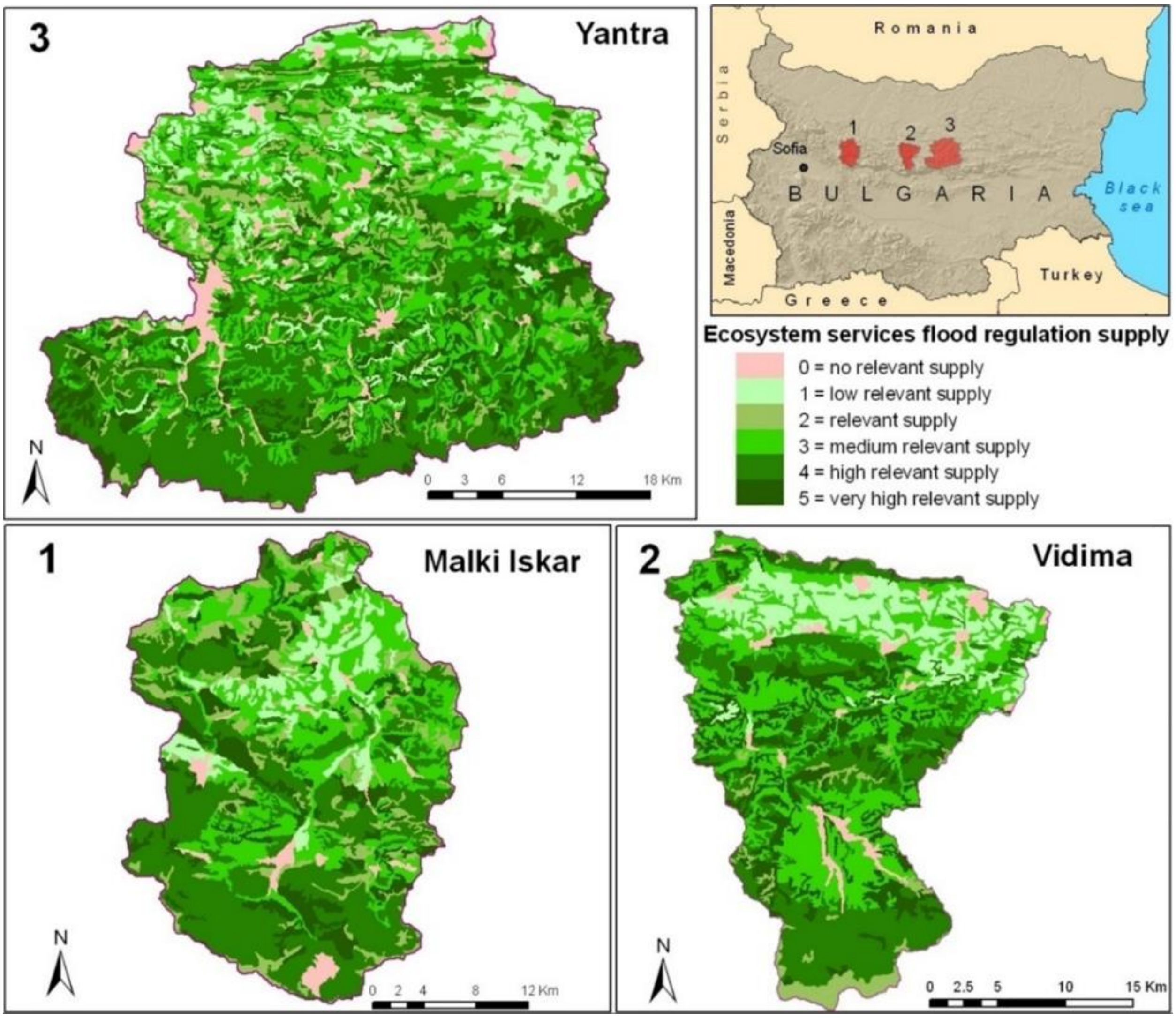


Figure 10. *Flood regulation supply capacity in three watersheds of Central Balkan area*

5.2. Socio-cultural methods for ES mapping and assessment

Social methods for mapping and assessment were applied only for cultural ES in the framework of TUNESinURB project.

5.2.1. 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 5.4, 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.

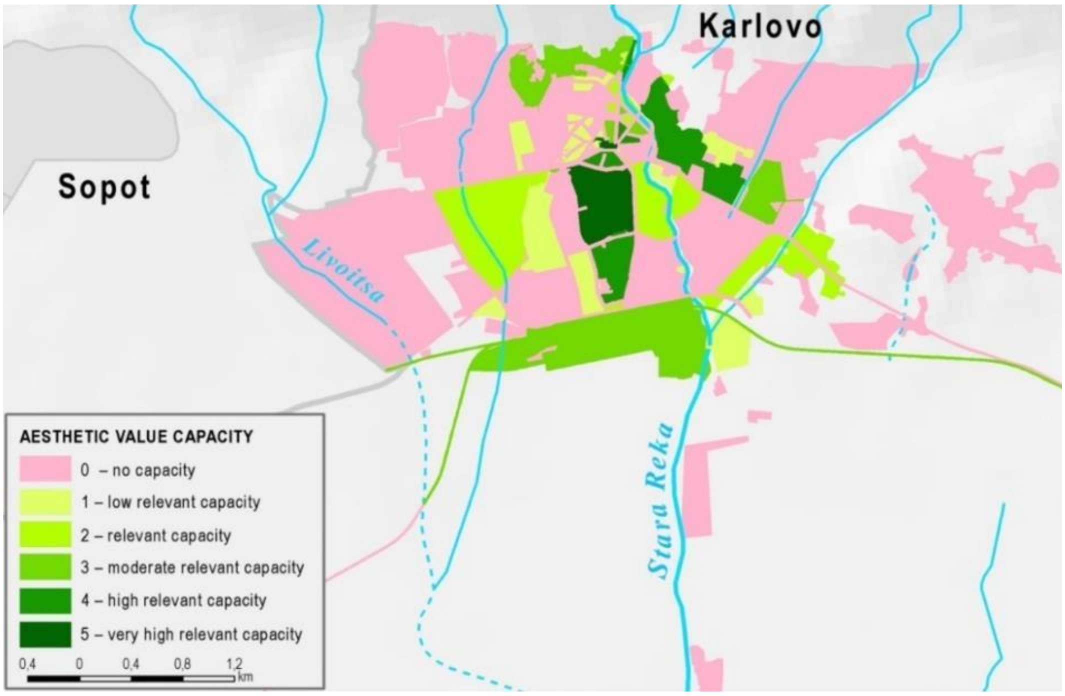


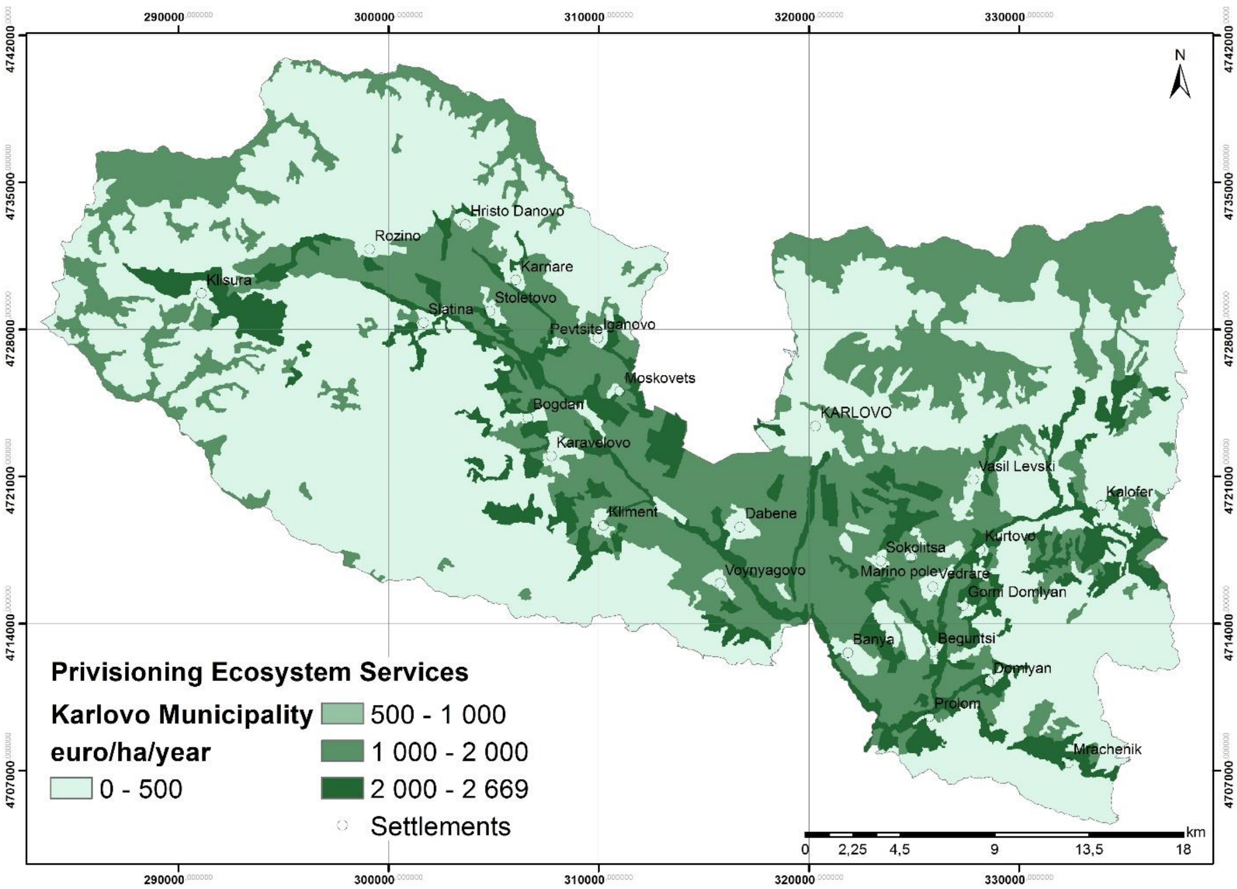
Figure 5.4. Aesthetic value of urban ecosystems in the city of Karlovo.

5.2.2. Economic methods for ES mapping and assessment

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, and 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.

5.2.3. 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.



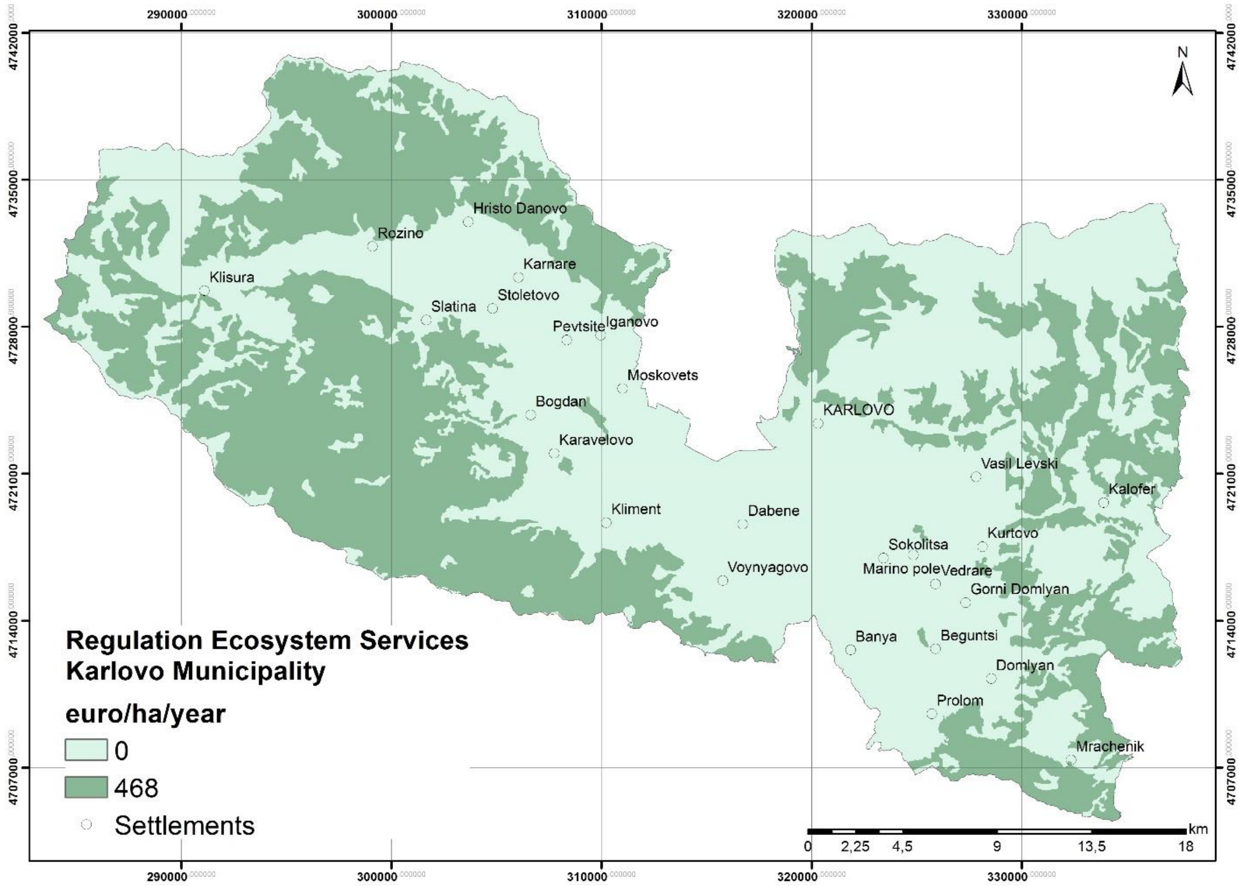
5.2.4. Mapping of regulating and maintenance services

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.

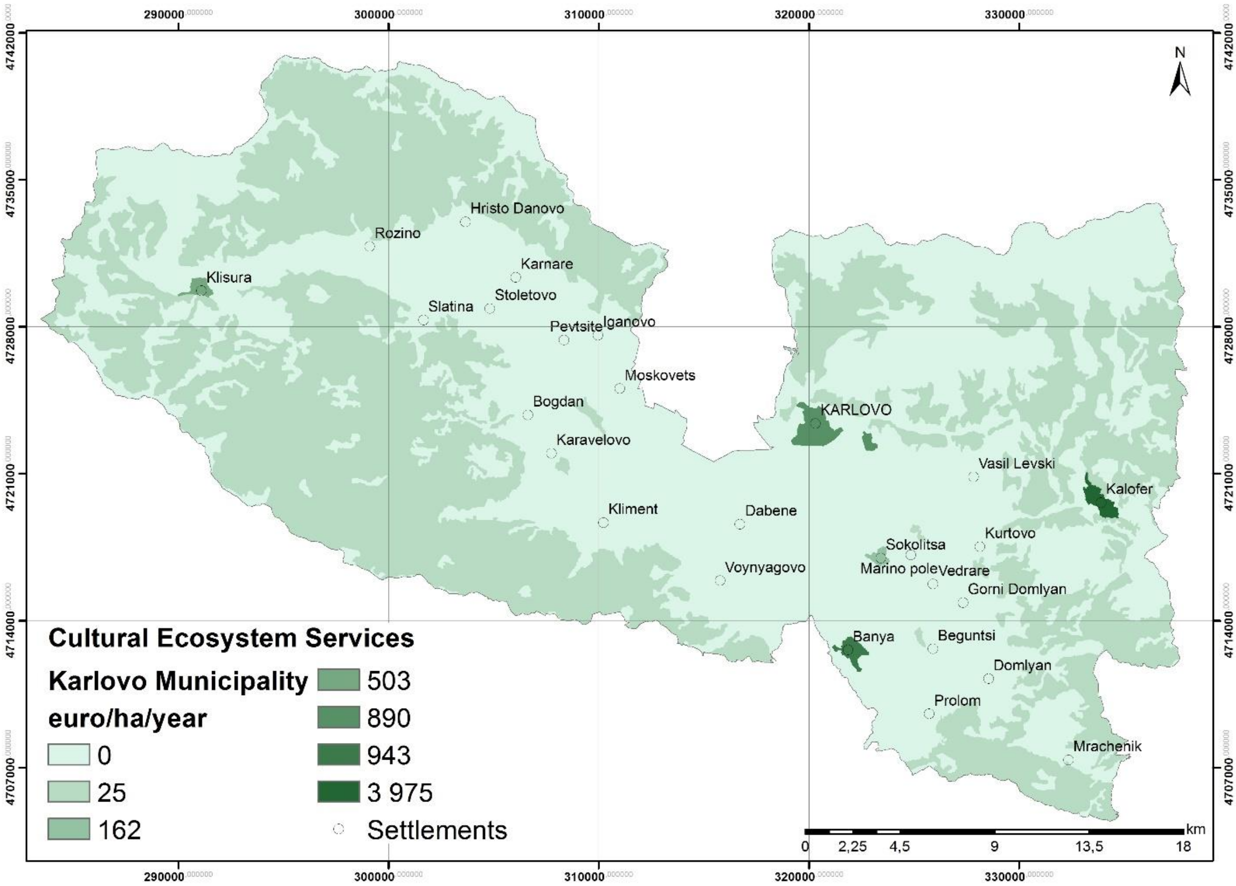


5.2.5. Mapping of cultural Services

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)



5.3. Integration of ES mapping and assessment results

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.

6. Dissemination and communication

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.

7. Implementation

The flood regulation ES as a part of nature based solution was proposed as an alternative choice to the traditional measures that include building or reinforcing existing dykes and dams. It was included in the preparation of the Karlovo municipality management plan. Ecosystem services provided by forests are already part of the legislation in forestry sector. The management plans at regional level should have maps of 9 ecosystem services provided by forests.

8. 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 8.1. *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)

METHOD APPLICATION CARD: PROCESS BASED MODELS (SWAT) Applied to: Surface water for drinking purpose (1.1.2.1)	
CASE STUDY	BULGARIA: Mapping and assessment of ES in Central Balkan area in Bulgaria at multiple scales
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	• Could be applied together with surveys for assessment of the demand side
Economic	• Could be linked to valuation of drinking water
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Low
Non-academic stakeholders	• Low
5. SPATIAL SCALE OF APPLICATION	
Local	• Applicable
Regional	• Mostly applicable
National	• Possible but not tested so far and the cost could be too high
Pan European	• Not applicable
6. EXAMPLES OF POLICY QUESTION	

	• What are the areas of water supply that should be under protection regime? • Does water supply meets the demand for water?
Suggested Citation: Nedkov, S., Borisova, B., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PROCESS-BASED MODELS (SWAT) applied to "Surface water for drinking purpose (1.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: PHOTO ELICITATION SURVEYS **Applied to: Aesthetic (3.1.2.5)**	
CASE STUDY	BULGARIA: Mapping and assessment of ES in Central Balkan area in Bulgaria at multiple scales
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
6. EXAMPLES OF POLICY QUESTION	
	• Which green spaces are most attractive for tourism? • Which urban ecosystems have high attractiveness? • What is the relation between the areas with high aesthetic value and the quality of life?
Suggested Citation: Nikolova, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PHOTO ELICITATION SURVEYS applied to "Aesthetics (3.1.2.5)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

ESMERALDA

CASE STUDY BOOKLET


(Picture by Miroslav Hátle)

Czech Republic Pilot National Assessment of ES

June 2018

ESMERALDA partner: Global Change Research Institute (CVGZ)

Case Study Coordinators: David Vačkář

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Vačkář, D., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: CZECH REPUBLIC PILOT NATIONAL ASSESSMENT OF ES prepared for "WS3 - Testing the methods across Europe" held in Prague, Czechia, 26-29 September 2016. ESMERALDA EC H2020 Grant Agreement no. 642007.

Acknowledgement: Preparation of the booklet was supported by EU H2020 project ESMERALDA (Enhancing Ecosystem Services Mapping for Policy and Decision Making), grant agreement No 642007, and by the Ministry of Education, Youth and Sports of the Czech Republic as part of the National Sustainability Programme I (NPU I), grant number LO1415.

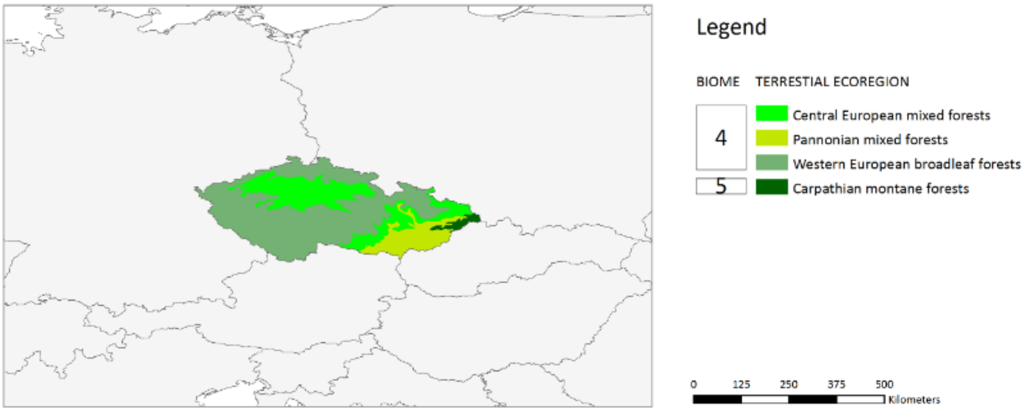
CASE STUDY FACTSHEET

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

1. Overview of the study area

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 (north eastern part) and the Danube River (south eastern part). As shown in Figure 3.6, 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.

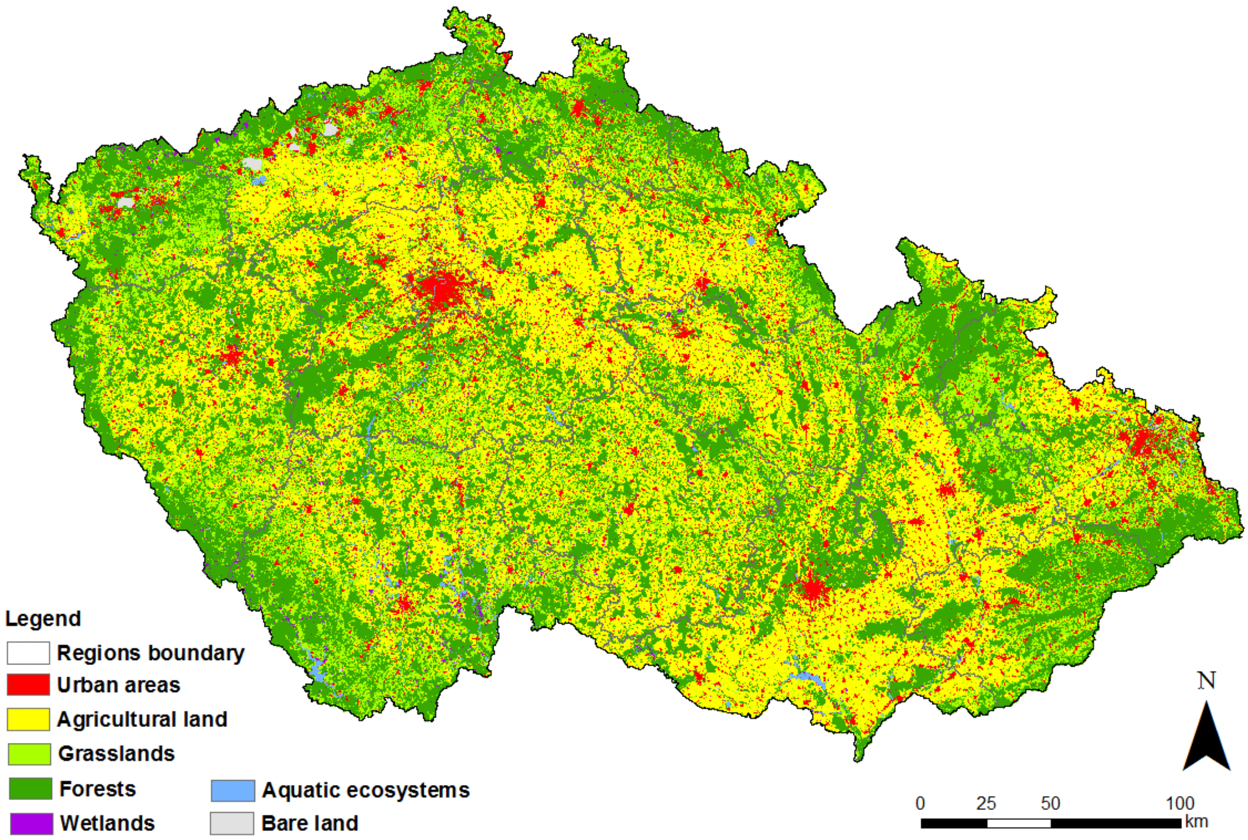


Figure 1.1. Land cover/use map of the Czech Republic (based on the Consolidated Layer of Ecosystems – see below for further source information)

2. Questions and Themes

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.

3. Stakeholders' Involvement

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[3]). 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.

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

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 8.1). The most general land cover categories consisted of agricultural land, grasslands, forests, urban areas, aquatic ecosystems and wetlands (e.g. Figure 4.1). 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

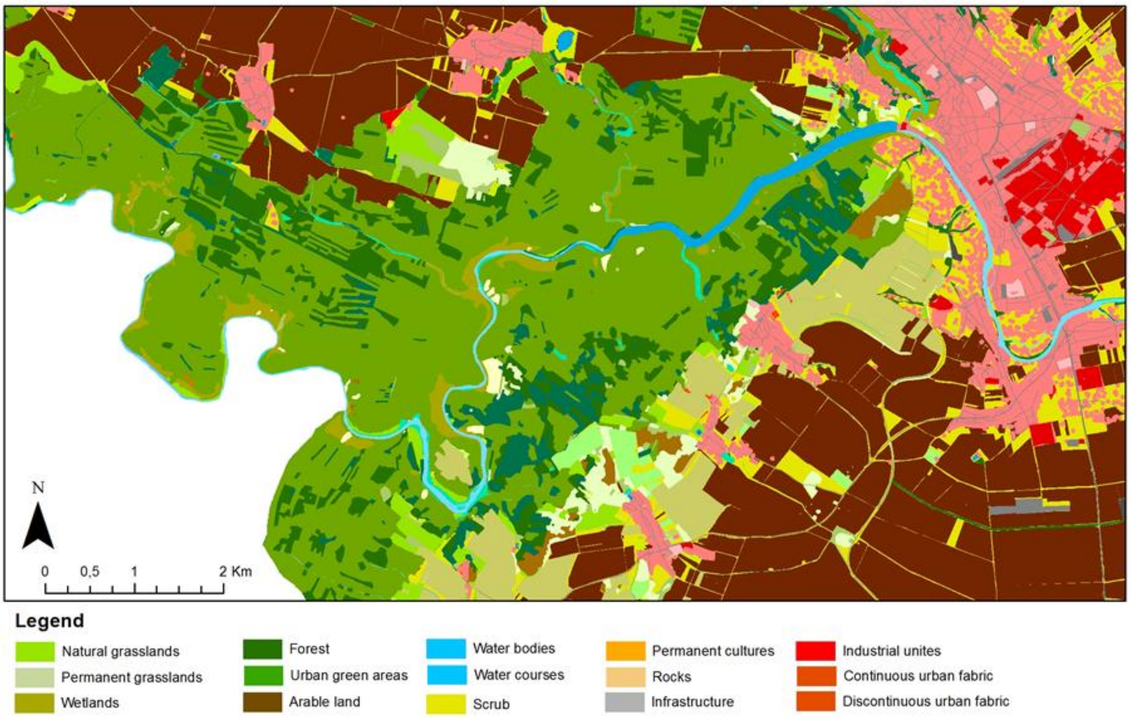


Figure 4.1. Example of consolidated layer of ecosystems for the national assessment and mapping of ES at the hierarchical level 4.

4.2. Assessing ecosystem conditions

The ecosystem conditions were not assessed in this study.

4.3. Selecting Ecosystem Services

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 8.2. 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 8.3 and Table 8.4.

Table 4.1 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 4.1. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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 5.1). 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).

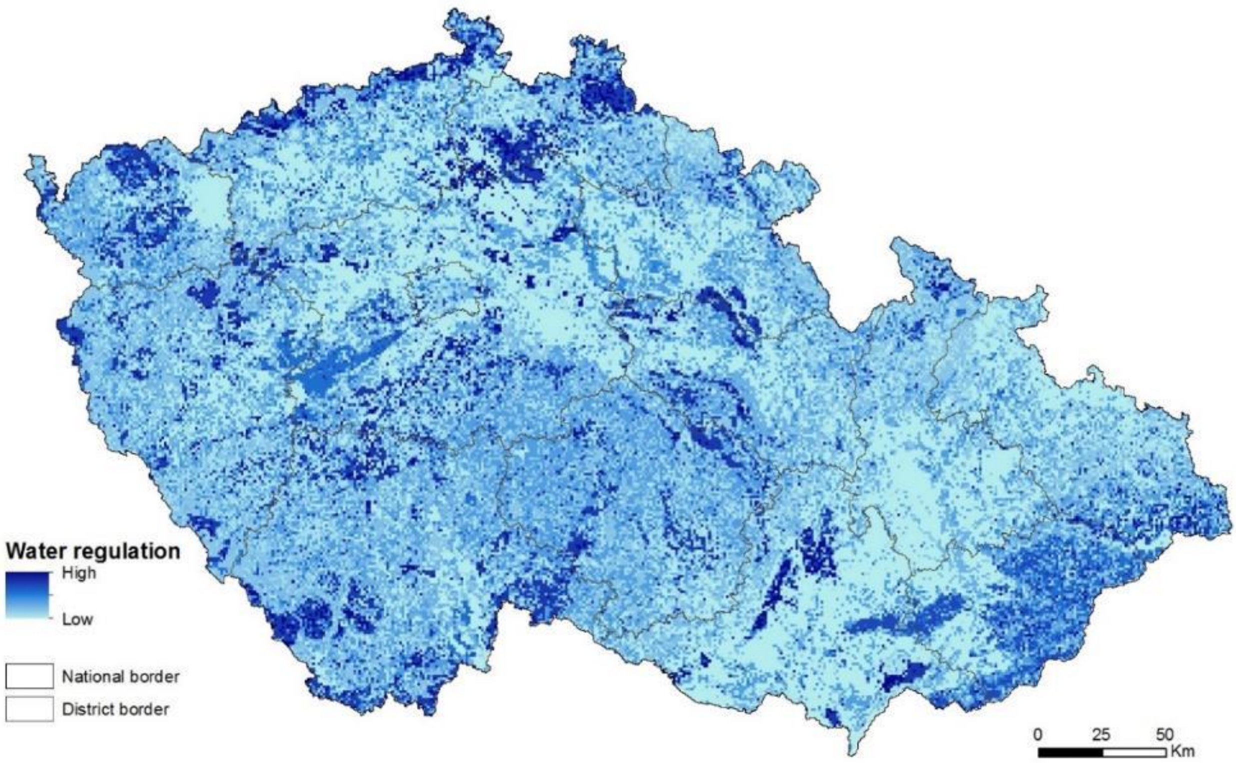


Figure 5.1. Map of water regulation potential based on biophysical mapping of soil water retention capacity.

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.

5.2. Economic methods for ES mapping and assessment

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 8.5.

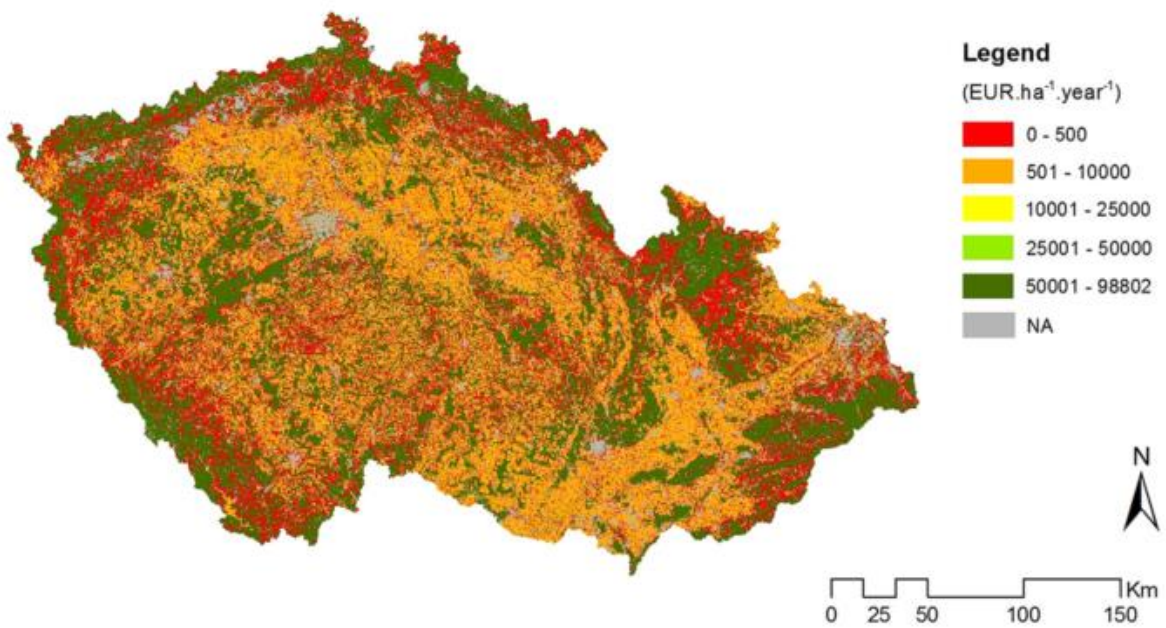


Figure 5.2. Final valuation map of ES in the Czech Republic.

5.3. Integration of ES mapping and assessment results

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.

6. Dissemination and communication

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 of the Czech Republic and are available for all interested partners.

7. Implementation

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.

8. References & Annexes

Reference

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Annexes

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

Table 8.1. 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 8.2. 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	Modelling 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 8.3. 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 8.4. 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 8.5. 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

METHOD APPLICATION CARD: VALUE (BENEFIT) TRANSFER Applied to: Surface water for drinking (1.1.2.1)	
CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
SCALE	National
TYPE	Economic
TIER	Tier 2
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	• Net Value Added (NVA)
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
6. EXAMPLES OF POLICY QUESTION	
• Which method is the most appropriate for valuation of surface drinking water? • How is the value of drinking water changing?	
Suggested Citation: Vačkář, D., Liekens, I., Broekx, S., Łowicki, D., Brander, L., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: VALUE (BENEFIT) TRANSFER applied to "Surface water for drinking (1.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: NET FACTOR INCOME Applied to: Surface water for drinking (1.1.2.1)	
CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
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	• Low-medium depending on availability data
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 biophysical methods, but it could be linked to different biophysical methods • Just cubic meters (basic physical method) could be enough • Hydrological understanding of ecosystem's role in the supply of water can be useful (e.g. contribution to recharge volumes)
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
6. EXAMPLES OF POLICY QUESTION	

- What is the contribution of the ecosystem in the production of drinking water?

- How large is the effect of the delivery of the service (e.g. groundwater recharge) on the availability of the marketed good (e.g. drinking water)?
- How much water can we use to keep its resources safe?
- Comparing supply to demand, what is the real price of drinking water?

Suggested Citation: Brander, L., Vačkář, D., Liekens, I., Broekx, S., Łowicki, D., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: NET FACTOR INCOME applied to “Surface water for drinking (1.1.2.1)”. ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

METHOD APPLICATION CARD: INTEGRATED MODELLING FRAMEWORKS (InVEST) Applied to: Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)

CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
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
6. EXAMPLES OF POLICY QUESTION	
• Where are located carbon hotspots – places with high carbon sequestration potential? • Are protected areas storing more carbon than regular landscape? • What are the past trends in carbon storage across a landscape? • How will carbon storage develop in the future, under different land cover change trends?	
Suggested Citation: Vačkář, D., Liekens, I., Broekx, S., Łowicki, D., Brander, L., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (InVEST) applied to "Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: VALUE (BENEFIT) TRANSFER **Applied to: Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)**	
CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
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	•
Quantitative	• The results form peer-reviewed articles published in recognized journals.
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
6. EXAMPLES OF POLICY QUESTION	
• What is the value of the ecosystem for supplying the ecosystem service in this case global climate regulation? • Which existing studies are usable for valuing the ecosystem service (in this case global climate regulation)? • What is the desired level of forest cover on a given region?	
Suggested Citation: Broekx, S., Vačkář, D., Liekens, I., Łowicki, D., Brander, L., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: VALUE (BENEFIT) TRANSFER applied to "Global climate regulation by reduction of greenhouse gas concentrations (2.3.5.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: INTEGRATED MODELLING FRAMEWORKS (ESTIMAP) Applied to: Entertainment (3.1.2.4)	
CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
SCALE	Local
TYPE	Socio-cultural
TIER	2/3
DESCRIPTION	
ESTIMAP is a suite of models developed by the JRC to map ES at the European scale. The ESTIMAP recreation model in particular assesses the potential and opportunities for nature-based recreation. The model is based on three consecutive steps that assess: 1) the Recreation Potential, i.e. the suitability to support different types of recreation activities based on the intrinsic characteristics of the areas; *2)* the Recreation Opportunity Spectrum, which combines the Recreation Potential with information about accessibility, i.e. proximity to residential areas and transport infrastructure; *3)* the Number of potential trips, which adds information about the distribution of the potential users. The Recreation Potential is a spatially-explicit indicator ranging from 0 to 1; the Recreation Opportunity Spectrum is also a spatially-explicit indicator classified into nine categories that combine high/medium/low Recreation Potential with high/medium/low level of accessibility.	
1. DATA REQUIREMENT	
Qualitative	• (For local application) scoring of different elements within the three steps of the model
Quantitative	• Natural features supporting recreation, e.g. for EU application: water elements with related quality, natural protected areas, land uses with related degree of naturalness • Accessibility parameters, e.g. for EU application: road network and urban areas • Demand of recreation, e.g. for EU application: population density map, • Other/more detailed data can be used in local applications (e.g. accessibility can be assessed based on the presence of cycle paths, bus stops, parking areas etc.)
2. RESOURCES REQUIREMENT	
Time	• Data preparation and adjustment of the model, to include all the elements of interest, are the most demanding part.

Cost	• Low – including only labour costs
Expertise	• GIS software expertise required for preparing the data. At present, the model can be run only with the support of experts from the JRC.
Tools & equipment	• Computer, GIS software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	• stakeholder and experts consultation to identify local preferences and validate results
Economic	• e.g. travel costs, choice experiment
4 COLLABORATION LEVEL	
Researchers own field	• None
Researchers other fields	• Researches with an interest on recreational activities in green areas can provide useful input
Non-academic stakeholders	• Local experts and stakeholders involved in the management of green areas or with an interest in nature-based recreational activities
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Yes, the model can be adapted to include locally relevant data (see e.g. in Zulian et al. 2017).
Regional	• Yes, the model can be adapted to include locally relevant data (see e.g. in Zulian et al. 2017).
National	• Yes. However, the results at the national level can be drawn from the EU level application
Pan European	• Yes. ESTIMAP was developed for this scale
6. EXAMPLES OF POLICY QUESTION	
• What is the recreational potential of the study area? • Are opportunities for nature-based recreation equally distributed across the study area? • How many citizens have access to an area of high recreation potential close to home?	
Suggested Citation: Vačkář, D., Liekens, I., Broekx, S., Łowicki, D., Brander, L., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (ESTIMAP) applied to "Entertainment (3.1.2.4)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: HEDONIC PRICING METHOD Applied to: Entertainment (3.1.2.4)	
CASE STUDY	CZECH REPUBLIC: Pilot National Assessment of ES
SCALE	National
TYPE	Economic
TIER	2
DESCRIPTION	
Hedonic Pricing Method (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 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 green; availability of schools, hospitals, train stations, etc.
2. RESOURCES REQUIREMENT	
Time	• Depends on the availability of data, 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 (privacy issues, if directly from a real estate company: they can ask for payment)
Expertise	• Expertise on statistical software
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	
Local	• Yes
Regional	• Yes
National	• Possible but very data demanding. A good geographic spread of the data is necessary
Pan European	• No. Primarily because we lack common database for whole Europe
6. EXAMPLES OF POLICY QUESTION	
• How does environmental quality effect housing prices? • How does the availability of green areas effect housing prices and to what distance they have an effect? • What is the economic amenity value of green areas close to residential areas? • How much should landscape protection cost? • What facilities for recreation are needed? • What kind of green/blue infrastructure are mostly desired?	
Suggested Citation: Łowicki, D., Vačkář, D., Liekens, I., Broekx, S., Brander, L., Viinikka, A., Pitkanen, K., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: HEDONIC PRICING METHOD applied to "Entertainment (3.1.2.4)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

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CASE STUDY BOOKLET

Green infrastructure and urban planning in the City of Järvenpää

June 2018

ESMERALDA partner: Finnish Environment Institute, SYKE

Case Study Coordinators: Arto Viinikka & Leena Kopperoinen

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Viinikka, A., Kopperoinen, L., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: GREEN INFRASTRUCTURE AND URBAN PLANNING IN THE CITY OF JÄRVENPÄÄ prepared for "WS 8 - Testing the final methods in policy- and decision-making (II): businesses and citizens" held in Eger, Hungary, 19-22 March 2018. ESMERALDA EC H2020 Grant Agreement no. 642007.

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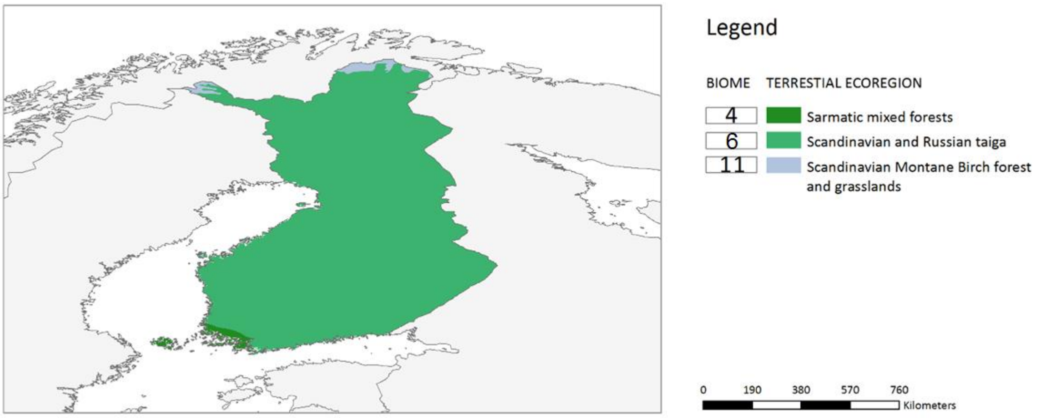
CASE STUDY FACTSHEET

Mapping green infrastructures and their ES in Järvenpää WS8_cs2a

NAME AND LOCATION OF STUDY AREA	City of Järvenpää
COUNTRY	Finland

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. 40 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

1. Overview of the study area

The City of Järvenpää is a compact city with tight boundaries in the Helsinki-Uusimaa Region (Figure 3). It is the fourth most densely populated city in Finland, with a population of around 42,000, and is predicted to grow significantly in the coming decades. It is a significant commercial and administrative centre in Central Helsinki-Uusimaa as well as part of the Helsinki Metropolitan Region economic and employment area due to its quick connections to Helsinki. City's compact structure means that new construction sites need to be found among the already built area, mainly in green space. Natural values come right into the city centre because the wetlands in the northern end of Lake Tuusulanjärvi belong to Natura 2000 network due to their importance for nesting and migratory birds.

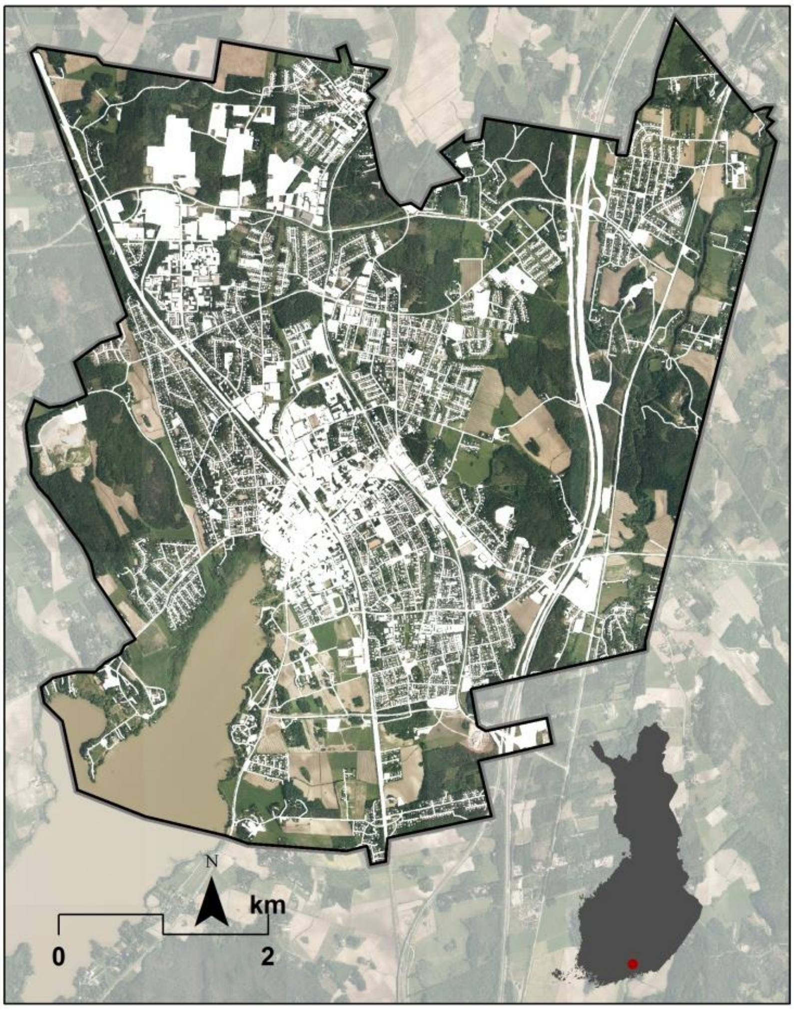


Figure 3. Map of the City of Järvenpää with impervious areas presented in white. Lake Tuusulanjärvi is seen in the south-western area.

2. Questions and Themes

The city of Järvenpää has an expected population growth of over 10 % by the year 2030. As a result, there is an exceptionally strong need for infill development to provide housing for new inhabitants as the master plan already covers the whole city and the neighbouring municipalities prevent the city to grow outside. Infill development and the fragmentation of the existing landscape structure require a more accurate assessment and development of the GI. The city's interest was to find the tools and criteria for valuing the sites excluded from construction (i.e. GI) so that future urban planning could compress up and intensify the urban structure without losing the most valuable features of the GI.

The objective of this study was to evaluate the green infrastructure in the city by mapping and assessing the supply and demand of the most important ecosystem services (ES) and assess the connectivity on green infrastructure (GI). In the first phase of ES mapping and assessment, the perspective was policy driven aiming to support the city planners for sustainable development on natural values and ES provided by green and blue areas while simultaneously identifying land for future construction. Mapping and assessment was done in three phases concentrating to the questions of: 1) how the provision of ES related benefits provided by the green infrastructure were distributed in the area; 2) how and where the citizens use these benefits and; 3) how the ecological processes providing these services were connected.

According to the Finnish Land use and building act plans urban planning must be prepared in interaction with such persons and bodies on whose circumstances or benefits the plan may have substantial impact. The authority preparing plans must publicize planning information so that those concerned are able to follow and influence the planning process (see: Finnish Land use and building act 132/1999, amendment 222/2003 included). The citizen role was considered by arranging workshop, via online questionnaire and sending survey to schools and kindergartens to map their perceptions related to cultural ecosystem services.

This real-life planning example provided also a good opportunity to test the spatial multi-criteria analysis (SMCA) for engagement of practitioners in enhanced integration of urban greenspaces and residential infill development. The results from the first phase were used as input data for this scientific driven method testing. Here the focus was especially in the interaction and the underlying processes behind stakeholder role during planning process that can support the future planning.

3. Stakeholders' Involvement

The case study was initiated by the city planners of the City of Järvenpää. Researchers and planners co-operated from the very beginning of the process by identifying relevant ES to be mapped and reviewing the relevant background information and spatial data from the national and city archives. Citizens were involved in the case study in a citizen workshop where they were asked to provide information about their perceptions and values related to (mainly cultural) ecosystem services. The participants of the workshop scored different green infrastructure types and features based on how important they were for them from the ES point of view in general, and after that participants were asked to place the most important areas to which they attached cultural ES based values on a map. Moreover, the citizen knowledge had already earlier been collected by using an online participatory GIS survey and this information was reclassified to derive spatially-explicit cultural ES related values of green infrastructure using content analysis. To better comprehend educational values of green and blue infrastructure a map survey was mailed to schools and kindergartens.

In the second phase, this real-life planning-related case study provided a good opportunity to test spatial multi-criteria analysis (SMCA) in engaging practitioners in enhanced integration of urban green spaces and residential infill development. Here the focus was especially in the interaction and the underlying processes behind stakeholders' roles during planning process that can support the future planning. Experts from different sectors of the city had an essential role in the process as they provided input on the criteria and thereafter, weighting of the criteria to find the most optimal sites for infill development.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

Starting point for this mapping and assessment exercise was the identification and extraction of green and blue areas with sufficient spatial accuracy required for planning purposes. Aim was to create a typology of green infrastructure (e.g. Cvejić et al. 2015). To capture the most detailed features in the study area, we used the combination of currently available multiple different datasets that were complemented with digitization using temporally accurate high resolution aerial images with 0.5 m resolution. A key dataset was city owned local biotope data including areas of uniform environmental conditions that was used as a baseline for the delineation. As a complementary we used multiple datasets such as aerial images and environmental features from Finnish National Land Survey database.

The green typology was a prerequisite for the mapping and assessment, but it was also a result being the most accurate digital representation of the prevailing land cover in the area (Figure 4). This provided a possibility for the land use planners to have more accurate overview of the city green and blue areas to support planning and the importance, for example, of the private gardens to provide of multiple ES and maintain connectivity could be pointed out.

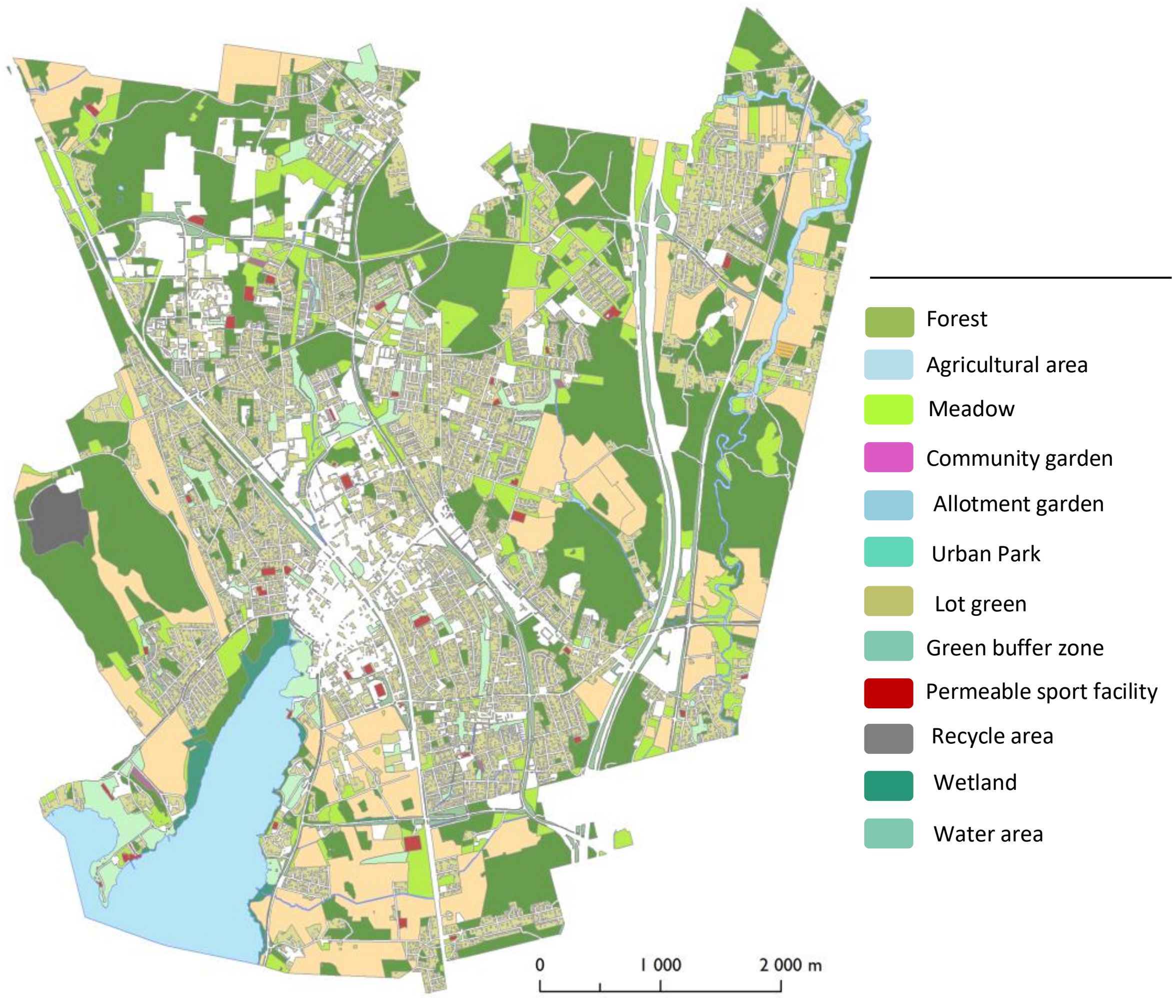


Figure 4. Järvenpää GI typology.

4.2. Assessing ecosystem conditions

Direct ecosystem condition assessment was not included in this study. However, ecosystem condition is directly linked to ecosystem relative service provision potential that was assessed in this study. Information about ecosystem conditions relevant for the case study were mostly related to structural analysis of urban green infrastructure components (e.g. connectivity) that is essential for the ecosystem sustainability and service provision.

4.3. Selecting Ecosystem Services

For the identification of relevant ES, we used the knowledge from previous mapping and assessment studies that were validated though a joint discussion with city planners. The objective of maintaining good opportunities for urban recreation and other cultural values supported the selection of all cultural ES according to CICES 4.3 to be mapped whereas provisioning and regulating and maintenance services consisted only the most relevant services in the area. **Table 11** includes the selected ES for the case study classified using the CICES v4.3 (2013) and the related assessment method categories where B = Biophysical, S = socio-cultural. Original CICES 4.3 was slightly modified by combining categories to fit better to the city needs. Economic assessment was not conducted in this study.

Table 33. Overview of the ES and related mapping and assessment methods in the city of Järvenpää

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.1 Cultivated crops	X		
1.1.1.3 Wild plants, animals and their outputs + 1.1.1.4 Wild animals and their outputs	X		
1.1.2.2 Ground water for drinking	X		
2.2.2.1 Hydrological cycle and water flow maintenance + 2.2.2.2 Flood protection	X		
2.3.1.1 Pollination and seed dispersal	X		
2.3.1.2 Maintaining nursery populations and habitats	X		
2.3.5.2 Micro and regional climate regulation	X		
3.1.1.1 Experiential use of plants, animals and land-/seascapes in different environmental settings + 3.1.1.2 Physical use of plants, animals land-/seascapes in different environmental	X	X	
3.1.2.1 Scientific + 3.1.2.2 Educational	X	X	
3.1.2.5 aesthetic + 3.1.2.3 Cultural heritage	X	X	
3.2.3.1 Symbolic + 3.2.3.2 Sacred and/or religious	X	X	
3.2.3.2 Existence + 3.2.4.2 Bequest values	X	X	

* ES selected for further discussion during ESMERALDA workshops 8 in Eger, Hungary;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

Total of three different biophysical methods were used to mapping and assessment. Spatial proxy method was applied to all ES listed in Table 11. The structural (potential) connectivity of GI was assessed using connectivity models and spatial multi criteria analysis was used to integration of urban greenspaces and residential infill development.

5.1.1. Mapping of provisioning, regulating and maintenance and cultural services

The potential provision of selected ES was assessed using Green Frame (GF) method that belongs to spatial proxy models (Kopperoinen et al.2014). GF is especially tailored for supporting planning processes due to its flexibility, transparency and operational possibilities. It provides an overview of the potential provision of ES in relative scale using spatial data and expert opinions. Analyses can be conducted in a short amount of time, which is usually a requirement in the planning process. Besides expert opinions, the method uses quantitative data when available, usually from provisioning ES such as timber volume (m^3) or ground water yield (m^3). The method uses multiple different datasets that were combined to themes and scored by the experts (Table 34). We utilized the results from the scoring workshop from previous year used for ES mapping and assessment in Uusimaa region as these were transferrable to local context. The scoring system for assessing the effect of each theme on the prerequisites for the provision potential of each ES group was:

3	2	1	0	-1	-2	-3
Very favourable	Favourable	Slightly favourable	No effect or neutral effect	Slightly harmful	Harmful	Very harmful

Table 34. Expert scoring applied into data themes

	Cultivated crops	Wild plants, animals and their outputs	Ground water for drinking	Hydrological cycle and water flow maintenance	Pollination and seed dispersal	Maintaining nursery populations and habitats	Micro and regional climate regulations	Recreation	Education	Aesthetic and cultural heriotage	Symbolic, Sacred and/or religious	Existence and bequest
Conseravtion areas	0	2	2	3	2	3	2,5	3	3	2	3	3
Valuable landscapes	3	1,5	1	1	2	2	1	2	2	3	2	2
Cultural heritage sites of built environments	2	1	0	1	2	1	1	3	1,5	3	2	2
Traditional biotopes	2	2	0	1	3	3	1	2	2	3	2	3
Areas of valuable environment according to Finnish forest act	0	2	1,5	2	2	3	1	2	3	2	2	3
Bogs	0	2	2	3	1	3	2	2	3	2	3	3
Important bird areas	0	1	0	1	1	3	1	2	3	2	2	3
Ground water formation areas	0	1	3	3	1	1	1	1	1	1	1	2
Agriculture areas with high nature values	3	1	0	1	2	2	1	2	2	2	2	2
Ekological condition of surface waters	0	2	3	2	0	3	0	3	3	2	2	3
Recreation areas	1	2	1	1	1	1	1	3	2	2	2	2

Respondents were advised to give a score of 0 if they saw no connection between the theme and the provision potential of the ES group in question. Scoring was also done to the Finnish national Corine Land Cover data to avoid empty areas in the mapping results. Although it is possible to map all the ES separately, the method reveals areas providing the multiple benefits (i.e. ES bundles) which are essential for comprehensive assessment of GI (Figure 4).

Figure 5. Provision of cultural ecosystem services in Järvenpää

Connectivity analyses

We used ecological connectivity models to evaluate the structural degree to which the GI facilitates potential movement of different ecological processes. Connectivity promotes the provision potential of many ES as connectivity is fundamentally linked to the ecological processes providing these services. In Järvenpää, assessment was conducted using two different approaches. Firstly, we applied Morphological Spatial Pattern Analysis (MSPA) that classified the green patches based to geometry, area and edge size (Vogt et al. 2007) (Figure 5).

Secondly, we used graph theory based Matrix Green and Conefor software's (Saura & Pascual-Hortal 2007) to quantify the theoretical importance of habitat to maintain the overall connectivity (Figure 6). Information of the attributes such as land cover and ES of GI were not included into the connectivity analyses, but rather all the GI habitats were handled equally.

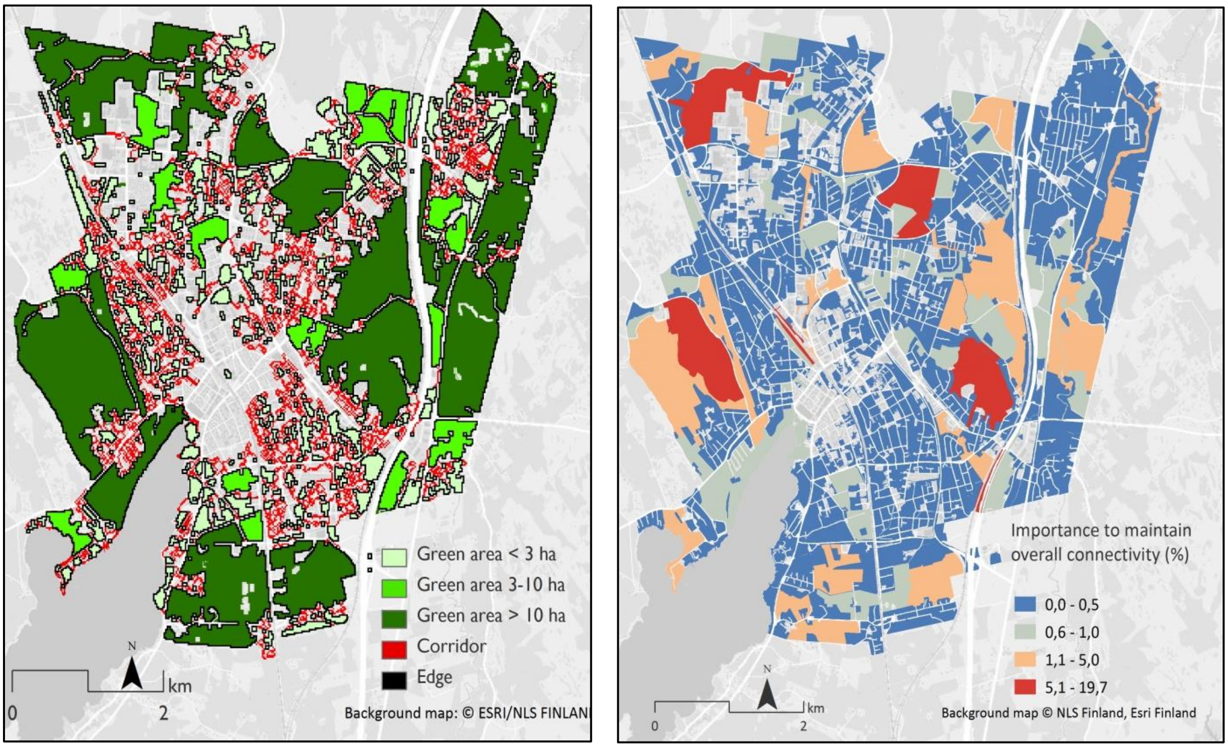


Figure 6. Structural connectivity of GI in Järvenpää.

Spatial Multi-Criteria Analysis

We tested the spatial multi-criteria analysis (SMCA) for engagement of practitioners aiming to enhance the integration of urban greenspaces and residential infill development. We applied a GIS-based Multi-Attribute Value Theory (MAVT) approach, which is a widely-used technique for supporting the decision making especially in the environmental field and urban planning (Ferretti and Comino, 2015, Huang et al., 2011).

Using the spatial assessment results from the ecosystem services and connectivity analyses integrated to the existing spatial knowledge of construction costs, transportation, accessibility to daily services and environmental nuisances and disturbance researchers drafted the initial version of the decision tree (Annex 1). The decision tree including the objectives and criteria was further discussed and altered on-the-fly according to the joint discussion based to the participant's expert knowledge on various sectors. Later, the stakeholders scored the criteria that were integrated to the spatial datasets to present the results on a map (Figure 6). Stakeholders participate in a follow-up table to discuss and validate the results of the ES mapping and assessment exercise.

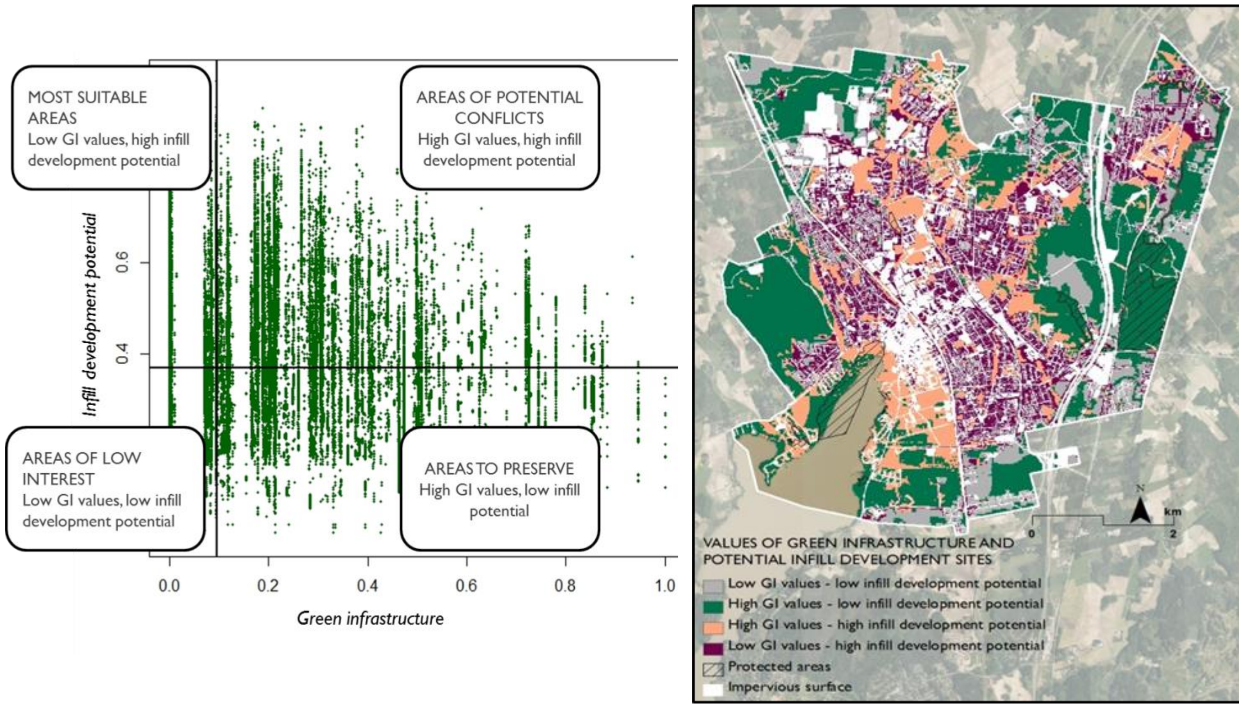


Figure 7. Normalized stakeholder median scores for each dataset pixels (left). Output map representing potential infill sites based to (right).

5.2. Socio-cultural methods for ES mapping and assessment

We used Participatory GIS to evaluates the spatial distribution of cultural ES (mainly) according to the perceptions and knowledge of citizens via workshop, surveys and online questionnaire (Figure 7). Citizen workshop was a twofold. In the first session participants scored green and blue areas according to the importance to provide ecosystem services (see: Annex 2). Method was highly subjective capturing respondent personal opinions. In the second phase, participants marked areas providing ES on a map.

Survey regarding the important educational sites was sent out to schools and kindergartens. In the survey the respondents were asked to mark on a map nature sites, routes or areas that are used for educational purposes. Respondents were also asked to mark areas that they would be willing to use with explanation why it is not possible.

We also utilized the results from the PGIS online survey from 2006 regarding the quality of environment in the area. Survey was not specifically tailored for ecosystem services, but by we were able to modify the results to fit our needs by classifying the answers into ES groups.

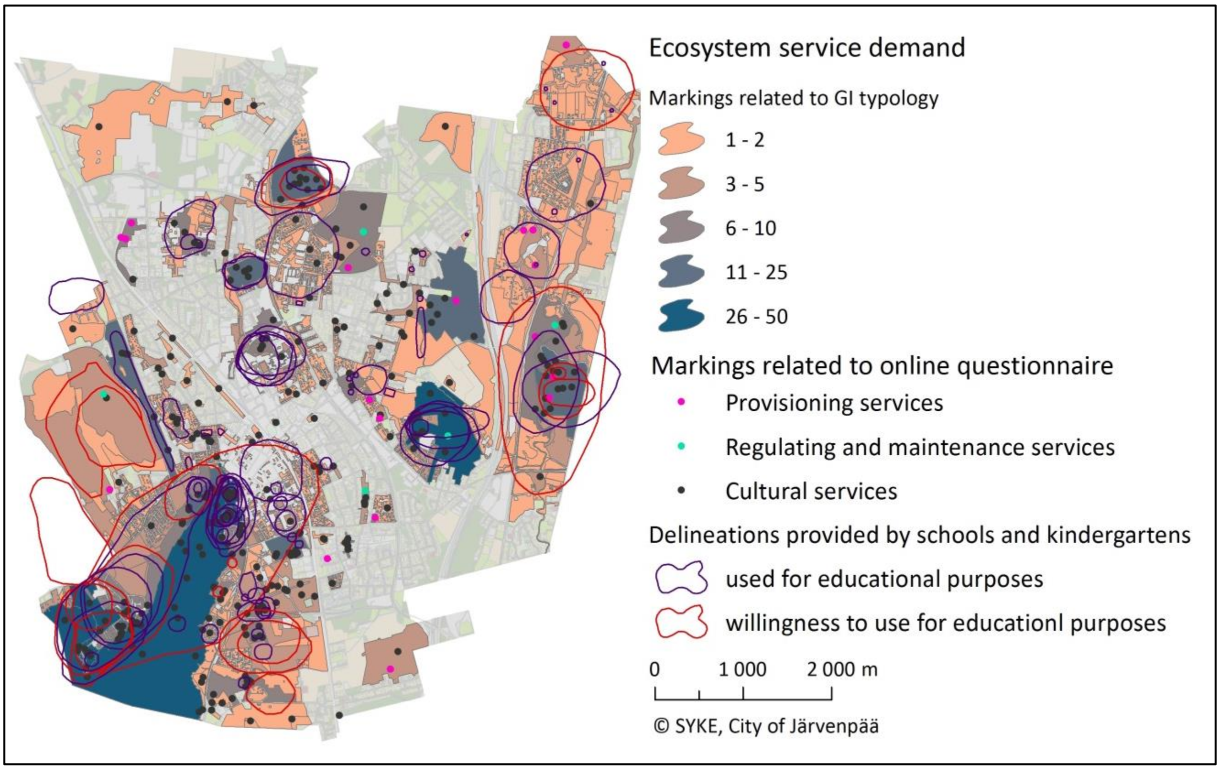


Figure 8. Compilation of the cultural ecosystem services demand in Järvenpää

5.3. Integration of ES mapping and assessment results

The mapping and assessment of ES in Järvenpää generated important information that helped to address the policy question on the better and more sustainable integration of GI and infill development. From a planning perspective, spatially explicit analysis results provided a way to compare potential ES supply, demand and connectivity between the planned infill development sites. Thus, the construction could be directed to areas not decreasing the quality of green and blue structure in the area.

Although each category of the ES was included, the main focus was in cultural ES. Provision potential combined to citizen preferences and values related to cultural benefits is directly linked to the wellbeing of the citizens, hence a useful tool to inform planning decisions in a way required in the Finnish land use and building act.

The SMCA mapping and assessment exercise allowed better engagement of the practitioners to the planning process. The decision tree was seen useful tool to structure the factors having impact to the infill development and provide a visual way to understand the challenge to weight different factors against each other. It provided also a way to include experts' knowledge and perceptions in equal manners.

6. Dissemination and communication

Communication and collaboration between planners and researcher were ongoing during the process through regular meetings and planners participation to the process. Analysis results including GIS-datasets and report (Kopperoinen et al. 2016 [in Finnish]) have been shared with municipal planners. The involvement of citizens, schools and kindergartens provided a way for a more effective policy-science-society interface and enhanced the knowledge exchange between participants in terms of cultural ES. The continuous collaboration along the entire process of mapping and assessment is expected to facilitate the introduction of the results into the ongoing urban planning process.

From the academic perspective, results obtained in this case study concerning the engagement of practitioners aiming to enhance the integration of urban greenspaces and residential infill development will be disseminated through scientific publications later this year (Tiitu et al. 2018). In addition, case study has been presented in international and various national conferences.

7. Implementation

The Järvenpää spatial planners employed the ES concept to value urban greenery in context of new infill development. A novelty, as active stakeholder involvement was ensured at each stage of the planning process, using PGIS methods in schools/kindergardens, an online survey and a citizen workshop, making sure that urban green stayed accessible by stakeholders. Combining municipal planning and research, also enabling citizens to co-shape new development plans enhanced the acceptance of new infill development and proves that the MAES, as applied in this case, bears great potential for upscaling, informing spatial urban developments at higher, regional levels

8. References & Annexes

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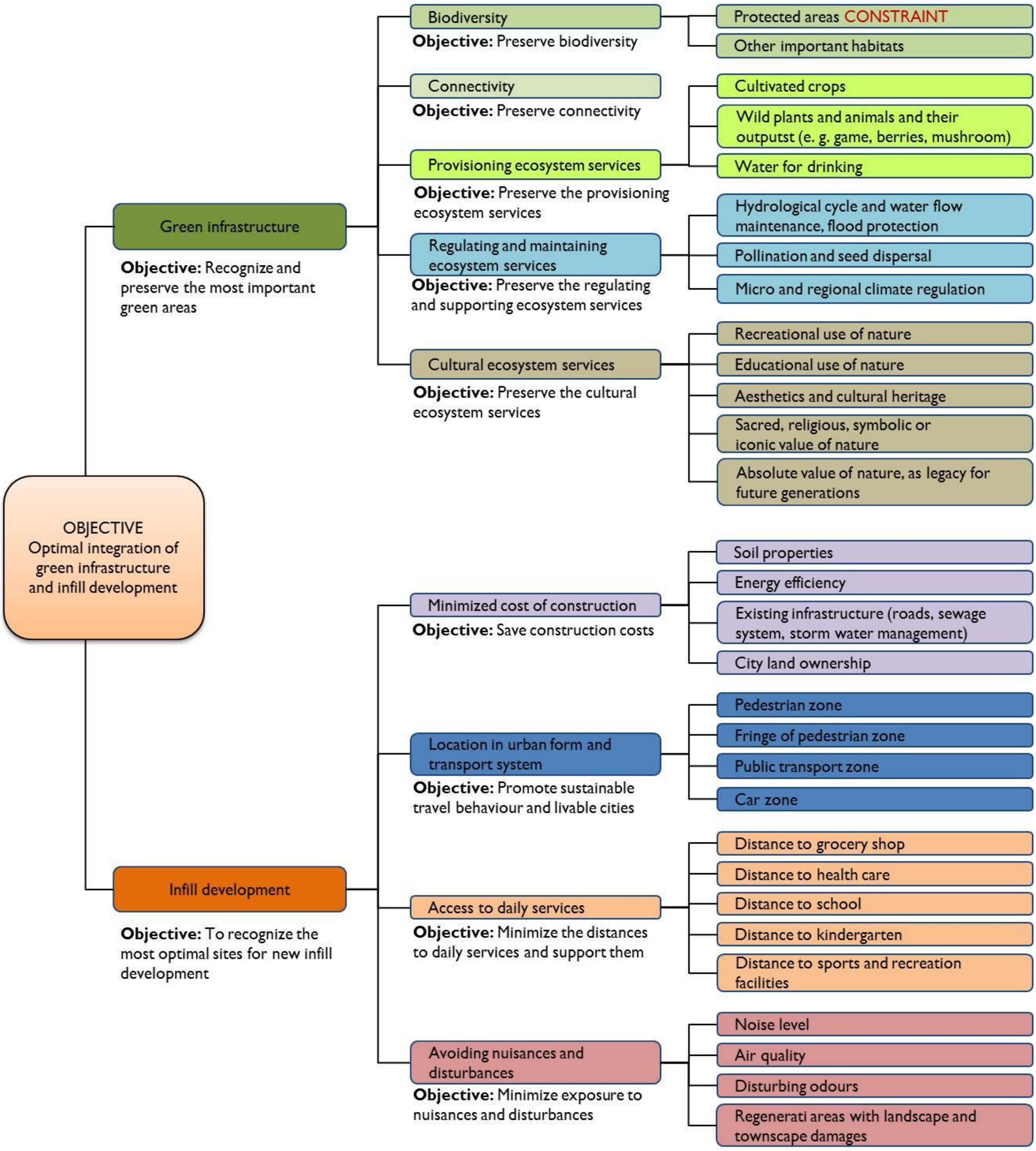
Annexes

Annex 1: Structure of the decision tree including objectives and criteria for the integration of green infrastructure (GI) and infill development.



Annex 2: Importance of green and blue areas as a provider of ecosystem services based to the respondents median scores from citizen workshop. Scale was from 0 to 2 (0= not important, 1= important, 2= very important).

	Forest	Agricultural area	Meadow	Community garden	Allotment garden	Urban park	Lot	Green buffer zone	Wetland	Lake	River	Stream
Recreation	2	0.8	1.4	0.8	0.6	1.9	1.9	1.3	1.3	2	1.8	1.1
Education	1.9	1.3	1.9	1	1	1.5	1.5	1.4	1.6	1.8	1.8	1.5
Aesthetic and cultural values	1.9	1.3	1.9	1.1	1.3	1.8	1.8	1.5	1.6	2	1.9	1.8
Artistic representation of nature	1.9	1.4	1.6	0.6	0.7	1.7	1.4	1.1	1.4	1.7	1.7	1.6
Symbolic meaning of nature	1.7	1	1.4	0.7	0.4	1.7	1.6	0.7	0.8	1.7	1.4	1.3
Spiritual values of nature	2	0.9	1.3	0.7	0.4	1.6	1.6	0.7	1	1.9	1.6	1.3
Sacred and/or religious	1.7	0.7	1.1	0.1	0.3	1	1	0.6	0.9	1.3	1.3	0.9
Existence and bequest	1.7	1	1.1	0.8	0.7	1.6	1.3	0.7	1.7	2	2	1.6
Cultivated crops	1.6	0.9	1.1	1	0.8	0.6	1.8	0.9	1.3	1	0.9	0.6
Micro and regional climate regulations	1.9	0.7	1	0.6	0.9	1.9	1.7	1.4	1.3	1.9	1.4	1.1

METHOD APPLICATION CARD: PARTICIPATORY GIS Applied to: Educational (3.1.2.2)	
CASE STUDY	FINLAND: Green infrastructure and urban planning in the City of Järvenpää
SCALE	Local
TYPE	Socio-Cultural
TIER	1/3
DESCRIPTION	
Participatory GIS was used to map the cultural ES in the city of Järvenpää. Survey regarding the nature's important educational sites was sent out to teachers in schools and kindergartens. In the survey the respondents were asked to mark on a map nature sites, routes or areas that are used for educational purposes. Respondents were also asked to mark areas that they would be willing to use with explanation why it is not possible. Results were combined together and converted to GIS-format for hot-spot analysis to find the most used and inaccessible educational sites based to respondents answers.	
1. DATA REQUIREMENT	
Qualitative	• Map of the study area (e.g. land cover data)
Quantitative	• Location of schools and kindergartens
2. RESOURCES REQUIREMENT	
Time	• Not much time needed for data preparation or analysis. • 1-2 weeks needed for respondents to answer to the survey (Via e-mail or regular mail)
Cost	• Low cost
Expertise	• Basic GIS skills needed to transfer answers to the GIS-format
Tools & equipment	• GIS software to present the answers
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	
Socio-cultural	• Preference assessment • Deliberative assessment • Participatory scenario planning
Economic	
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	•
Non-academic stakeholders	• Collaboration with local teachers
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate
Regional	• Applicable
National	• Not applicable.
Pan European	• Not applicable.
6. EXAMPLES OF POLICY QUESTION	
• Which and where the nature's educational sites are situated in the city?	
Suggested Citation: Kopperoinen, L., Viinikka, A., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PARTICIPATORY GIS applied to "Educational (3.1.2.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: INTEGRATED MODELLING FRAMEWORK (SPATIAL MULTI-CRITERIA DECISION ANALYSIS) **Applied to: Integration of Green infrastructure and infill development***	
CASE STUDY	FINLAND: Green infrastructure and urban planning in the City of Järvenpää
SCALE	Local
TYPE	Biophysical/Socio-Cultural
TIER	2/3
DESCRIPTION	
Spatial Multi-Criteria Decision Analysis (SMCDA) approach was tested to compare and evaluate the social, ecological and economic impacts of integrating residential infill development and urban green spaces in the City of Järvenpää. Method uses decision tree approach, including the objectives and criteria that were developed in co-operation with the practitioners from the city of Järvenpää. Practitioner's weighted the criteria in the decision tree numerically between 0-100 based on the importance of the criteria's impact on the objectives. Final decision tree included a common view on the objectives and relevant criteria to support the integration of GI and infill development. The basic statistics (e.g. median) was calculated from the individual criteria weights and integrated to the corresponding spatial datasets to assess the GI values and potential infill development sites on a map. Standardisation functions were applied to make the criteria comparable by translating the original scores to a common scale ranging from 0 to 1. Resulting map consisted of the combination of individual pixel's GI values and suitability for infill development based to practitioners scoring.	
1. DATA REQUIREMENT	
Qualitative	• Available relevant spatial data describing the GI and grey infrastructure in the area (e.g. Conservation areas and other important natural areas, soil properties, roads, sewage system)
Quantitative	• Available relevant spatial data describing the GI and grey infrastructure in the area (e.g. water yield, distance to daily services (e.g. schools, grocery shops, recreation areas etc.)
2. RESOURCES REQUIREMENT	
Time	• Time for data preparation and model building depends highly of the amount of criteria (days or weeks). • Expert workshop needed for data scoring. Model itself runs quickly after it has been built.
Cost	• The analysis can be run with free GIS software
Expertise	• Basic GIS skills needed.
Tools & equipment	• GIS software to run the model.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Possibility to use existing mapping results as input data
Socio-cultural	• Preference assessment • Deliberative assessment • Participatory scenario planning
Economic	
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	•
Non-academic stakeholders	• High collaboration level with local stakeholders, practitioners, land use planners
5. SPATIAL SCALE OF APPLICATION	
Local	• Appropriate, the method was specifically tested in urban contexts (in Finland)
Regional	• Applicable, however, not for integration of residential infill development and urban green spaces
National	• Not applicable.
Pan European	• Not applicable.
6. EXAMPLES OF POLICY QUESTION	
• Find the most potential infill development sites without losing the most valuable features of the GI	

Suggested Citation: Kopperoinen, L., Viinikka, A., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (MULTI-CRITERIA ES ASSESSMENT MODEL) applied to “Integration of GI and ES for infill development”. ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

* This Method Application Card refers to the integration of multiple ES associated with GI to inform infill development.

CASE STUDY BOOKLET

(Picture taken ca. 1990)

Mapping ecosystem services dynamics in an agricultural landscape in Germany

June 2018

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

Suggested Citation: Burkhard, B., Kruse, M., Müller, F., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: MAPPING ES DYNAMICS IN AN AGRICULTURAL LANDSCAPE IN GERMANY prepared for "WS3 - Testing the methods across Europe" held in Prague, Czechia, 26-29 September 2016. ESMERALDA EC H2020 Grant Agreement no. 642007.

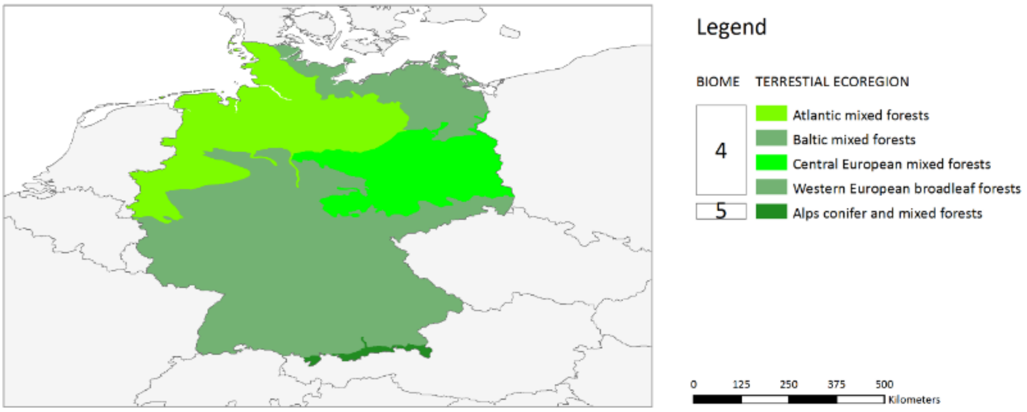
CASE STUDY FACTSHEET

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

1. Overview of the study area

[*Copied & modified from Kandziora et al. 2014*[4]] 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 3.8 and Figure 6.5), 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.

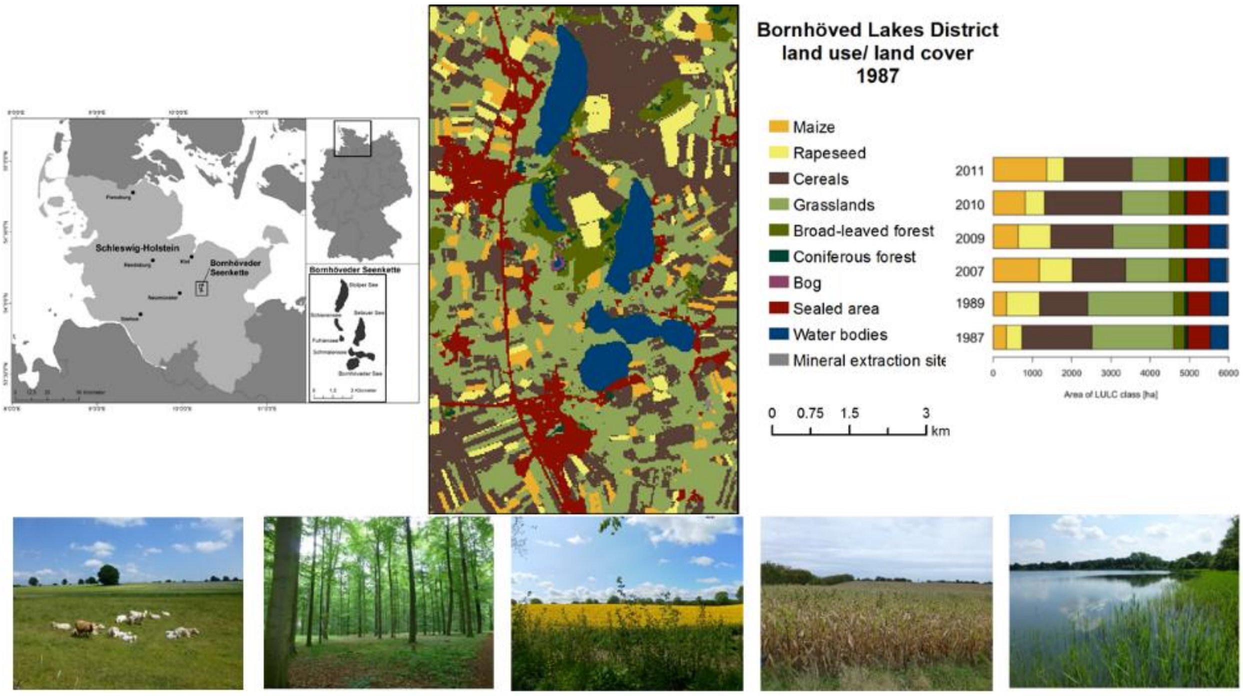


Figure 1.1. Location of the study area (top left; example land use/land cover map and their dynamics (top right); impressions from the area (bottom: All photos taken by Marion Kandziora Kruse).

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

2. Questions and Themes

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[5]). 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[6]. 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 2.1). 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*?"

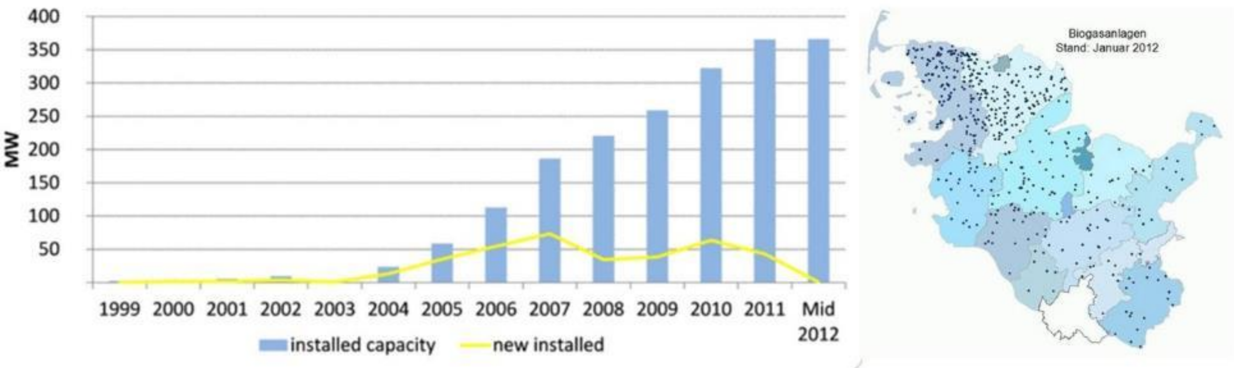


Figure 2.1. Development of electricity generation based on biomass (left) and map of biogas power plants (right) in the federal state of Schleswig-Holstein (Source[7]).

3. Stakeholders' involvement

Landowners/farmers were involved in the preceding project "Long-Term Research in the Bornhöved Lake District" (see Fränzle et al. 2008[8]) in order to carry out research on their property or to acquire 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).

[5] http://www.springer.com/de/book/9783540758105
[6] http://www.bmwi.de/EN/Topics/Energy/renewable-energy.html
[7] http://info.furgy.eu/en/energiethemen/bioenergie/bioenergy-in-schleswig-holstein
[8] http://www.springer.com/de/book/9783540758105

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 behaviour (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[9] 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.

4. Initiating Mapping and Assessment

4.1. 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[10] (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.

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

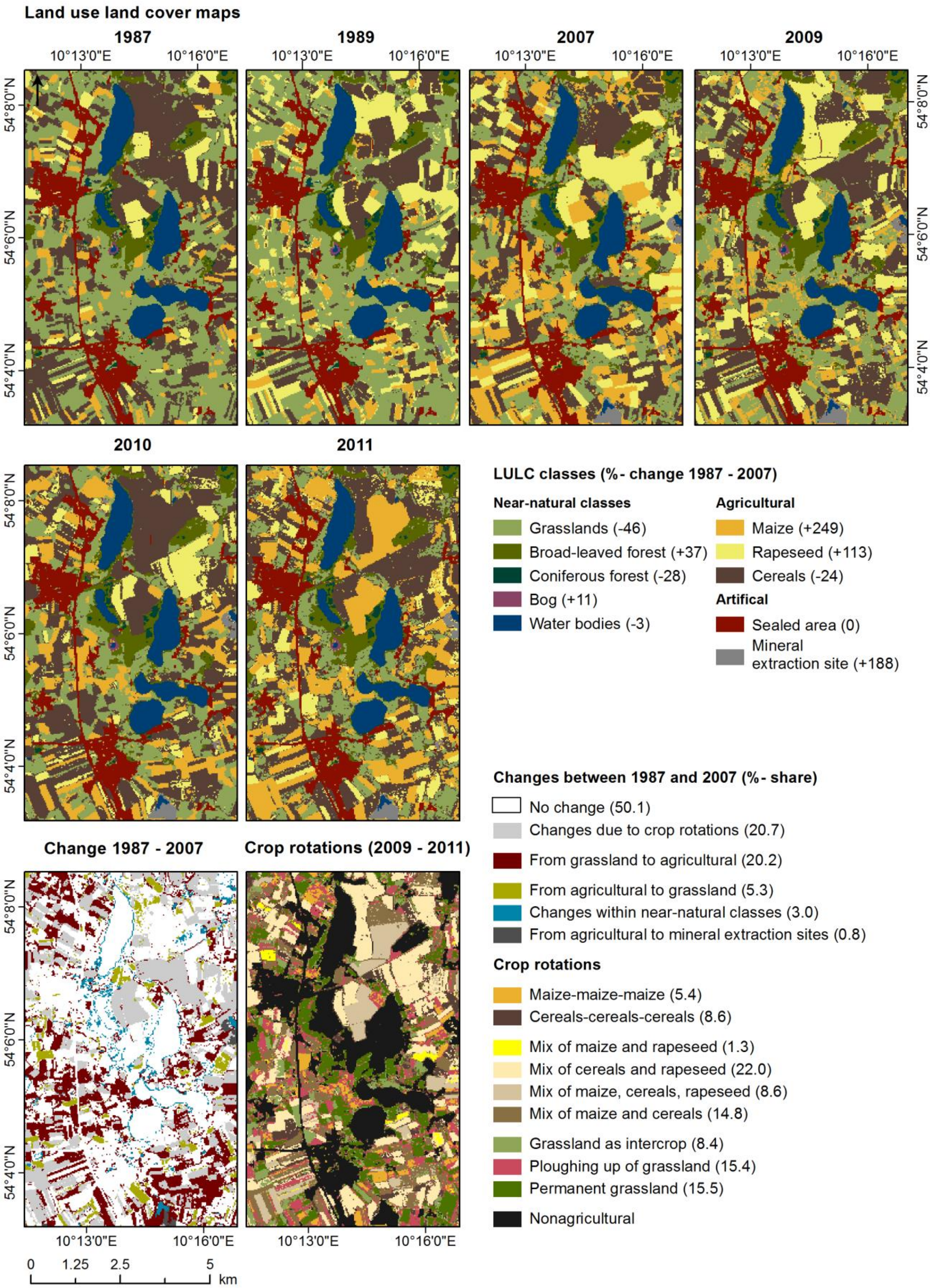


Figure 4.1. Land use / land cover maps for the Bornhöved Lakes District. Changes [%] in area between 1987 and 2007 are listed in parentheses (see legend) and illustrated spatially in the third row. The third row presents retrieved crop rotations from 2009 – 2011. Share [%] is shown in parentheses (see legend) [Kandziora et al. 2014].

4.2. Assessing 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 neighbouring arable land ecosystem (see Figure 4.2). Both ecosystems had a similar agricultural use before the forest was planted.

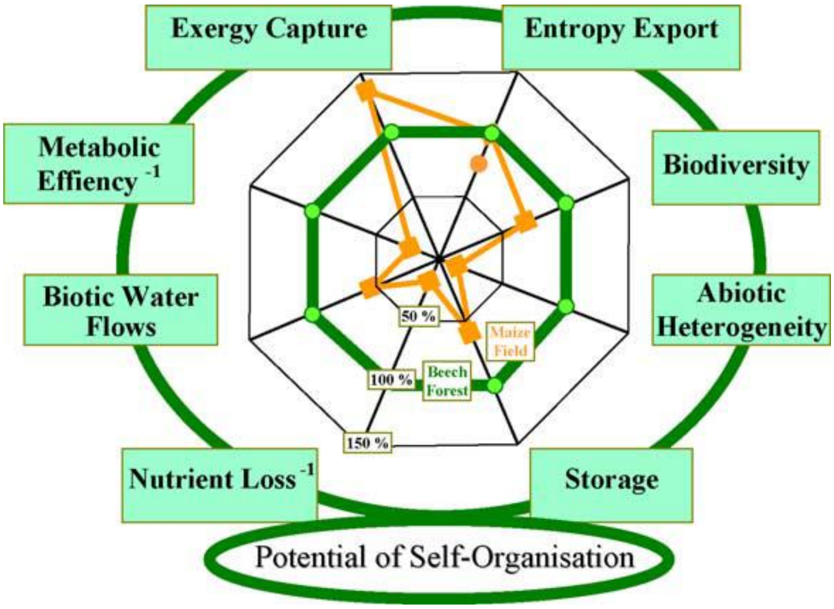


Figure 4.2. Synopsis of the ecological integrity indicator values for the two compared ecosystems (Source: Müller 2005[11]).

In a next step, the ecological integrity indicators were (hypothetically) related to the main categories of ES (see Table 4.1). These hypotheses and individual relations should be tested in further studies.

Table 4.1. Ecological integrity (ecosystem conditions) as basis for ES provision (Source: Müller & Burkhard 2007[12]).

		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

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

4.3. Selecting Ecosystem Services

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 4.2 shows the ES considered in the study according to the CICES classification. Besides the ES mentioned in Table 4.2, 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 4.2. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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.

5.1.1. 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)[13]. Additional information can also be found in Kandziora et al. (2014)[14].

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].

5.1.2. 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 analyse 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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[13] 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.

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

in parts of the study area (Jähne 2016)[15]. 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.

5.2. Socio-cultural methods for ES mapping and assessment

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)[16]. Two cultural ES have been assessed in another study (Mocior and Kruse 2016[17]) based on questionnaires.

5.2.1. Mapping of cultural services

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.

5.3. Integration of ES mapping and assessment results

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.

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

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

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

6. Dissemination and communication

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.

7. References & Annexes

Reference

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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.

METHOD APPLICATION CARD: SPATIAL PROXY METHOD Applied to: Plant-based [energy] resources (1.3.1.1)	
CASE STUDY	GERMANY: Mapping ES dynamics in an agricultural landscape
SCALE	Regional
TYPE	Biophysical
TIER	2
DESCRIPTION	
Spatial proxy methods 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.
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.

6. EXAMPLES OF POLICY QUESTION

- How does land use change affect the provision of the ecosystem service “plant-based resources” (crop for energy production)?
- Does the ecosystem service “plant-based resources” supply (crop for energy production) meet the (local) demand?

Suggested Citation: Burkhard, B., Kruse, M., Bicking, S., Adamescu, M., Balzan, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD applied to “Plant-based [energy] resources (1.3.1.1)”. ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

METHOD APPLICATION CARD: REPLACEMENT COSTS
Applied to: Plant-based [energy] resources (1.3.1.1)

CASE STUDY	GERMANY: Mapping ES dynamics in an agricultural landscape
SCALE	Regional
TYPE	Economical
TIER	2

DESCRIPTION

The replacement cost methods, as well as damage cost avoided and substitute cost methods, are related methods that estimate values of ES 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 ES 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 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

g) 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	• could be used for many ES, from regulating to provisioning; it 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
6. EXAMPLES OF POLICY QUESTION	
•	
Suggested Citation: Adamescu, M., Burkhard, B., Kruse, M., Bicking, S., Balzan, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: REPLACEMENT COSTS applied to "Plant-based [energy] resources (1.3.1.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (GISCAME) Applied to: Buffering and attenuation of mass flows (2.2.1.2)	
CASE STUDY	GERMANY: Mapping ES dynamics in an agricultural landscape
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: 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.
6. EXAMPLES OF POLICY QUESTION	
• How does land use change influence water erosion potential? • How does the distribution of a specific crop or management style affect water erosion potential?	
Suggested Citation: Burkhard, B., Kruse, M., Bicking, S., Adamescu, M., Balzan, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (GISCAME) applied to "Buffering and attenuation of mass flows (2.2.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.	

METHOD APPLICATION CARD: BAYESIAN BELIEF NETWORK Applied to: Buffering and attenuation of mass flows (2.2.1.2)	
CASE STUDY	GERMANY: Mapping ES dynamics in an agricultural landscape (based on experience from Oslo, Norway, Openness case-study)
SCALE	Regional/Local
TYPE	Biophysical
TIER	2/3
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. • Also qualitative information / data, e.g. expert opinions, can be used in a BBN model.

Quantitative	• Exemplary BBN model is included in Appendix I
	• *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;*
	  ○ *Spillover: wood volume; neighboring 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. Oslo case includes noise & pollution reduction by 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 case in 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
6. EXAMPLES OF POLICY QUESTION	
•	
Suggested Citation: Balzan, M., Burkhard, B., Kruse, M., Bicking, S., Adamescu, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: BAYESIAN BELIEF NETWORK applied to "Buffering and attenuation of mass flows (2.2.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: NARRATIVE ASSESSMENT **Applied to: Educational (3.1.2.2)**	
CASE STUDY	GERMANY: Mapping ES dynamics in an agricultural landscape
SCALE	Local
TYPE	Socio-cultural
TIER	
DESCRIPTION	
NARRATIVE ASSESSMENT 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.
6. EXAMPLES OF POLICY QUESTION	
• Which landscape type provides educational services to the public? • Which landscape type does the society identify as most valuable in terms of educational services? • How does the environment provide educational services to the public?	

- How should options for field experience/excursions etc. be integrated and guided in land use management?

Suggested Citation: Burkhard, B., Kruse, M., Bicking, S., Adamescu, M., Balzan, M., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: NARRATIVE ASSESSMENT applied to "Educational (3.1.2.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.

CASE STUDY BOOKLET

ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park, Hungary

June 2018

ESMERALDA partner: MTA ÖK

Case Study Coordinators: Ildikó Arany, Béla Kuslits, Tamás Kállay

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Arany, I., Kuslits, B., Kállay, T., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: ES MAPPING AND ASSESSMENT FOR DEVELOPING PRO-BIODIVERSITY BUSINESSES IN THE BÜKK NATIONAL PARK, HUNGARY prepared for "WS 8 - Testing the final methods in policy- and decision-making (II): businesses and citizens" held in Eger, Hungary, 19-22 March 2018. ESMERALDA EC H2020 Grant Agreement no. 642007.

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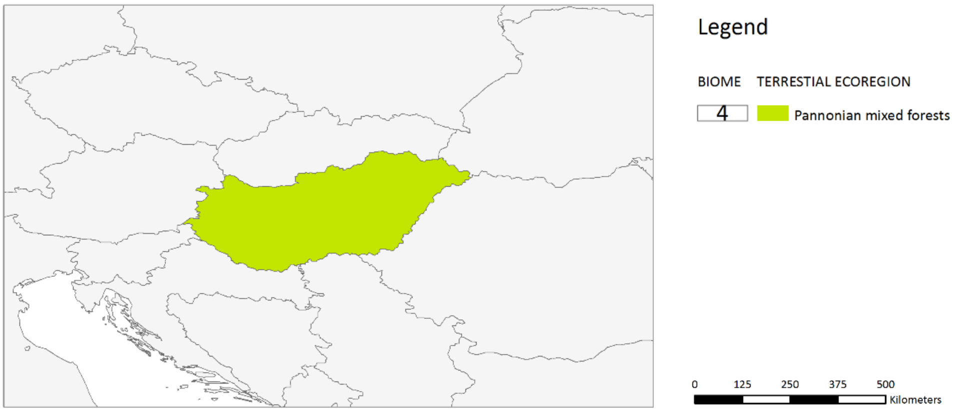
CASE STUDY FACTSHEET

ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park **WS8_cs1**

NAME AND LOCATION OF STUDY AREA	Bükk National Park, Northern Hungary region, Hungary
COUNTRY	Hungary

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	**432 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

1. Overview of the study area

Bükk National Park – located in the Bükk Mountains, a part of the Northern Mountain Range of Hungary - was established in 1977 and it covers 43,168.8 hectares. This area is managed and utilized mainly as forest (94.27%) and to a smaller extent, grassland (3.35%, meadow and pasture), while 1.95% is withdrawn from cultivation, 0.42% is arable land, and the remaining 0.01% is vineyards and orchards. Some 97.7% of the national park is state owned, with two forestry companies as managing organizations in charge, while only 2.5% of the area is managed by the Bükk National Park Directorate. However, the subject of our project is the wider local socio-ecological system containing low-intensity areas of settlements, arable lands, grasslands, vineyards and orchards adjacent to the NP territory, reflecting the significance of these land uses and the opportunities offered by them to involve business and citizens (see Figure *3.9*. Map of Bükk National Park. Boundaries of the larger focus area represent the whole social-ecological system, and an inclusive core area, with all important spatial information.).

The Bükk has a great geological diversity including a central karst area with its special features: sumps, caves, deep gorge valleys, lofty rocks. Among others, 45 of its 853 explored caves are strictly protected, including the deepest cave of the country. The karst water treasure in the depth of the mountain is the greatest value of the Bükk, providing more than 1 million people with clear fresh water. As pollution may get into the karst galleries together with the precipitation, karst water is very sensitive. The diversity of geological characteristics, bedrock, soil types, climate and land use allows a great biodiversity of Bükk: it is home to approximately 1500 vascular plants, several endemic fish and invertebrates, high number of bats and diurnal birds of prey as well as large carnivores, to mention a few.

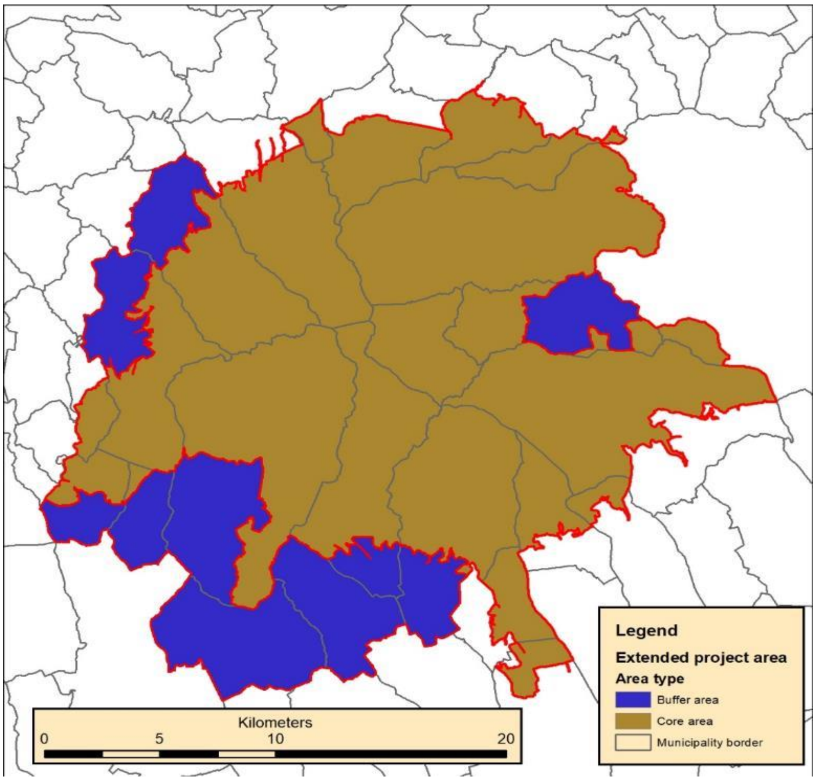


Figure 3. Sample map of Bükk National Park by András Schmotzer. Boundaries of the larger focus area represents the whole social-ecological system, and an inclusive core area, with all important spatial information (with special regard to the ecosystem map). The area around the core area is the buffer.

2. Questions and Themes

The project 'Ecosystem services of karst protected areas – driving force of local sustainable development (Eco Karst), funded by the EU Territorial Cooperation Programme, builds on the opportunity to use the natural heritage of protected areas as an economic development factor. The project has started in 2017 and is ongoing until June 2019. It aims to support local development based on the raised awareness and sustainable management of karst ecosystems across the Danube region. The project works with a series of pilot areas including the Bükk National Park in Hungary and combines different disciplines and methods, develops customized methodologies for ES assessment and applies them to the case studies. Ecosystem types are mapped, ES identified, assessed and, where applicable, economically valued and spatially visualized. The results of ES assessment will be a basic resource for the discussion on increasing pro-biodiversity business (PBB) opportunities. Involving various public and private actors into capacity building, networking and know-how transfer, local PBB action plan will be developed by participatory approach. This will contribute to a better balance between nature conservation and local entrepreneurship based on the conservation of biodiversity and awareness on ES. At the time of the compilation of this document, the project is in its first stage, which is why most of the following chapters present concepts, methods or in some cases preliminary results but no final results.

3. Stakeholders' Involvement

In general, the Bükk National Park Directorate is a key stakeholders in the region. Its main task is to secure the good state of natural ecosystems, which can provide a wide range of ES. As a non-authority public body they need to cooperate with many regional partners in order to be successful in fulfilling this task. It also authorizes the use of the 'National Park Product' brand for products primarily made from local materials and ingredients. Public awareness-raising, education, introduction of natural values and eco-tourism as well as organization and management of research programmes are also important tasks of BNPD.

More specifically, within the Eco Karst project, assessment of ecosystem services, development of local action plans and the facilitation of pro-biodiversity businesses is directly related to stakeholder involvement. The goal of the process is to involve a big enough group of local people with diverse backgrounds, economic status, expertise and experience. High diversity improves the quality of work significantly, representative selection of stakeholders is important to define goals which are feasible on the longer run. The below steps are followed.

Step 1: Identification of major stakeholder groups and the most important ESs they interact with. This was done by the national park administration, based on their knowledge of the area (Figure 4).

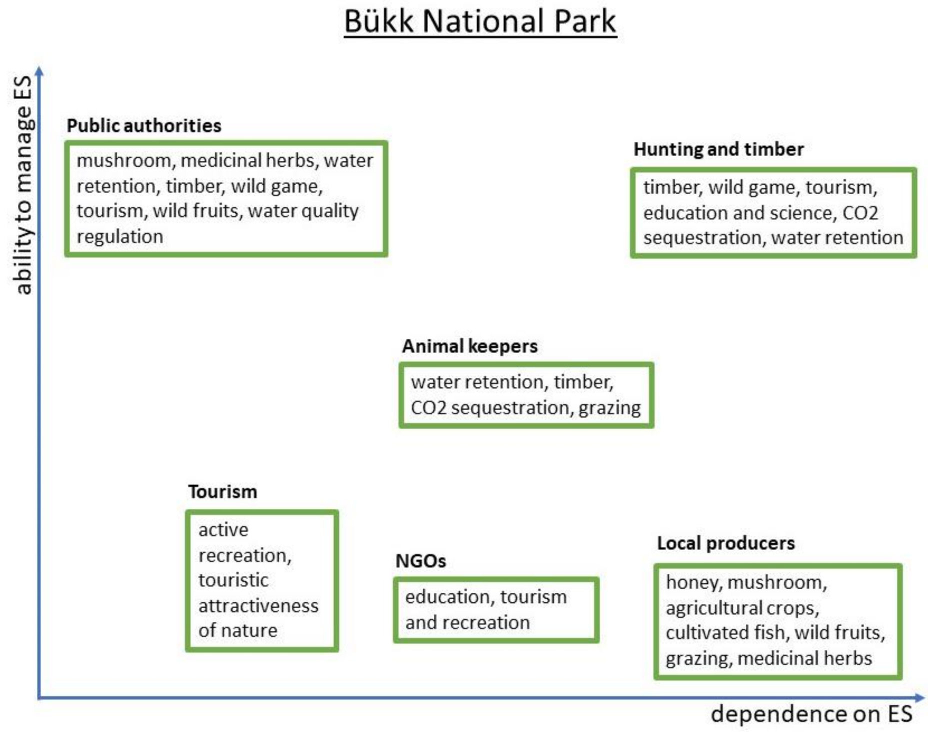


Figure 4. Major stakeholder groups of the Bükk NP and the most important ESs they interact with.

Step 2: Stakeholder selection with social network analysis. This method intends to select a relevant sample for larger workshops, where a larger group and the highest possible diversity of views is desirable. The process consists of two main steps: (1) data collection with a simple survey (see questionnaire in Annex 1) and (2) creation of network layout and identification key players among respondents (Figure 5). The network layout is drawn by Gephi, which is an open-source network-layout designer software.

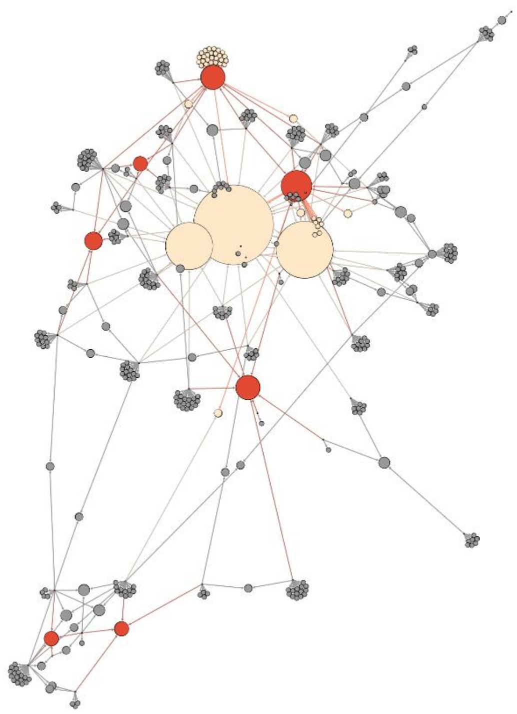


Figure 5. First preliminary graph of the social network in Bükk, based on online survey of stakeholders. Nodes represent people or organizations, edges represent communication.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

The goal of ecosystem type mapping is to provide the necessary spatial units and basic input for the ES assessment and mapping. The input requirements may differ for the different services and thus the typology and scale of the ecosystem type map needs to be chosen carefully. In this project we use categories of EUNIS level 3. After assembling available information (e.g. existing vegetation/habitat maps) a conversion table was created, where each original class was assigned a EUNIS category. See the conversion workflow in Figure *6.6* and the resulting map in Figure 7.

For most ES, further specific customization of the ecosystem type map is necessary. In most cases 'customizing' means a simplification, in order to reduce the number of categories to be considered. It is most easily done by merging some classes. Since in Eco EUNIS is a hierarchical classification, in case of certain ecosystem services we can simply consider using the EUNIS level 2 categorisation of our maps, rather than level 3. But it is also possible to choose other considerations on how to merge the categories according to the ecosystem service we are working with. Technically the simplest way of carrying out this merging of categories is to create a conversion table (old categories → new categories) and join it to the original ecosystem type map layer. This would not necessarily mean a physical merging of habitat patches, only a reclassification added to the attribute table of the map.

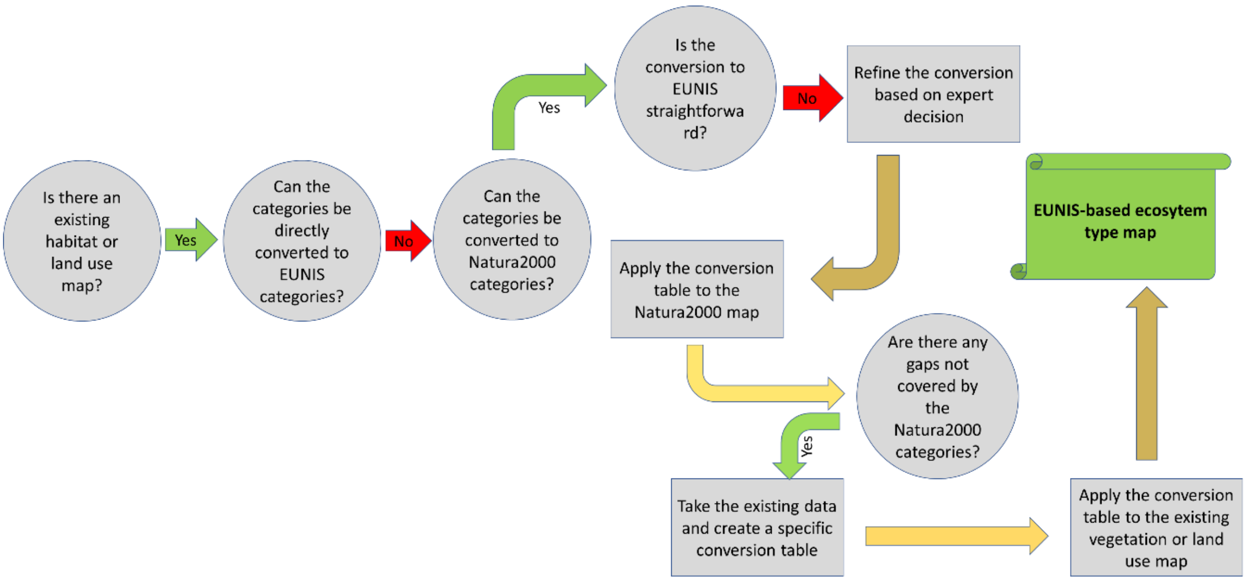


Figure 72. Workflow for creating ecosystem type map of the Bükk NP

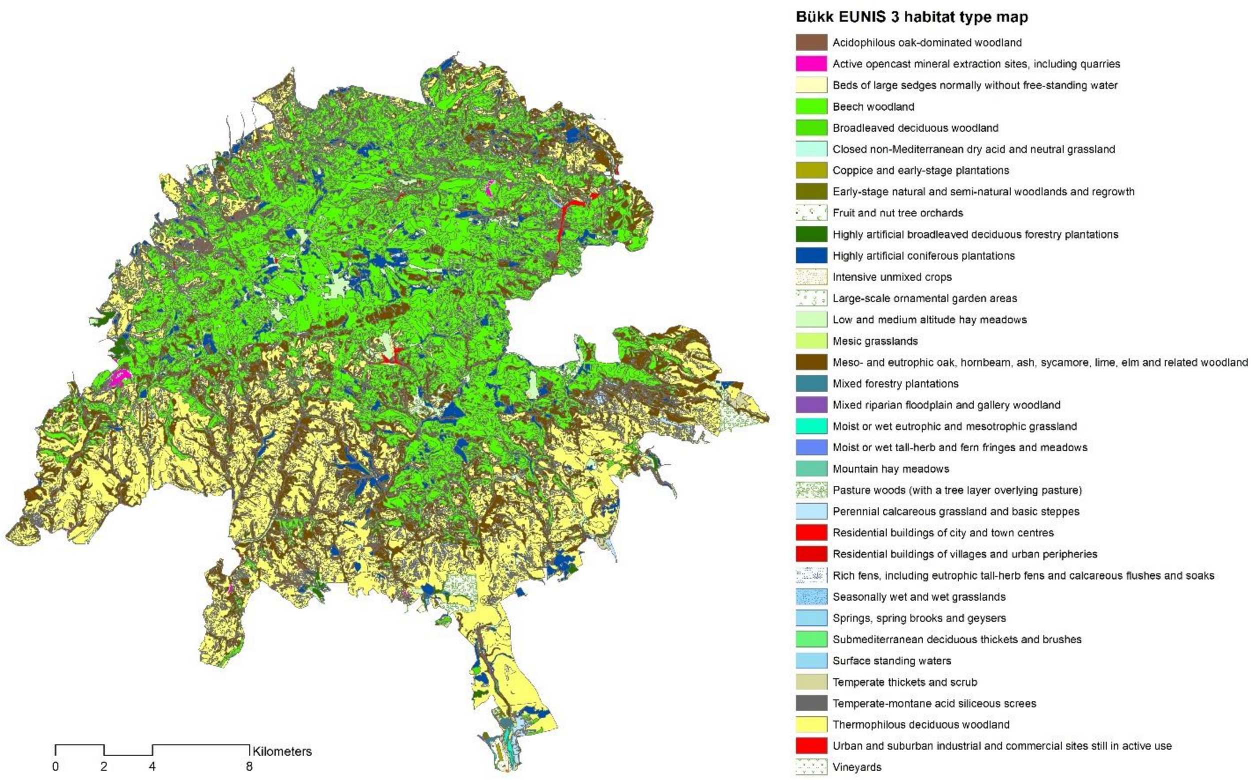


Figure 7. EUNIS 3 ecosystem type map of the Bükk National Park.

4.2. Assessing ecosystem conditions

A simple model of habitat condition (Figure *6.15*) is being developed in the project for mapping ecosystem condition, using naturalness values assigned to ecosystem types and a single modification factor based on the number of protected vascular plant species present in each patch. The method follows the one used in the mapping and evaluation of ecosystem services of Luxembourg by Becerra-Jurado et al. (2015). The naturalness map will be used as input data for the ES maps. The model has the following main components:

- In the first step, all the ecosystem types were assigned a general naturalness value
- In the second step, this categorisation was further refined on the basis of the number of protected species found in each polygon. Modification factors were defined according to the number of protected species present in the polygon: a polygon with 0 or 1 protected species gets 0 as a modification factor, 2-7 species +1 and more than 8 species +2. The scores and the modification values were then added up. In the final step we reclassified the resulting values so that the scale remains 1-5 (in this case values of 6 or 7 were reclassified to 5).

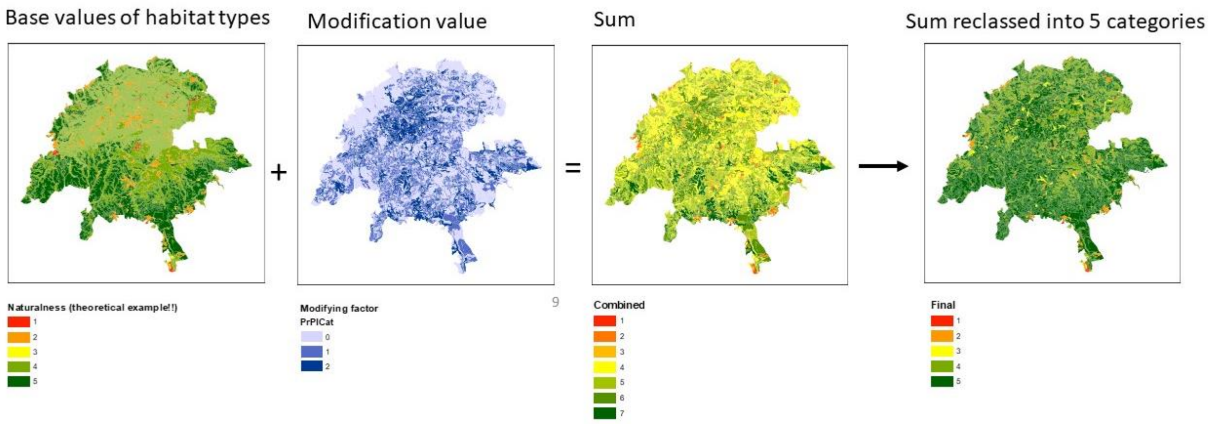


Figure 74. Components of habitat condition map of the Bükk National Park.

4.3. Selecting Ecosystem Services

As a first step, semi-structured interviews with experts of the pilot area were carried out to collect preliminary information on the dominant natural characteristics and land use. An initial list of ES was derived corresponding to the Common International Classification for Ecosystem Services (CICES, v5.1, www.cices.eu). This list was slightly customized (some ES split or merged) to a list of 15 ES as subject of prioritization.

To enable a comparable, comprehensive and documented ES prioritization which takes several aspects into consideration, a list of selection criteria was drawn (see Table 3). These criteria are listed in the below textbox. The adjusted list of ecosystem services was assessed one by one against the selection criteria, estimating whether a certain ES is relevant or not (scoring 1 or 0) considering each criteria. This resulted in an aggregated score of 'relevance' for each service. Based on these aggregated scores, ES could be ranked according to their relevance in the area.

Table 3. Criteria for prioritization and selection of ecosystem services

1. **Ecosystem types concerned**
   a. can be linked to specific karst ecosystems
   b. can be linked to an ecosystem type of large land surface within the pilot area
   c. can be linked to an ecosystem type of small land surface, but high conservation value
2. **Benefits for local people**
   a. provides economic benefit for the local economy (in terms of jobs or GDP)
   b. provides non-marketed livelihood for local people (e.g. grazing animals for self-sustaining, collecting mushrooms)
   c. has a high capacity for benefit which is still underutilized, predicting a potential for PBB development
3. **Local relevance**
   a. important in the perception of local people e.g. cultural heritage, local customs and events, local identity
   b. is part of an important local issue in some way, e.g. subject of development plan or land use conflict
4. **Relation to other ES**
   a. is inherently bundled with one or more other ES, thus its assessment can indirectly provide information for those too
   b. is in trade-off with one or more other ES, thus its assessment can indirectly provide information for those too

The following list shows the 7 highest ranked ES selected for mapping and assessment.

1. touristic attractiveness of nature
2. water quality protection (pollutant removal, drinking water quality)
3. timber and firewood provision
4. hay and fodder provision (output of grazing livestock)
5. agricultural crop provision
6. medicinal herbs
7. carbon sequestration and storage

Table 11. Overview of the ES and related mapping and assessment methods in Hungary case study

Ecosystem Service selected for mapping and assessment	B	S	E
Agricultural crop (1.1.1.1)			
Animals reared to provide nutrition, fibres and other materials (1.1.1.2, 1.2.1.2)			
Timber and firewood (1.2.1.1)			
Medicinal herbs (1.1.1.3, 1.2.1.1)			
Water quality protection (pollutant removal, drinking water quality) (2.1.1.2)			
Carbon sequestration and storage (2.3.5.1)			
Touristic attractiveness of nature (3.1.1.1, 3.1.1.2)			

* ES selected for further discussion during ESMERALDA workshops 8 in Eger, Hungary;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

The simplest models are compiled with local experts using the ES **matrix model,** assigning values to certain land use/land cover classes for each ecosystem service. Instead of data, the necessary information is provided directly by experts or stakeholders in the form of synthetic judgements. Local experts assign scores from 1 to 5 to the capacity of specific habitats to provide different services.

In Eco Karst, most of our models are rule-based **extended matrix model**. Besides (or in some cases, instead of) the baseline expert matrix, indicators are calculated using either a statistical model or a set of rules linking the value of the indicator to additional background variables. The variables included in the models are based on expert recommendations or international literature, so that the models take into account additional environmental factors (e.g. the altitude of a given location). Data should be available at the required spatial resolution and they should determine the value of the indicator (at least to a certain degree) or be correlated to it. We design specific workflows to ease the creation and visualization of matrix results using ArcGIS and Excel. In order to avoid repeating processes for similar ES models, and also for better documentation, we create workflows in ArcGIS ModelBuilder. As a final step resulting scores are estimated in terms of physical quantities (e.g. m3 wood/ha/year). A general overview of the model is shown in Figure 75.Detailed models for the two ES discussed in the Esmeralda workshop (touristic attractiveness of nature; hay and fodder provision) are in Annex 2 and 3.

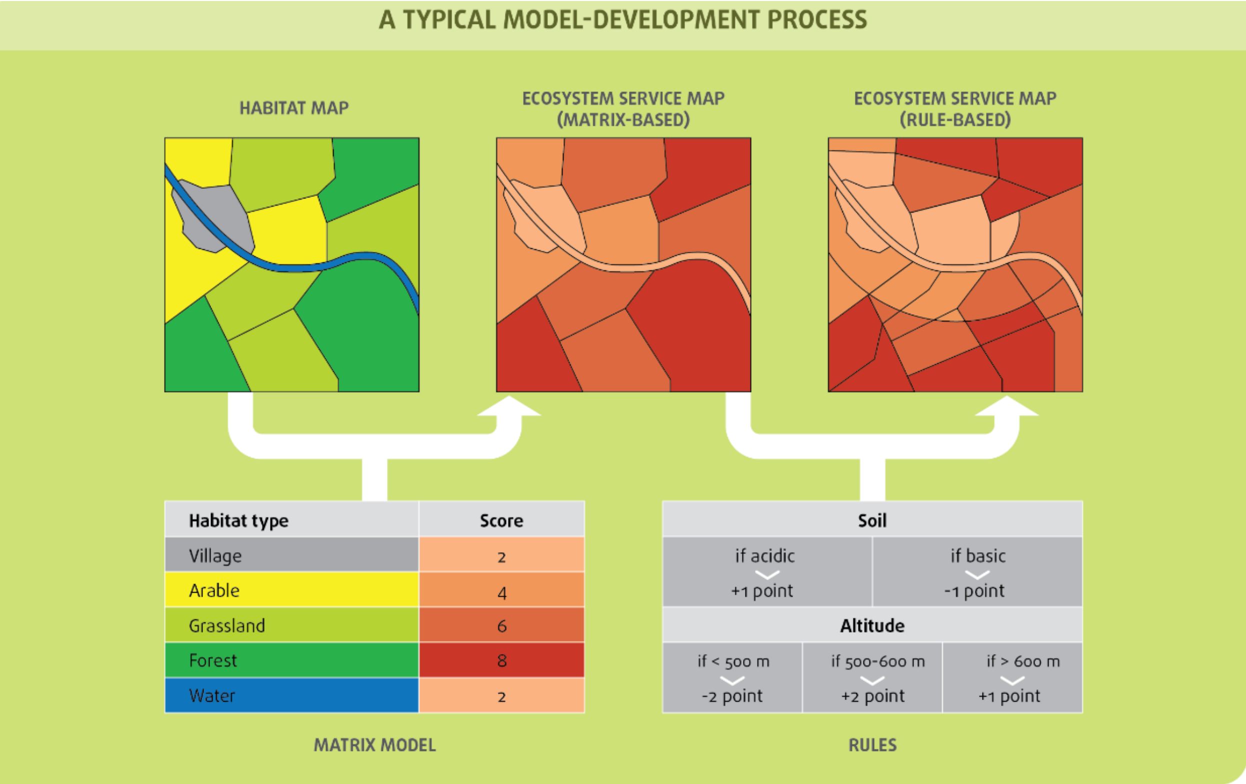


Figure 75. ES extended matrix model scheme.

5.2. Socio-cultural methods for ES mapping and assessment

Socio-economic methods are used at the integration and implementation stage of this project, see 1.5.1.

5.3. Economic methods for ES mapping and assessment

Within the Eco Karst project the potential and actual use of ecosystem services are compared in order to identify the gap between the two. The economic valuation of ESs is able to quantify the value stemming from the actual use of ESs. For all ES we use market price method, being the most straightforward approach within the scope of this study. However, we are aware that there are certain limitations of such valuation. First, it does not show if the use of ESs is sustainable or not. Second, statistical data is not always available or limited for even provisioning services therefore, other data sources are needed for precise calculation. Third, market prices can be used only for those ESs and only for those amounts that appear in the market (e.g. producing for family consumption or grey economy are excluded). When using economic valuation results in decision making, it is important to reflect on the limitations of the methods.

Final calculations of economic valuation are not available at the time of compiling this document. However, we can share the concept and methods already. In Annex 4, we present 3 potential indicators for the economic valuation of the ES natural forage and fodder. To avoid double counting, only one of these indicators will be selected and calculated.

5.4. Integration of ES mapping and assessment results

One of the main objectives of the project is to explore and verify pro-biodiversity business (PBB) potentials and create a local action plan for new PBB development with the active participation of stakeholders, in particular SMEs. A pro-biodiversity business (PBB) is dependent on biodiversity for its core business and through that, business effects contributes to biodiversity conservation. ES maps and valuation provides crucial information to ensure that the resulting action plans are indeed sustainable and support biodiversity. The below path is followed in order to effectively influence business decisions.

1. A gap analysis comparing biodiversity-related businesses in the case study area with international best practice PBB examples from different sectors will explore the current situation and form the basis for identifying new and innovative biodiversity-based business opportunities. Its focus will be on sectors identified as irrelevant, such as forestry, non-timber forest products, agriculture and tourism, and mainly on SMEs which play a key role in the development of PBB. The gap analysis will explore the current situation and allow identifying new and innovative biodiversity-based business opportunities in the pilot karst areas. Methodological approaches and results of previous and ongoing projects on PBB such as the Biodiversity Technical Assistance Unit (BTAU) EU project and the work under the Workstream INNOVATION FOR BIODIVERSITY AND BUSINESS of the EU Business@Biodiversity Platform will be integrated into the design of activities. Further, national business and biodiversity initiatives as well as the CBD Global B+B Platform will provide the latest innovative biodiversity-based business examples.
2. Two workshops will be organized with the relevant business-related stakeholders to verify the feasibility of PBB ideas suggested by the gap analysis, and to examine new business models that use existing ES more sustainably and secure local livelihoods. To enable that, a participatory multi-criteria analysis will be completed, creating the 'missing link' between local ES assessments and the PBB action plan. In this analysis, developed based on the impact matrix of Martinez-Alier and his colleagues, alternative scenarios are compared to each other as well as to the present status, such as the single ES maximized (intensive land use), multiple ES optimized (sustainable land use) biodiversity maximized (conservation) and land use change scenario. These theoretical scenarios are compared along a pre-defined set of criteria: biodiversity impact, monetary value of ES and emergent opportunities (including the potential of new PBBs) and challenges, repeated in the aspect of all relevant ES. After completing the assessment for each individual ES, a summary table is compiled allowing the assessment of overall effect, opportunities and trade-offs of the scenarios. When considering opportunities and requirements of local PBB development, results of the above analysis will allow a strategic context at national park level. The business opportunities identified as viable and sustainable will be further screened with regard to potential challenges, needed competences and conditions, like financial requirements, capacity building, market access, incentives, etc. Workshop result will be a refined list of potential PBBs and agreed next steps to analyse the ideas viability.
3. In the second pilot area workshop the realization of identified business opportunities will be discussed and further developed with chambers of commerce, associations, land owners and local communes. This will verify the feasibility of business ideas and motivate all involved actors to support new PBB, remove obstacles and plan the next steps.

6. Dissemination and communication

The project has a strong communication activity targeting a large range of external stakeholders (local authorities, agencies, higher education, research, SMEs and NGOs) and aiming to achieve a change in at least one of the following three characteristics: knowledge, attitude and practice. For that, a number of communication channels are used from scientific publications and conferences to press releases social media, at levels from local to international. In particular, all the participating stakeholders from the pilot areas will at the end of this activity receive a PBB Development Guide.

7. Implementation

All participating stakeholders from the pilot areas will receive a PBB Development Guide at the end of this activity. This Guide will inform on factors of success of existing best practice examples (cross-sectoral/ sector specific), relevant steps for developing a PBB, and legal requirements to be considered. The guidance will also be applicable for businesses outside the pilot areas. A 'Best PBB idea' title is awarded across the seven pilot areas of the project. Owners of this idea will be given professional help for its realization.

8. References & Annexes

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Annexes

Annex 1. Social Network Survey questionnaire

Social Network Survey questionnaire

The following information will be used to understand how people communicate within/around the area of Bükk National Park about the use of natural resources. After processing the data, it will be treated ***anonymous****, no personal answer will be shared with anyone outside the project team. The results will only be published or presented in a form where no respondent can be identified.*

Your name:	
Your organization:	
Your settlement:	
Your occupation:	

Do you communicate with any institutional player on natural resources usage in the Bükk National Park? Please list up to 5 institutions:

Name	**Organization**	**Settlement**	**Occupation**

Do you communicate with anyone from animal keepers on natural resources usage in the Bükk National Park? Please list up to 5 names:

Name	**Organization**	**Settlement**	**Occupation**

The above table is repeated in the questionnaire 4 more times referring to the following sectors: hunting and forestry, NGOs, local producers, tourism.

Annex 2. Detailed model of the ES hay and fodder provision

Natural forage and fodder (hay)

Definition: Potential forage supply provided by the ecosystems through mowing or grazing. Cultivated or marketed roughage and grain feed are not included while grazing on fallow land and stubble as well as plants spontaneously occurring on waysides and banks are included in this service.

Workflow

➢ Data pre-processing:
- define categories of soil fertility based on the soil types of the soil map
- create grazing pressure categories for pastures based on land use data (e.g. livestock number)

➢ organize a mini-workshop with 2-4 local farmers to set up the ES model:
- create a customized **ecosystem type map** optimized for hay provision (merge some habitat types and potentially divide others)
- **score** hay provision capacity along a relative scale (1-5) for the customized **ecosystem types**

➢ Rules according to expert judgement, identify rules modifying the scores:
- elevation (example: >500 m: +0.5 score)
- soil fertility (example: low soil fertility: -0.5 high soil fertility: +0.5)
- biodiversity (example: lower tertile scores: -0.5 upper tertile scores: +0.5)
- grazing intensity (example: high: -0.5 very high: -1)
- slope steepness (example: steep (11-27°): -0.5 very steep (>27°): -1)

fix the scale: transform scores into fodder units (FU) which serves as a basis for transforming capacity scores into benefit volumes (e.g. hay, sheep/mutton, cattle/beef, milk) /ha/yr

➢ Create draft map
based on the established model

➢ Calibrate and if necessary, fine-tune the yield potentials calculated by the model with literature data / statistical data / additional expert consultation

➢ Validate the draft map on the stakeholder workshop
if needed, modify the scores and rules according to the suggestions of validation

➢ Create final map

Potential pitfalls
Separate scoring for pasture and meadow might be reasonable in some cases. Uncertainties of the results might be high due to the uncertainties of the input maps (habitats and soil), the transformation to fodder units, and the ambiguities in the fodder unit approach itself.

*Input data **
- ecosystem type map
- biodiversity (condition indicator prepared for all pilots)
- grazing intensity (based on land use data in sites dominated by grazing, in pilots where overgrazing or abandonement of pastures is an issue)
- soil fertility (based on soil type)
- elevation (digital elevation model)
- steepness (digital elevation model)

** consult with experts which are needed*

Expert involvement
individual consultations:

data pre-processing phase:
- identification of soil fertility categories of soil types (individual soil expert)
- identification of grazing pressure categories (individual agriculture expert)

calibration phase:
- farming expert (preferentially the participant of the mini-workshop) to calibrate and fine-tune the yield potentials calculated by the model

mini-workshop with local farmers (persons selected according to their experience and overview of the whole area):
- establish the ES model
- wider representation of stakeholders for validation of the result map

Data templates provided by MTA ÖK
- definition of input data classes and categories and necessary location accuracy
- xls template

Annex 3. Detailed model of the ES touristic attractiveness of nature

Touristic attractiveness of nature (tourism)

Definition: ecological or landscape features and attributes that attract people for recreational or cultural activities

Workflow

➢ Data pre-processing:

- simplify habitat type map, if needed
- calculate landscape diversity, distance from water, distance from specific features

➢ organize a mini-workshop with 2-4 local experts to set up the ES model:

- assign a base attractiveness score (e.g. from 1-5: worst →best) to each habitat type based on expert decision

➢ Rules

define the rules for each modifying factor
(Example - distance from water:
<100 m: +8
100-200 m: +6
200-500 m: +4
500-1000 m: +2)
if ecosystem type-specific species are used, assign each pool to the habitat types
assemble the point data of the chosen species
fill in data gaps with expert help, if possible

➢ Create draft map

based on the established model

➢ validate the draft map on the stakeholder workshop

if needed, modify the scores and rules according to the result of validation

➢ Create final map

Input data *

- habitat type map
- habitat condition (e.g. the biodiversity-based condition map or other relevant indicator e.g. forest age / tree size /etc)
- landscape diversity (generated from habitat type map, e.g. using a moving window)
- point data of species observations
- elevation
- distance from water
- distance from specific (natural) features of interest (e.g. caves, rock formations, etc)
- accessibility (not strictly nature-related but very relevant)

* consult with experts *which are needed*

Expert involvement

- Experts or stakeholders should be consulted concerning the scoring and the creation of the rules, possibly in the frames of a mini-workshop.
- Wider representation of stakeholders are involved for validation of the result map during the stakeholder workshop.

Data templates provided by MTA ÖK

- guide for facilitators

Potential pitfalls

Accessibility is not nature's contribution. However, it should not be entirely left out, because it very strongly defines where the tourists can go.
Possible solution: accessibility could be included as the last step and two maps could be generated - with and without

Annex 4. Economic valuation options of the ES hay and fodder provision

INDICATOR 1: ECONOMIC VALUE OF FODDER/FORAGE	INDICATOR 2: ECONOMIC VALUE OF THE MEAT OF GRAZED ANIMALS	INDICATOR 3: ECONOMIC VALUE OF THE MILK OF GRAZED ANIMALS
COMPONENTS OF THE INDICATOR		
- fodder produced in the area (by type) (kg),	- annual meat production in the area (by type) (kg)	- annual milk production in the area (by type) (l),
- annual sale of fodder (by type) (kg),	- annual number of live animals sold by type (kg)	- annual sale of milk (by type) (l),
- price of fodder sold (by type) (local currency, Euro)	- annual sale of meat (by type) (kg)	- producer/consumer price of milk sold (local currency, Euro)
	- annual sale of live animals by type (kg)	
	- producer/consumer price of meat sold (local currency, Euro)	
DATA COLLECTION		
- local or regional statistical data,	- local or regional statistical data,	- local or regional statistical data,
- data from farmers and professional associations,	- data from meat or animal-breeder associations,	- data from milk associations,
- data of local markets	- data of local markets	- data of local markets
CALCULATION		
OPTION 1:	OPTION 1: If animals are sold in producer market (in larger quantities, without further processing):	OPTION 1: If milk is sold in producer market (in larger quantities, without further processing):
Revenue from fodder production = quantity of fodder (kg/year) * **producer price** (local currency/kg, annual average).	Annual revenue from meat production from animal grazing= quantity of meat (kg/year) * **producer price** (local currency/kg, annual average).	Annual revenue from milk production = quantity of milk (l/year) * **producer price** (local currency/kg, annual average).
cost of fodder production = quantity of fodder (kg/year) * estimated value unit cost (EUR/kg) of fodder production estimated by the producers	Annual cost of meat production = quantity of meat (kg/year) * estimated unit cost (EUR/kg) of meat production estimated by the farmers/animal breeders	Annual cost of milk production = quantity of milk (l/year) * estimated unit cost (EUR/l) of milk production estimated by the milk producers
Economic value of fodder = revenue - cost.	Annual economic value of meat = annual Revenue – annual cost.	Annual economic value of milk = annual revenue – annual cost.
	OPTION 2: If meat is sold in consumer market (smaller quantities, individually packaged, sold by kilograms)	OPTION 2: If milk is sold in consumer market (smaller quantities, individually packaged)
	Annual revenue from meat production from animal grazing= quantity of meat (kg/year) * **consumer price** (local currency/kg, annual average).	Revenue from milk production = quantity of milk (l/year) * **consumer price** (local currency/kg, annual average).
	Annual cost of meat production = quantity of meat (kg/year) * estimated unit cost (EUR/kg) of meat production estimated by the farmers/animal breeders	cost of milk production = quantity of milk (l/year) * (estimated value) the unit cost (EUR/l) of milk production estimated by the milk producers
	Annual economic value of meat = annual revenue – annual cost.	Economic value of milk = revenue - cost.

METHOD APPLICATION CARD: SPATIAL PROXY METHOD (RULE-BASED MATRIX MODEL) Applied to: Animals reared to provide nutrition, fibres and other materials (1.1.1.2, 1.2.1.2)	
CASE STUDY	HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park
SCALE	Local
TYPE	Biophysical
TIER	2

DESCRIPTION

In order to create maps of ecosystem condition or services, spatially explicit input data are needed. Models link biophysical data spatially represented by input maps with variables (indicators) describing the ecosystems with respect to a specific aspect of their condition, or their capacity to provide a certain ES.

Due to their simplicity and flexibility matrix models are a particularly popular ES assessment technique (Burkhard et al. 2010, Jacobs et al. 2015). The only spatial input to the model is the ecosystem map (or a similar simple categorical map, e.g. a land cover/land use map, or a habitat map) of the study area. The model itself is no more than a simple lookup table ('matrix') which links the ecosystem types to indicator scores. Matrix models are ideal for participatory model building involving local experts, but there are also several other ways to populate the matrix with scores (e.g. Bagstad et al. 2013).

Rule-based matrix models are an extension to matrix models. By identifying additional relevant spatial input data and including them into map calculation operations the rough maps resulting from a matrix model can be highly refined. Similarly to matrix models, the transparency and intuitiveness of this model type can facilitate expert involvement. If experts are used for setting the rules and verifying the model outputs then the resulting models can also be called expert models (Wainger and Mazzotta 2011).

Resources:

- Bagstad K, Johnson G, Voigt B, Villa F (2013) Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. Ecosystem Services 4: 117-125. https://doi.org/10.1016/j.ecoser.2012.07.012
- Burkhard B, Kroll F, Müller F (2010) Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover based Assessments. Landscape Online 1-22. https://doi.org/10.3097/LO.200915
- Jacobs S, Burkhard B, Daele TV, Staes J, Schneiders A (2015) 'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services. Ecological Modelling 295: 21-30. https://doi.org/10.1016/j.ecolmodel.2014.08.024
- Waigner L, Mazzotta M (2011) Realizing the Potential of Ecosystem Services: A Framework for Relating Ecological Changes to Economic Benefits. Environmental Management 48 (4): 710-733. https://doi.org/10.1007/s00267-011-9726-0

1. DATA REQUIREMENT

Qualitative	• Expert knowledge
Quantitative	• Ecosystem type map • Spatially explicit data on influential factors identified as relevant by experts, e.g. management intensity, local statistical data on actual land use, literature data, digital terrain model, biodiversity indicator, soil fertility, hydrography etc.

2. RESOURCES REQUIREMENT

Time	• Organizing expert workshops requires preparation and follow-up, time demand depending on the extent and efficiency of existing networks • Data preparation and setting up the model takes additional time before and after the expert workshops
Cost	• ArcGIS license is costly, however the analysis can be run with free GIS software alternatively
Expertise	• Social sciences background might be beneficial for facilitating expert knowledge elicitation • GIS software expertise required for preparing the data • ES expertise required for setting up the model
Tools & equipment	• ArcGIS model builder (alternatively QGIS) or QuickScan

3. LINKS AND DEPENDENCY ON OTHER METHODS

Biophysical	• If primary measurements of tier 3 model results are available for a smaller included area, it can be used for model calibration and validation of the results.

Socio-cultural	• The method is highly dependent on the careful selection of involved experts to set up and validate the model. The selection can be based on social network analysis (SNA). Results of the rule-based matrix model method can be used by several socio-cultural methods, e.g. scenario development.
Economic	• If the scores are translated into biophysical unit values, economic valuation of the ES with market price method is possible.
4 COLLABORATION LEVEL	
Researchers own field	• --
Researchers other fields	• GIS • depending on the model rules, involvement of researchers in agriculture might be beneficial
Non-academic stakeholders	• Experts with experience and overview of the capacity and actual use of the particular ES at the relevant level has to be identified and involved, e.g. animal keepers, agricultural advisors, representatives of agricultural associations etc.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• The method is applicable at all levels, however ecosystem type map has to be adjusted to, as well as representation of experts has to reflect the required level
Regional	• Applicable, see above
National	• Applicable, see above
Pan European	• Applicable, see above
6. EXAMPLES OF POLICY QUESTION	
• What is the potential of the area to supply grazing livestock with fodder or hay? • What are the most relevant environmental or land use factors that influence this capacity? • How does the ES capacity relate to the actual use of the service? • (in case several ES are mapped with the method at the same time) What are the trade-offs and synergies between ES?	
Suggested Citation: Arany, I., Kallay, T., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHODS (RULE-BASED MATRIX MODEL) applied to "Animals reared to provide nutrition, fibres and other materials (1.1.1.2, 1.2.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: SPATIAL PROXY METHODS (RULE-BASED MATRIX MODEL) Applied to: Touristic attractiveness of nature (3.1.1.1, 3.1.1.2)	
CASE STUDY	HUNGARY: ES mapping and assessment for developing pro-biodiversity businesses in the Bükk National Park
SCALE	Local
TYPE	Biophysical
TIER	2
DESCRIPTION	
In order to create maps of ecosystem condition or services, spatially explicit input data are needed. Models link biophysical data spatially represented by input maps with variables (indicators) describing the ecosystems with respect to a specific aspect of their condition, or their capacity to provide a certain ES. Due to their simplicity and flexibility **matrix models** are a particularly popular ES assessment technique (Burkhard et al. 2010, Jacobs et al. 2015). The only spatial input to the model is the ecosystem map (or a similar simple categorical map, e.g. a land cover/land use map, or a habitat map) of the study area. The model itself is no more than a simple lookup table ('matrix') which links the ecosystem types to indicator scores. Matrix models are ideal for participatory model building involving local experts, but there are also several other ways to populate the matrix with scores (e.g. Bagstad et al. 2013). **Rule-based matrix models** are an extension to matrix models. By identifying additional relevant spatial input data and including them into map calculation operations the rough maps resulting from a matrix model can be highly refined. Similarly to matrix models, the transparency and intuitiveness of this model type can facilitate expert involvement. If experts are used for setting the rules and verifying the model outputs then the resulting models can also be called expert models (Wainger and Mazzotta 2011).	

Resources:

- Bagstad K, Johnson G, Voigt B, Villa F (2013) Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. Ecosystem Services 4: 117-125. https://doi.org/10.1016/j.ecoser.2012.07.012
- Burkhard B, Kroll F, Müller F (2010) Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover based Assessments. Landscape Online 1-22. https://doi.org/10.3097/LO.200915
- Jacobs S, Burkhard B, Daele TV, Staes J, Schneiders A (2015) 'The Matrix Reloaded': A review of expert knowledge use for mapping ecosystem services. Ecological Modelling 295: 21-30. https://doi.org/10.1016/j.ecolmodel.2014.08.024
- Waigner L, Mazzotta M (2011) Realizing the Potential of Ecosystem Services: A Framework for Relating Ecological Changes to Economic Benefits. Environmental Management 48 (4): 710-733. https://doi.org/10.1007/s00267-011-9726-0

1. DATA REQUIREMENT	
Qualitative	• Expert knowledge
Quantitative	• Ecosystem type map • Spatially explicit data on influential factors identified as relevant by experts, e.g. accessibility (distance from roads and from tourism infrastructure), distance from water, habitat naturalness, landscape diversity, distance and density of specific natural features of interest etc.
2. RESOURCES REQUIREMENT	
Time	• Organizing expert workshops requires preparation and follow-up, time demand depending on the extent and efficiency of existing networks • Data preparation and setting up the model takes additional time before and after the expert workshops
Cost	• ArcGIS license is costly, however the analysis can be run with free GIS software alternatively
Expertise	• Social sciences background might be beneficial for facilitating expert knowledge elicitation • GIS software expertise required for preparing the data • ES expertise required for setting up the model
Tools & equipment	• ArcGIS model builder (alternatively QGIS) or QuickScan
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• If primary measurements of tier 3 model results (e.g. ESTIMAP recreation module) are available for a smaller included area, it can be used for model calibration and validation of the results.
Socio-cultural	• The method is highly dependent on the careful selection of involved experts to set up and validate the model. The selection can be based on social network analysis (SNA). Results of the rule-based matrix model method can be used by several socio-cultural methods, e.g. scenario development.
Economic	• The method can be well complemented by any economic valuation method relevant for the touristic attractiveness of nature, e.g. travel cost method.
4 COLLABORATION LEVEL	
Researchers own field	• --
Researchers other fields	• GIS • depending on the model rules, involvement of social scientists might be beneficial
Non-academic stakeholders	• Experts with experience and overview of the capacity and actual use of the particular ES at the relevant level has to be identified and involved, e.g. tour operators, nature tourism guides, land managers, representatives of outdoor sports associations and relevant authorities etc.
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• The method is applicable at all levels, however ecosystem type map has to be adjusted to, as well as representation of experts has to reflect the required level
Regional	• Applicable, see above
National	• Applicable, see above
Pan European	• Applicable, see above
6. EXAMPLES OF POLICY QUESTION	
• What are the most attractive features (or combination of features) of the area for nature tourism?	

- How does the potential attractiveness relate to the actual number of visits? Is the potential over- or underexploited?
- How can a balanced strategy be created which benefits both local income and biodiversity protection?
- (in case several ES are mapped with the method at the same time) What are the trade-offs and synergies between ES?

Suggested Citation: Arany, I., Kallay, T., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHODS (RULE-BASED MATRIX MODEL) applied to "Touristic attractiveness of nature (3.1.1.1, 3.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.

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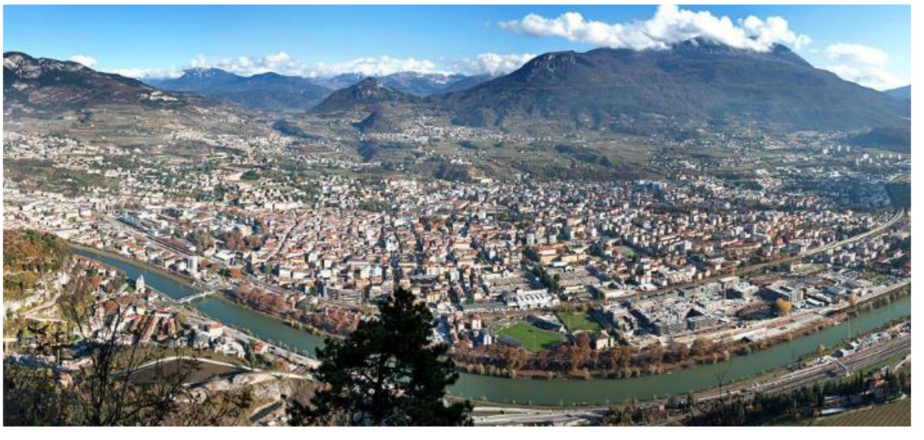
CASE STUDY BOOKLET



ES mapping and assessment for urban planning in Trento

June 2018

ESMERALDA partner: University of Trento, UNITN

Case Study Coordinators: Davide Geneletti, Chiara Cortinovis, Linda Zardo, Blal Adem Esmail

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Geneletti, D., Cortinovis, C., Zardo, L., Adem Esmail, B., (2018). Case Study Booklet: ES MAPPING AND ASSESSMENT FOR URBAN PLANNING IN TRENTO prepared for "WS 7 - Testing the final methods in policy- and decision-making (I)" held in Trento, Italy, 22-25 January 2018. ESMERALDA EC H2020 Grant Agreement no. 642007.

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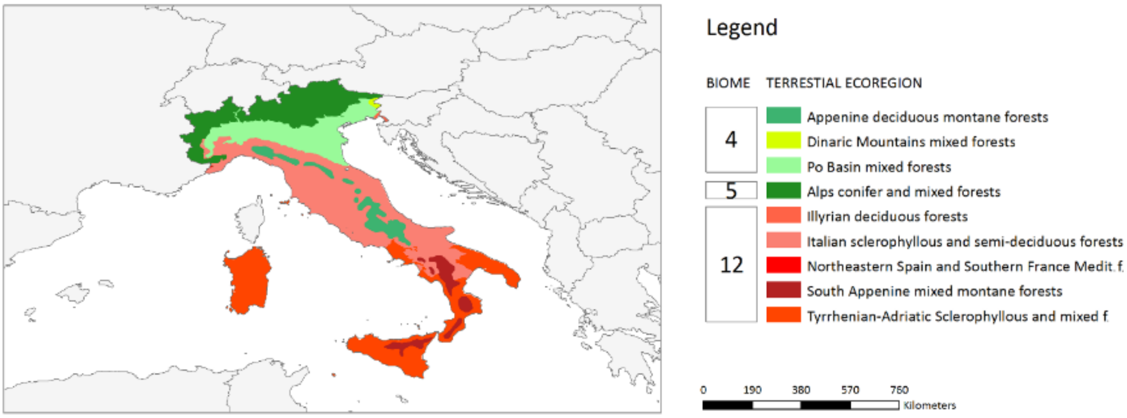
CASE STUDY FACTSHEET

ES mapping and assessment for urban planning in Trento WS7_cs1

NAME AND LOCATION OF STUDY AREA	City of Trento, Trentino Alto Adige, Italy
COUNTRY	Italy

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	156 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

1. Overview of the study area

The city of Trento is located in Northern Italy, in the valley of the River Adige, which flows from the Dolomites to the Adriatic Sea. It is the capital of the Autonomous Province of Trento (Trentino), with a population of around 117,300 inhabitants. The city centre is in the valley floor at 194 m above sea level and hosts around 70% of the population. The remaining 30% lives in small villages spread across the surrounding hills and mountains, which rapidly reach the altitude of more than 2000 m. The local economy is driven by the service industry (around 70% of the local companies) as well as by a quite consolidated public-private partnership. Overall, of the total city area (156 km^2), 22% is covered by urban areas, while forests account for one third of the surface. More than 10 km^2 are natural protected areas, including 7 Natura2000 sites and 3 local reserves.

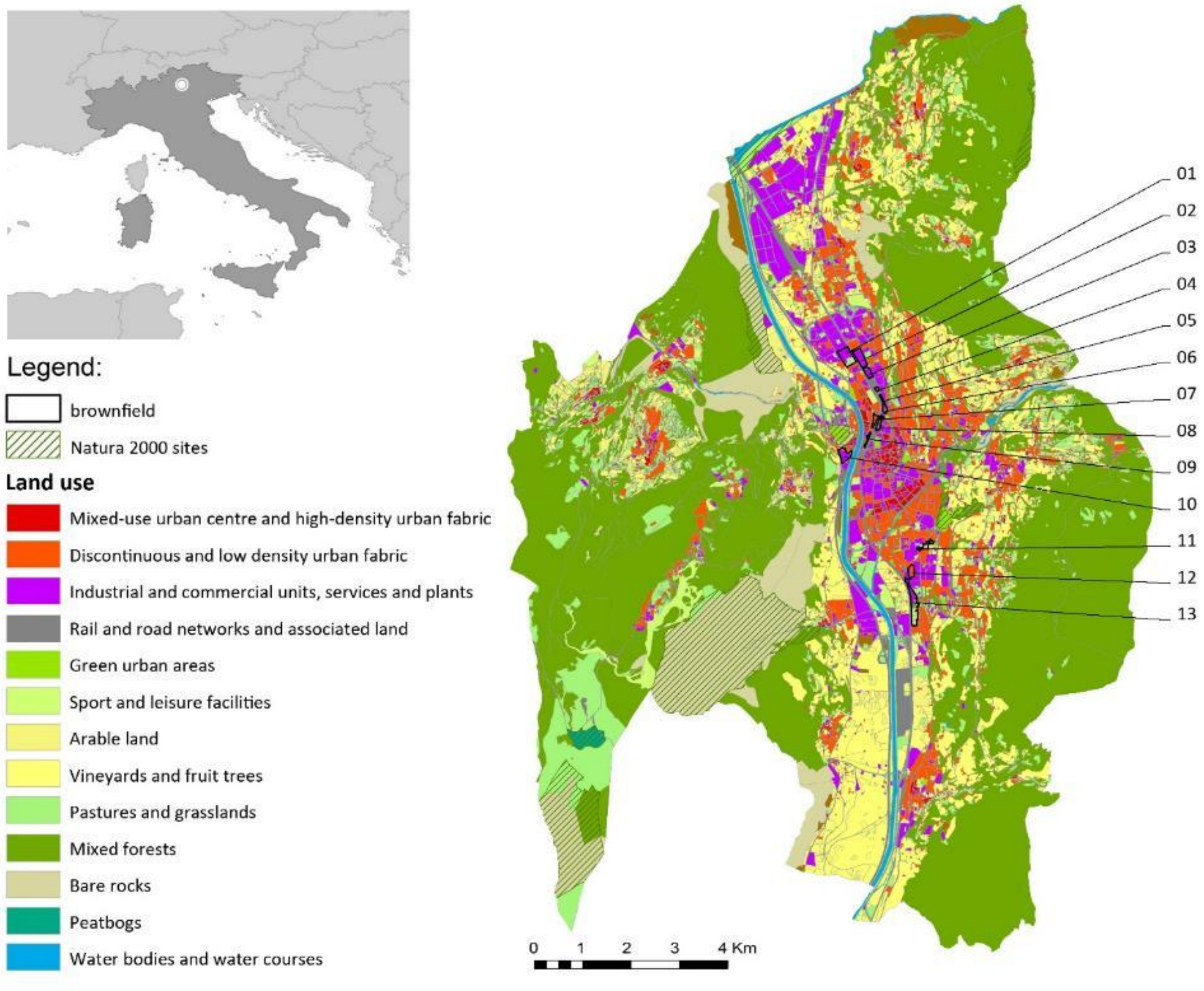


Figure 1.1: Land use map in the Trento case study area and the thirteen brownfields considered in the analysis.

2. Questions and Themes

In its first phases, the present ES mapping and assessment exercise was scientifically-driven; nevertheless, intermediate results have been used to establish an interface with the local administration, and to progressively engage in a shared discussion on urban green infrastructures and ES. Along this process, the study benefitted from the involvement of the city of Trento as a case study in the MAES Urban Pilot (2015-2016) and, later on, in the follow-up project EnRoute (ongoing). From the primary scientific interest of developing and testing credible methods for urban ES mapping and assessment, the aim of the study gradually shifted towards producing relevant knowledge, able to support the local administration in pursuing its objectives of enhancing citizens' wellbeing.

The drafting of the new urban plan, just started in 2017, indeed represents a window of opportunity for the administration to revise and update the strategies regarding urban green infrastructures, as well as an occasion to propose and test the ES approach as a tool to support the planning process. In this context, the scope of an ES mapping and assessment is twofold: first, describing how ES and related benefits produced by urban green infrastructures are currently distributed across the city, and second, supporting the design and assessment of planning actions from an ES perspective.

Among the main challenges for the new urban plan are the redevelopment of brownfields and abandoned areas. Most of them are big urban voids, whose regeneration has been debated for years without finding a proper solution. The actual plan identified 13 brownfields (Figure 1.1), mostly former industrial sites or partially abandoned residential areas, with an extension ranging from 0.5 to 9.9 ha. Due to a mixture of economic, bureaucratical, and technical reasons, the conversion of all of them into new residential or productive areas within the time-frame of the plan is highly unlikely, hence it is possible to hypothesize the conversion of some of them into a (temporary or permanent) green area. Based on their location and dimension, and on the type of intervention proposed, the benefits that could be expected from the intervention are different. The aim of the ES mapping and assessment application was to assess alternative greening scenarios for the redevelopment of brownfields, based on their effects on key urban ES for the city of Trento.

3. Stakeholders' Involvement

Within the ES mapping and assessment process, key staff from the local administration were involved. In the first phases, the interaction was limited to the provision of baseline data and to preliminary, informal discussions on the most pressing issues to address. Later on, also following the requirements of the EnRoute project, a "city-lab" was established composed of members from the city administration and the University of Trento. The city lab was the opportunity for a closer collaboration, grounded on the discussion of preliminary results and of their usefulness for planning and management purposes. This helped identifying key requirements and needs to enhance the usability of the results (e.g., ways of presenting and summarizing information).

From discussions in the city lab the idea of involving other experts in some steps of the ES mapping and assessment process emerged. Thus, 20 people including officers from several municipal and provincial departments, researchers and academics from the university and other research institutions in the city, and local practitioners were asked to provide their opinion through an on-line questionnaire. Later on, most of them agreed to participate in a follow-up table to discuss and validate the results of the ES mapping and assessment exercise.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

Although relatively few data are specifically collected for the purpose of analysing and monitoring urban green infrastructures, the combination of currently available datasets allowed gaining the information necessary for the ES mapping and assessment exercise. The most relevant data were the high-resolution aerial photograph produced in 2015 and the recent land use map purposely-realized by the municipality to provide a base layer for the drafting of the new plan. Other key information was retrieved from the municipal databases of public green areas and public trees. The database of public green areas is a highly detailed mapping of urban green areas managed by the municipality, providing information on all the elements that compose the area (walking and cycling paths, tree and water areas, flowerbeds, etc.) as well as on their use and management. The database of public trees collects valuable information about species, dimensions, ages, and management activities. Detailed data for public green infrastructures from the two databases were integrated with more rough and coarse data about private areas.

4.2. Assessing ecosystem conditions

Ecosystem condition, i.e. the effective capacity of an ecosystem to provide services relative to its potential capacity (MA, 2005), was assessed rather indirectly within this case-study. Information about ecosystem conditions relevant for the case study were mostly related to two aspects: the structural analysis of urban green infrastructure components, and their management. More specifically, the structural analysis involved a preliminary assessment of soil cover and tree canopy coverage across the whole study area. Information about management that were collected concern the property of green areas (public vs. private), their opening to the public, and the presence of infrastructures and facilities. This could indeed be considered as first step towards assessing ecosystem condition.

4.3. Selecting Ecosystem Services

The identification of key urban ES was based on the knowledge of the local context and validated though a joint discussion with stakeholders. The selected ES cover pressing environmental issues for the city, as well as priority themes that the plan aims to address. The objective of providing all citizens with equal opportunities for nature-based recreation supported the identification of “Physical use of landscape” as one of the main urban ES. At the same time, the increasing intensity and frequency of heatwaves with growing negative consequences for citizens’ health and wellbeing, particularly in the valley floor, led to the selection of “Micro-climate regulation” as another key urban ES.
Table 11 lists the ES selected in the case study, classified using the CICES v4.3 (2013) classification, and the related assessment method categories.

Table 5. Overview of the ES and related mapping and assessment methods in the Trento case study

Ecosystem Service selected for mapping and assessment	B	S	E
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 7 in Trento;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

A biophysical method was applied to map and assess microclimate regulation provided by urban green infrastructures in the valley floor under the present condition and the two redevelopment scenarios hypothesized for each brownfield. The biophysical method moved from the analysis of the structural features of urban green infrastructure to assess their capacity for microclimate regulation.

5.1.1. Mapping of regulating and maintenance services

2.3.5.2. Micro and regional climate regulation
Indicator: *Cooling capacity (classes from A+ to E) (Capacity)*
Indicator: *Cooling effect (classes from A+ to E) (Capacity)*
Indicator: *Total and vulnerable beneficiaries under the different scenarios (Flow)*

A process-based model for assessing the cooling capacity of urban green infrastructure was developed during the study (for a detailed illustration refer to Zardo et al. (2017)). The method is specifically tailored for assessments in urban contexts, and is aimed at supporting a design of new urban green infrastructures that maximize their cooling capacity and effect on the surrounding areas. The method estimates the two main functions involved in cooling, namely shading and evapotranspiration, based on the structural features of urban green infrastructure components (i.e., soil cover, percentage of canopy cover, and dimension of the area). The cooling capacity of each green infrastructure component is assessed in a scale 0-100 and then classified into 6 classes that, depending on the climatic zone (i.e. Atlantic, Continental, and Mediterranean) can be linked to a range of temperature differences between the analysed area and the surrounding.

Given the omnidirectional flow of the ES, the cooling effect perceived in the surroundings is modelled by applying different spatial decay functions depending on the dimension and the shape of the green infrastructure component that provide the service. Thus, it is possible to assess to what extent the presence of urban green infrastructures affects the microclimate of the city. The cooling effect is also classified into 6 classes, from A+ to E.

The model was applied to the current condition and to assess different planning scenarios (Figure 5.1). Each scenario simulates the regeneration of one of the existing brownfields through its conversion into an urban park (a homogeneous grassy area with tree coverage higher than 80%). The scenarios were compared based on the benefits in terms of enhanced cooling effect experienced by the surrounding residents. By combining the maps of the cooling effect with census tract data and the location of residential buildings, it was possible to count the number of beneficiaries within each class of cooling effect in the baseline as well as in the different planning scenarios. The quantification of the beneficiaries was done both by considering the beneficiaries as whole and by identifying the vulnerable groups Young children (<5 years) and the elderly (>65 years) were selected as the most vulnerable, based on their higher sensitivity to heat stress (Basu & Samet 2002; Kabisch et al. 2017).

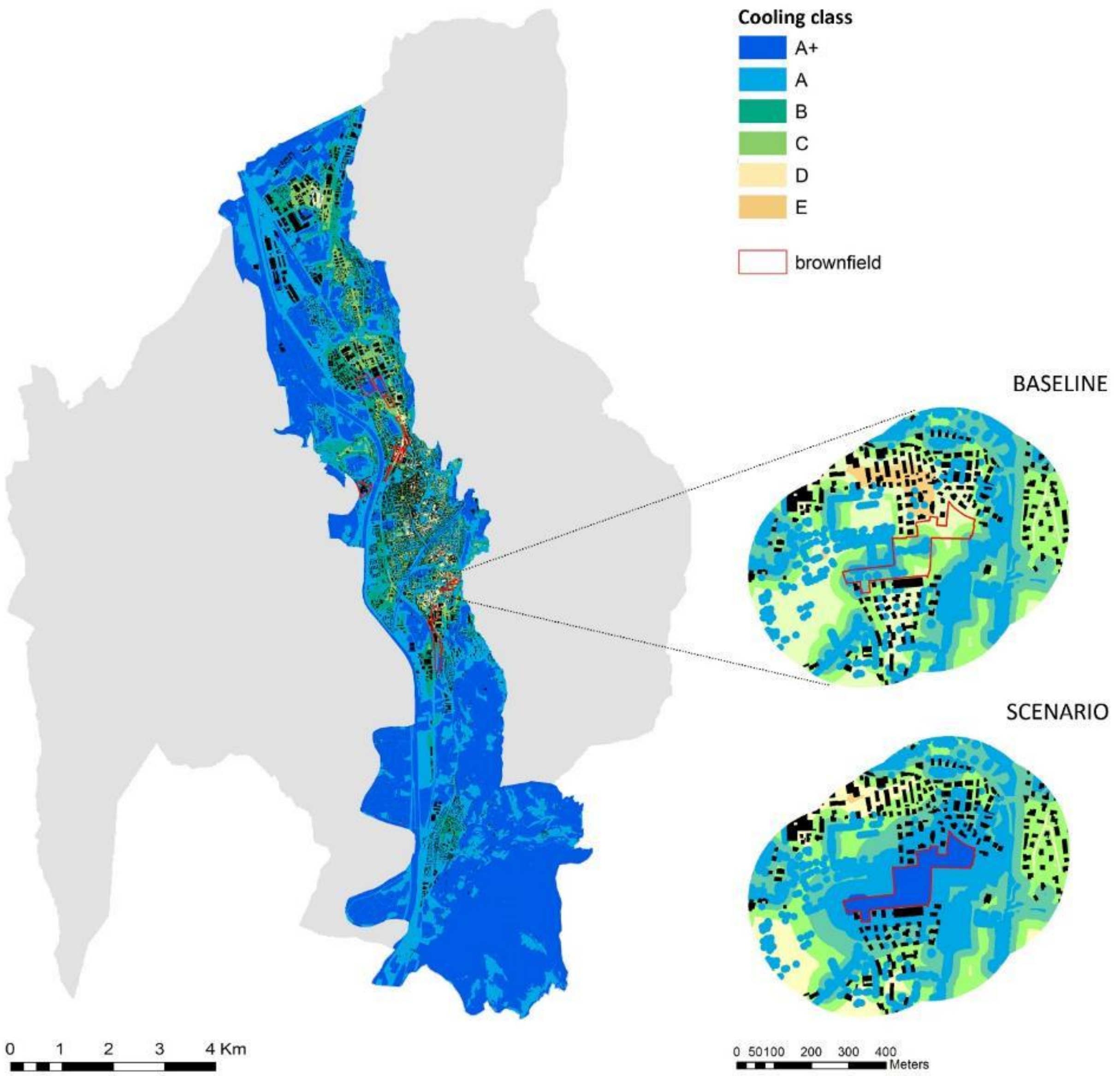


Figure 5.1. Map of the cooling effect of urban green infrastructure in the most urbanised part of the city of Trento (baseline condition) and an example of a planning scenario related to the regeneration of brownfield 11.

5.2. Socio cultural methods for ES mapping and assessment

A social method was applied to map and assess the recreation potential and opportunities offered by the green infrastructures in the city. The potential benefits provided by the redevelopment of brownfields into new urban parks were quantified based on a comparison between the present condition and the redevelopment scenario. The social method combines data about the presence and characteristics of green infrastructures with information about their use by the citizens, hence about the values associated to them.

5.2.1. Mapping of Cultural services

3.1.1.2 Physical use of land- /seascapes in different environmental settings.
Indicator: *Recreation Potential (normalized score) (Capacity)*

Indicator: *Recreation Opportunity Spectrum (categories) (Capacity)*
Indicator: *Total beneficiaries and beneficiaries in specific age groups under the different scenarios (Flow)*

The ESTIMAP recreation model (Paracchini et al. 2014) was applied to assess the potential and the opportunities for nature-based recreation provided by the urban green infrastructure in Trento. The model, originally developed for EU-wide assessments, has been already adopted, with case-specific adjustments, in a number of local scale applications (Zulian et al. 2018). The model was considered suitable for the case study due to its capacity of accounting for the whole range of nature-based recreational activities carried out in the city area. The location and the peculiar shape of the settlements determine a high proximity of residential areas to peri- and extra-urban green areas, hence a wider range of opportunities for nature-based recreation compared to other cities. As a result, activities typically carried out in forests and mountain areas (e.g., hiking, mountain-biking, climbing) are common, day-to-day activities for many people in Trento.

The model was used to assess the Recreation Potential and the Recreation Opportunity Spectrum for nature-based recreation in the whole area of the city. The Recreation Potential measures the suitability of green infrastructure to support different activities based on the intrinsic characteristics of the area. The assessment of the Recreation Potential accounts for three groups of thematic information: the presence of relevant and attractive natural features (i.e., mountain peaks, river areas, cascades, etc.), the structural characteristics of urban green areas (i.e., size, presence of vegetation and water, etc.) and the influence of the context (i.e., land use). The elements in the three groups are weighted and then combined in a normalized score.

The assessment of the Recreation Opportunity Spectrum combines the map of the Recreation Potential with information about facilities and infrastructures. To allow for an easier assessment, these are divided into two groups: access-related (i.e., road network, cycle paths, bus stops, etc.), and use-related (i.e., picnic areas, playgrounds, mountain tracks, etc.). The elements in the two groups are weighted and summed. The final value is cross-tabulated with the score of the Recreation Potential to identify 9 categories defined by the combination of low, medium, and high Recreation Potential with low, medium, and high availability of infrastructures and facilities.

Spatial data for the assessment were retrieved both from publicly-available datasets owned by the city and the province, and from OpenStreetMap, which allowed the inclusion of information about specific activities (e.g., MTB trails and rock climbing routes). Although these data can be considered quite accurate and reliable, their completeness, hence the full coverage of the area, is uncertain. The weighting phase is the most delicate in the application of the model. In this case, we involved 20 experts including researchers and academics from the university and other research institutions in the city, officers from the municipal and provincial departments with an interest in outdoor recreational activities, and local practitioners, who were invited to fill-in an on-line questionnaire.

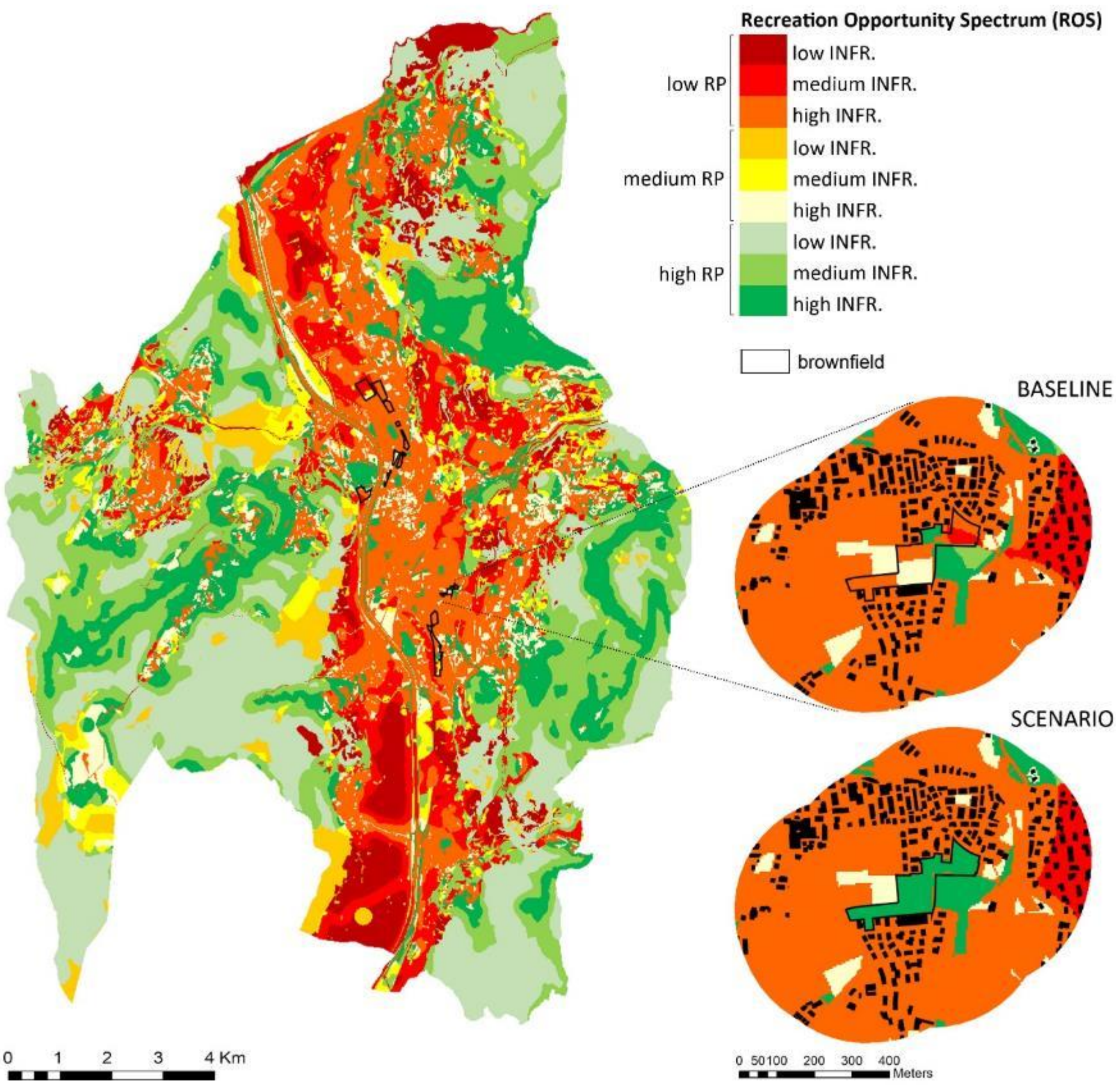


Figure 5.2. Map of the Recreation Opportunity Spectrum (ROS) in Trento calculated through the locally-adjusted version of the ESTIMAP-recreation model (baseline condition) and example of planning scenario related to the regeneration of brownfield 11.

The model was applied to analyse the current condition and to assess different scenarios of brownfield redevelopment (Figure 5.2). The new urban parks obtained by the regeneration of existing brownfields were assigned to the land use class 'green urban areas' and assumed to be equipped with the same infrastructure and facilities as other parks in the city with comparable dimensions. Current conditions and future scenarios were compared based on the benefits in terms of enhanced opportunities for nature-based recreation. More specifically, people living within 300 m from the new parks were considered as the main beneficiaries of the transformation (Stessens et al. 2017), and children and teenagers (<20 years) and the elderly (>65 years) were selected as the most vulnerable groups, based on the higher demand for close-to-home recreation and relaxation areas (Kabisch & Haase 2014).

5.3. Integration of ES mapping and assessment results

The ES mapping and assessment in the case study generated credible and relevant information that can help to address the starting policy question on how a green-oriented redevelopment of brownfields could contribute to increase the availability of key ES and related benefits for the citizens of Trento.

More specifically, 13 brownfields identified as areas for future re-development were investigated based on their actual and potential provision of two illustrative and crucial ES for the city of Trento: microclimate regulation and recreation. In the case of microclimate regulation, the biophysical analysis was combined with the quantification of the beneficiaries of the cooling effect, considering both the surrounding residents in general and specific vulnerable groups among them. In the case of recreation, the spatially-explicit assessment of the recreation potential and of the opportunities for nature-based recreation based on expert evaluation allowed comparing the current condition with the case of redevelopment of brownfields to new urban parks. The quantification of beneficiaries was done by considering the number of people (total and for specific age groups) with increased availability of areas in the highest class of recreation opportunity within walking distance from home.

From a planning perspective, although each analysis provided useful information, especially on the current needs of the city, the integration of the results of the two mapping and assessment exercises was far more interesting. The integration, carried out in a multicriteria fashion, allowed exploring synergies and trade-offs between the ES in the specific context, considering their combined impact of the potential beneficiaries of the transformation. The two ES and the different categories of beneficiaries based on the level of vulnerability were used as criteria and sub-criteria, respectively. The multi-criteria analysis allowed exploring different combinations of weights corresponding to different stakeholders' opinions and policy perspectives, providing a priority ranking of the alternative scenarios (Figure 5.3). This beneficiary-based assessment proved to be consistent with the administration objective of increasing the wellbeing of the citizens, hence a useful tool to inform planning decisions.

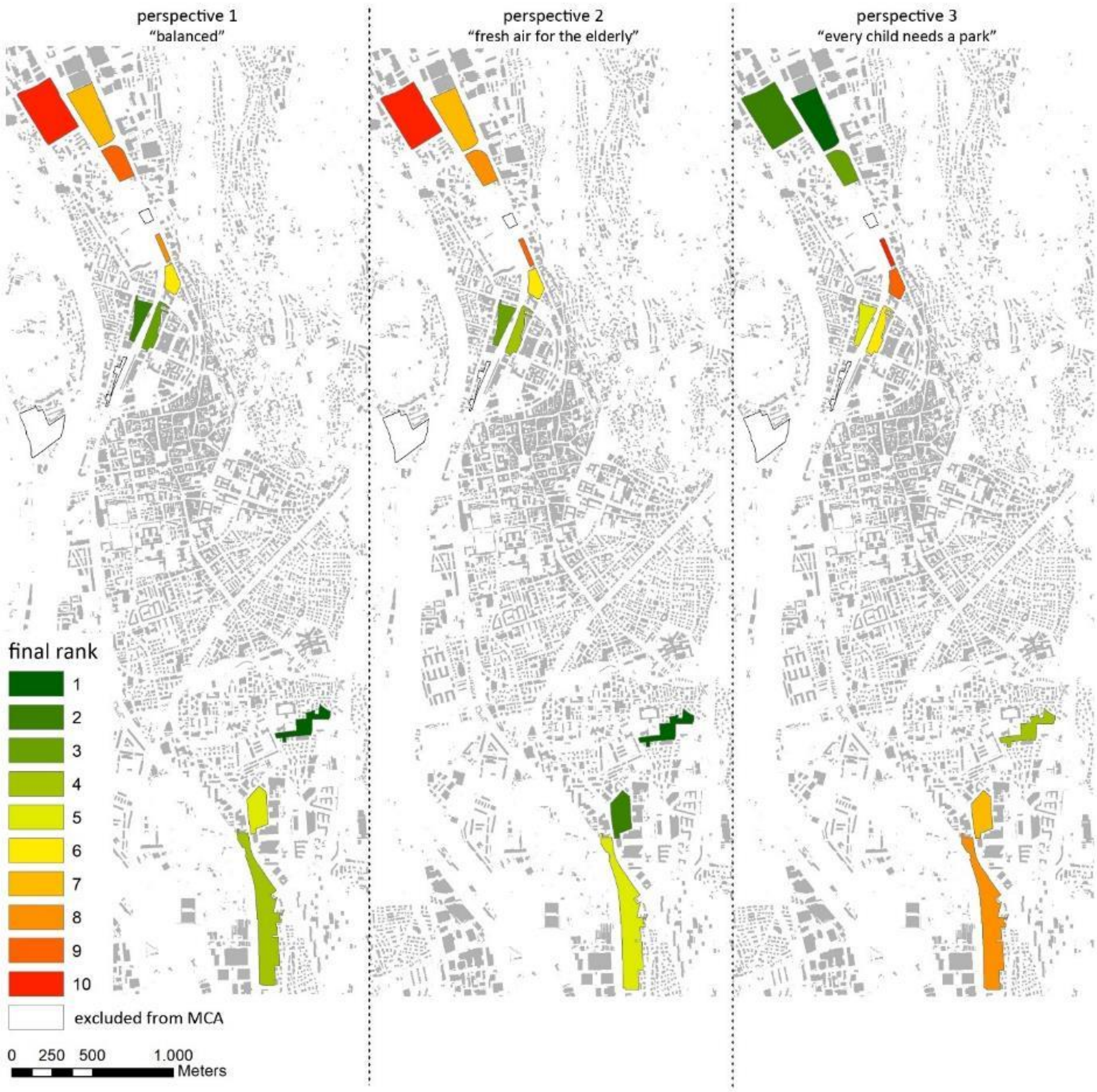


Figure 5.3. Map of the priority level of brownfield regeneration scenarios according to three perspectives considered in the multi-criteria analysis.

6. Dissemination and communication

From the academic perspective, results obtained in this case study have been disseminated through scientific publications (e.g. Geneletti et al. (2016); Zardo et al. (2017)), and communications in international and national conferences. Furthermore, the involvement of the city in the MAES Urban Pilot and EnRoute projects was the occasion to communicate and disseminate the results in the respective networks through publications (the MAES report) and project websites (https://oppla.eu/enroute).

Above all, results have been shared with municipal officers responsible for planning and managing urban green infrastructures in the city of Trento, through regular meetings and their direct participation to the project activities. Moreover, the involvement - as experts - of officers from other municipal and provincial departments and from other institutions with an interest in nature-based recreation provided a table for discussion and paved the way for a more effective policy-science-society interface and for a closer cross-sectoral collaboration.

7. Implementation

The continuous interaction along the entire process of mapping and assessment is expected to facilitate the introduction of the results into the ongoing urban planning process.

8. References & Annexes

References

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Annexes

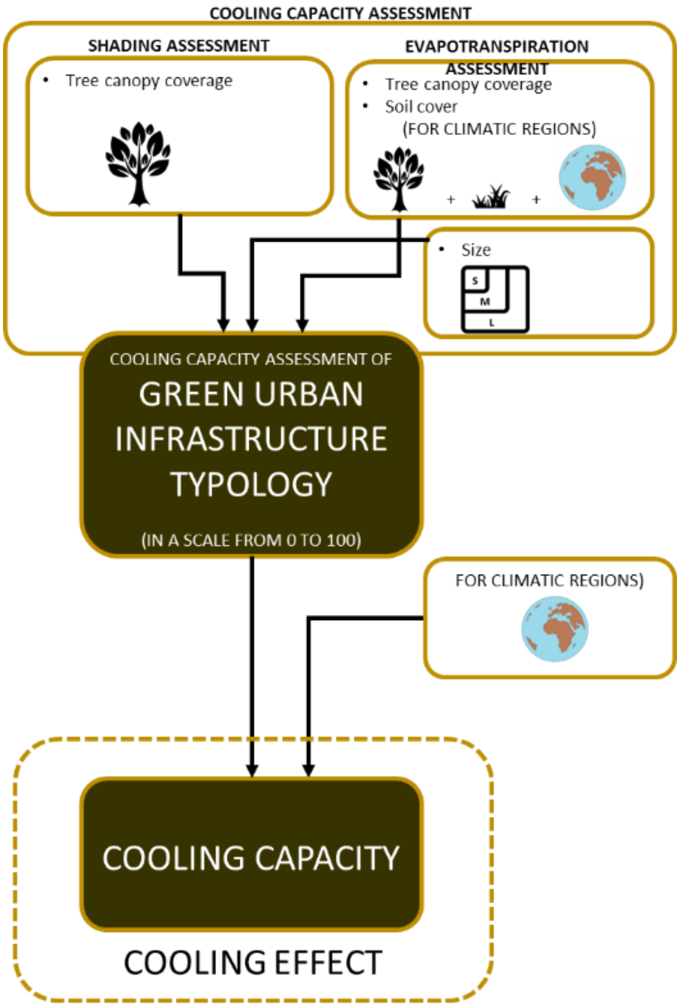

Figure 8.1. An approach for assessing the cooling capacity of green urban areas (Source: Zardo et al. 2017).

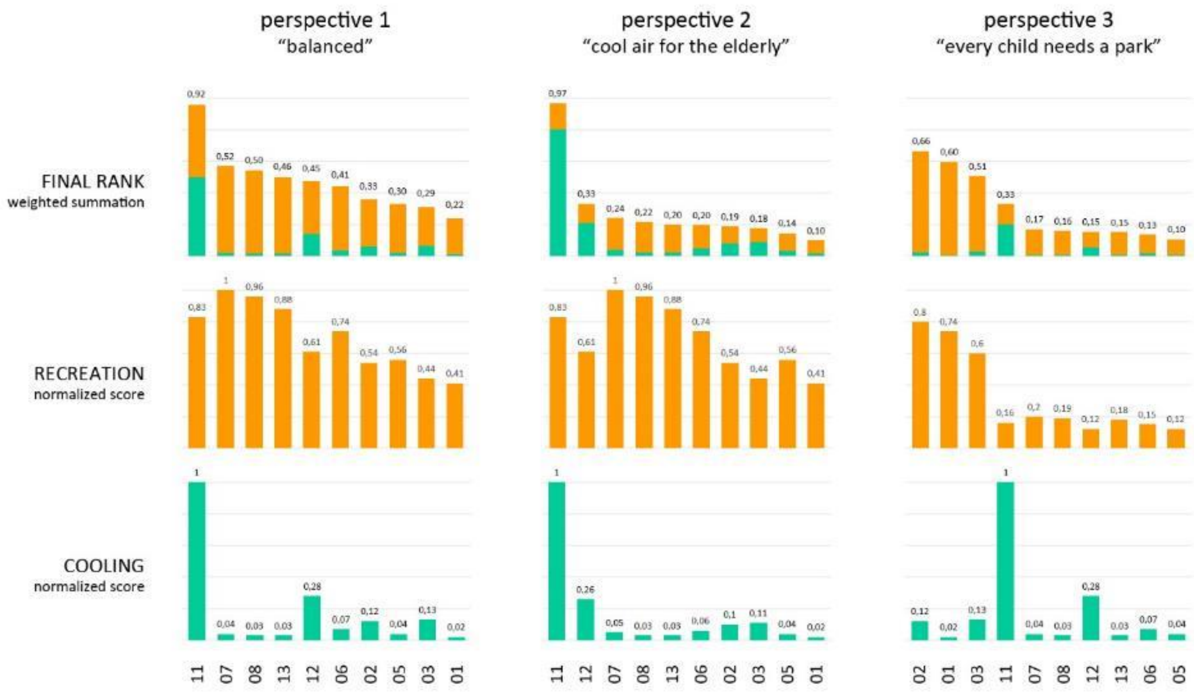

Figure 8.2. Results of the multi-criteria analysis for the regeneration of the thirteen brownfields under the three perspectives (i.e., combinations of weights) explored in the analysis.

METHOD APPLICATION CARD: PROCESS-BASED MODEL Applied to: Micro and regional climate regulation (2.3.5.2)	
CASE STUDY	ITALY: ES mapping and assessment for urban planning in Trento
SCALE	Local
TYPE	Biophysical
TIER	2/3
DESCRIPTION	
The method is specifically tailored for the assessment of the cooling capacity and cooling effect of urban green infrastructure, in the European context. It estimates the two main functions involved in cooling, namely shading and evapotranspiration, depending on the structural features of urban green infrastructure components (i.e., soil cover, percentage of canopy cover, and dimension of the area). Based on an analysis of the three structural features, each green infrastructure component can be classified into one of the 50 combinations identified by the model. For each combination, the cooling capacity is expressed by a score from 0 to 100. The scores can then be classified into 5 classes, from A to E, which correspond to a range of temperature differences between the analysed area and the surrounding, depending on the climatic zone (i.e. Atlantic, Continental, and Mediterranean). Finally, the cooling effect perceived in the surroundings is modelled by applying different omnidirectional spatial decay functions depending on the dimension and the shape of the green infrastructure component. For a detailed illustration of the method and the scoring tables refer to Zardo et al. (2017).	
1. DATA REQUIREMENT	
Qualitative	• Climatic zone, i.e. Atlantic, Continental, or Mediterranean
Quantitative	• Soil cover map classified into 5 categories (i.e. water, grass, heterogeneous, bare soil, sealed) and dimension of each area of homogenous soil cover. • Percentage of canopy coverage over each area (e.g. based on aerial or satellite images).
2. RESOURCES REQUIREMENT	
Time	• Running the model on a city can take a few days, data preparation may be more demanding
Cost	• The analysis can be run with free GIS software, related paper is open access.
Expertise	• Good GIS skills needed.
Tools & equipment	• GIS software to run the model.
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	•
Socio-cultural	• Analysis of the different categories of beneficiaries and levels of demand (e.g. vulnerability to heat stress). • Accessibility analysis.
Economic	• Replacement cost methods (e.g. savings in artificial cooling) • Avoided cost (e.g. health benefits in terms of reduced hospital admissions)
4 COLLABORATION LEVEL	
Researchers own field	•
Researchers other fields	•
Non-academic stakeholders	•
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Appropriate, the method was specifically developed for urban contexts (in Europe).
Regional	• Not applicable.
National	• Not applicable.
Pan European	• Not applicable.
6. EXAMPLES OF POLICY QUESTION	
• How does green urban infrastructures affect the local microclimate? • Which parts of the city benefit most from the cooling effect of urban green infrastructure? • How to design new areas that maximize the related cooling effect?	
Suggested Citation: Zardo, L., Geneletti, D., Cortinovis, C., Adem Esmail, B., Nedkov, S., (2018): Method Application Card: PROCESS-BASED MODELS applied to “Microclimate (and regional) regulation (2.3.5.2)”. ESMERALDA EC H2020 Grant Agreement no. 642007.	

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (ESTIMAP) Applied to: Physical use of land- /seascapes in different environmental settings (3.1.1.2)	
CASE STUDY	ITALY: ES mapping and assessment for urban planning in Trento
SCALE	Local
TYPE	Socio-cultural
TIER	2/3
DESCRIPTION	
ESTIMAP (Ecosystem Service Mapping Tool) is a GIS model based approach to spatially quantify ES, developed to support ES policies at a European scale (Zulian et al., 2013b; Zulian *et al.*, 2017). The ESTIMAP models for recreation (Liquete et al., 2016; Paracchini et al., 2014; Zulian et al., 2013b; Zulian *et al.*, 2017) is an Advanced multiple layer LookUp Tables" (Advanced LUT); it measures the capacity of ecosystems to provide nature-based outdoor recreational and leisure opportunities. It consists of three basic sections: (1) The Recreation Potential (RP), which estimates the potential capacity of ecosystems to support nature-based recreation activities based on land suitability for recreation and the natural, infrastructure and water features that influence recreational opportunity provision; (2) The Recreation Opportunity Spectrum map (ROS), which combines a proximity-remoteness concept with the potential supply (RP), and depends on the presence of infrastructure to allow access and profit from the potential opportunities; and (3) The use, or demand, of a service based on an analysis of population or users accessibility. The Recreation Potential is a spatially-explicit indicator ranging from 0 to 1; the Recreation Opportunity Spectrum is also a spatially-explicit indicator classified into nine categories that combine high/medium/low Recreation Potential with high/medium/low level of accessibility.	
1. DATA REQUIREMENT	
Qualitative	• (For local applications) input from local experts and stakeholders to assign weights to the different data used in the model
Quantitative	• Natural features supporting recreation, e.g. for EU application: water elements with related quality, natural protected areas, land uses with related degree of naturalness; • Accessibility parameters, e.g. for EU application: road network and urban areas; • Demand of recreation, e.g. for EU application: population density map; • Other/more detailed data can be used in local applications (e.g. accessibility can be assessed based on the presence of cycle paths, bus stops, parking areas etc.)
2. RESOURCES REQUIREMENT	
Time	• Data preparation and adjustment of the model to include all the elements of interest are the most demanding part.
Cost	• The analysis can be run with free GIS software.
Expertise	• GIS software expertise required for preparing the data. At present, to run the model may require some support from experts at the JRC.
Tools & equipment	• Computer, GIS software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• No needed
Socio-cultural	• stakeholder and experts consultation to identify local preferences and validate results
Economic	• e.g. travel costs or choice experiment to derive weights
4 COLLABORATION LEVEL	
Researchers own field	• None
Researchers other fields	• Researches from both natural and social sciences with an interest in green areas of in recreational activities can provide useful input
Non-academic stakeholders	• Local experts and stakeholders involved in the management of green areas or with an interest in nature-based recreational activities
5. SPATIAL SCALE OF APPLICATION[1]	

Local	• Yes, the model can be adapted to include locally relevant data (e.g. in Zulian et al. 2017).
Regional	• Yes, the model can be adapted to include locally relevant data (e.g. in Zulian et al. 2017).
National	• Yes. However, the results at the national level can be drawn from the EU level application
Pan European	• Yes. ESTIMAP was developed for this scale

6. EXAMPLES OF POLICY QUESTION

- What is the recreational potential of the study area?
- Are opportunities for nature-based recreation equally distributed across the study area?
- How many citizens have access to an area of high recreation potential close to home?

Suggested Citation: Cortinovis, C., Geneletti, D., Adem Esmail, B., Nedkov, S., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (ESTIMAP) applied to "Physical use of landscapes in different environmental settings (3.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.

CASE STUDY BOOKLET

(Picture by Ilze Strēle)

Mapping marine ES in Latvia

June 2018

ESMERALDA partner: Baltic Environmental Forum (BEF)

Case Study Coordinators: Anda Ruskule & Kristina Veidemane

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Ruskule, A., Veidemane, K., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: MAPPING MARINE ES IN LATVIA prepared for "WS3 - Testing the methods across Europe" held in Prague, Czechia, 26-29 September 2016. ESMERALDA EC H2020 Grant Agreement no. 642007.

Disclaimer: This document is the final version of the Case Study Booklet produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/overview_of_esmeralda_case_studies).

CASE STUDY FACTSHEET

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

1. Overview of the study area

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 3.11). It corresponds to 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. It 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).

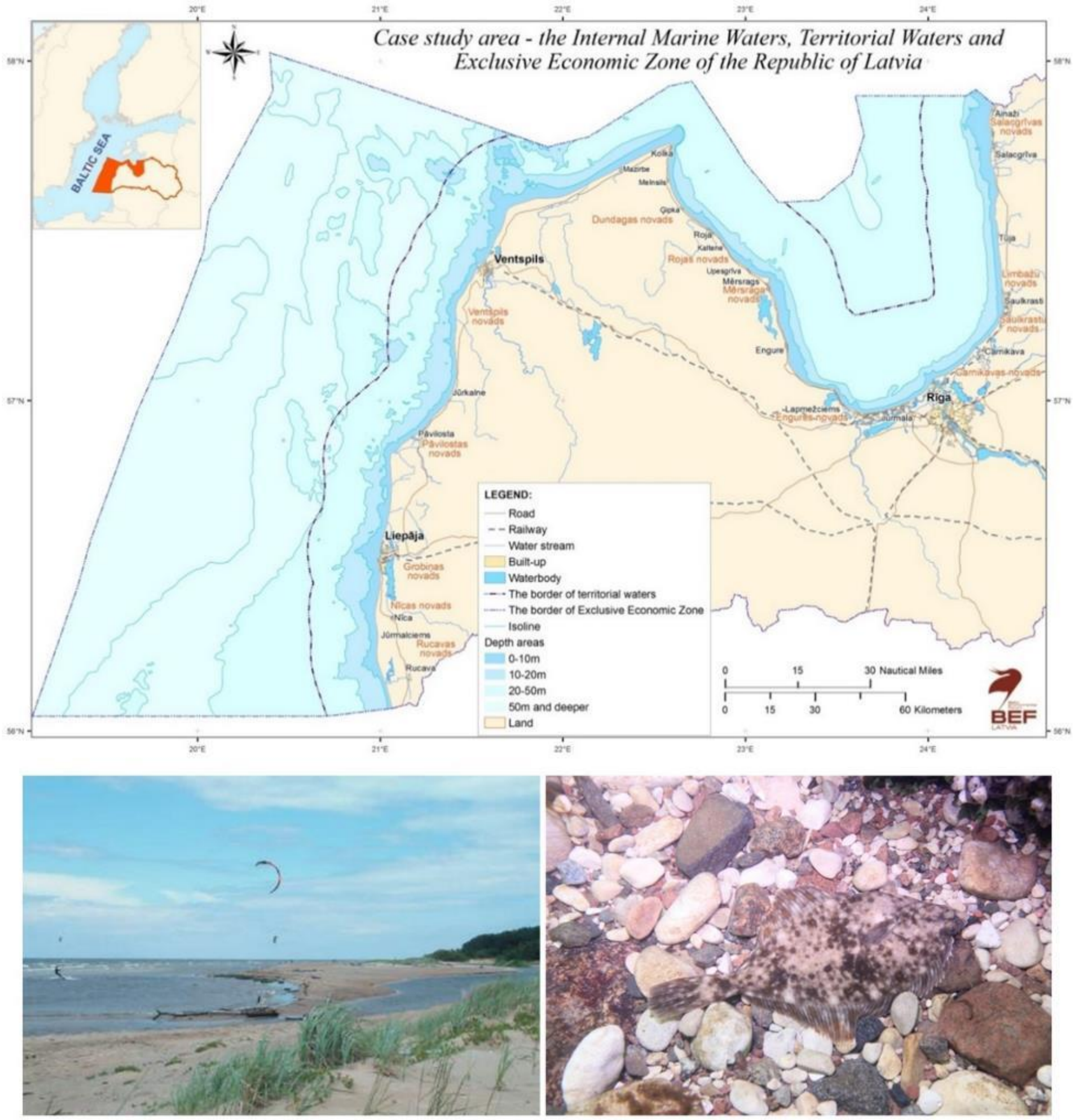

Figure 1.1. Case study area including the internal marine Waters, territorial waters and Exclusive Economic Zone of the Republic of Latvia. Data source: Latvian Maritime Administration and Latvian Geospatial Information Agency).

2. Questions and Themes

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) (Veidemane et al., 2017). 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.

3. Stakeholders' Involvement

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 Region 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.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem types

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 *6.8*); 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 4.2). 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).

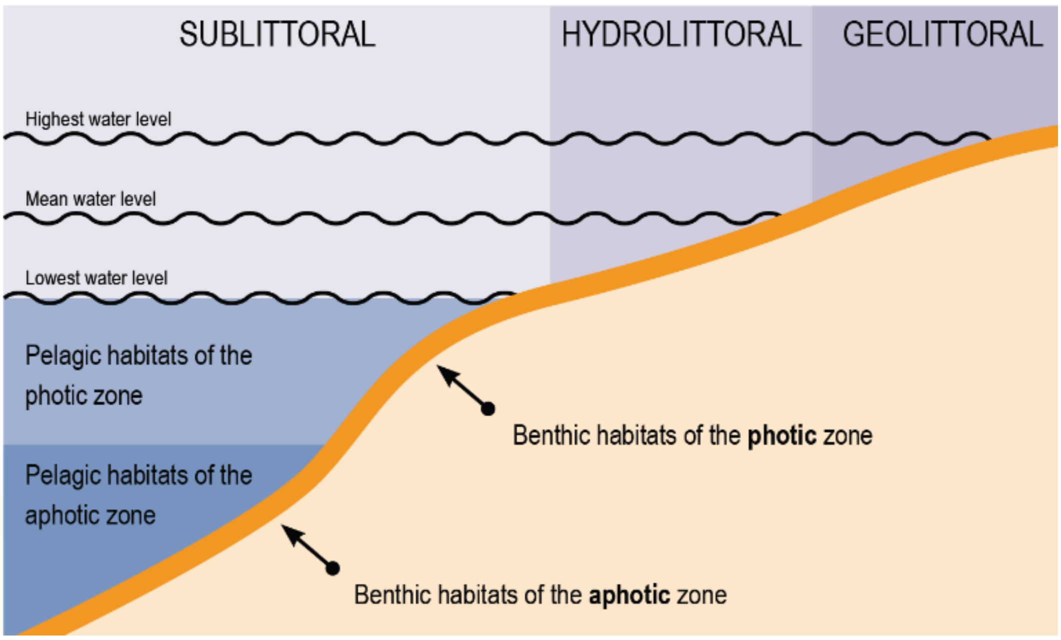

Figure 4.1. Zonation of marine habitats. Source: Baltic Environmental forum, 2009; adopted from D. Boedeker, Federal Agency of Nature Conservation, Germany, 1998.

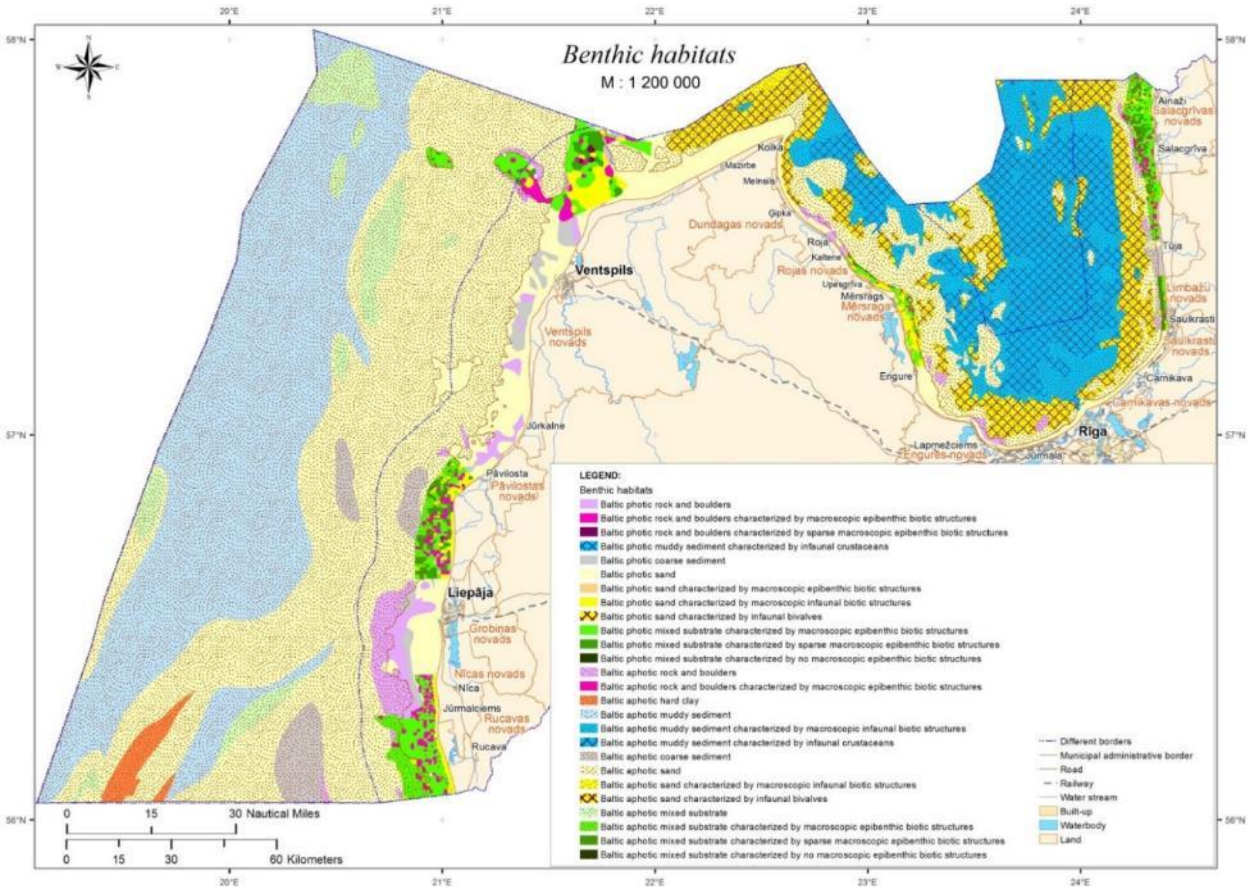

Figure 4.2. Benthic habitat map of the Latvian marine waters, developed by LIAE, 2015. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016

4.2. Assessing 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 *6.16* - 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 *6.16*- Right).

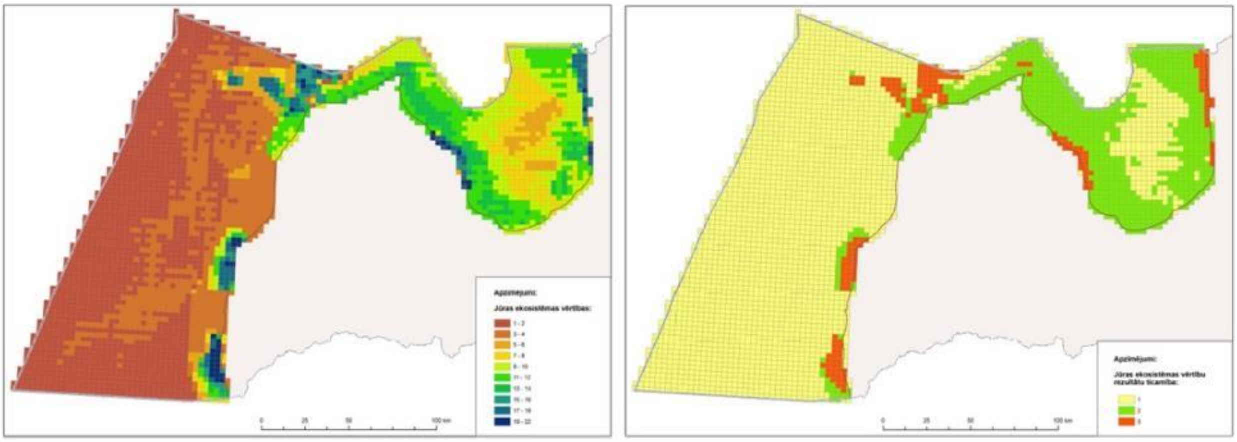

Figure 4.3. (LEFT) Sum of ecosystem values estimated by different criteria. Legend: ecosystem value from low (red) to very high (dark blue). Source: LIAE, 2015. (RIGHT) Estimation of certainty of the results. Legend: level of certainty - low (yellow); medium (green); high (red). Source: LIAE, 2015.

4.3. Selecting Ecosystem Services

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 Table 4.1, 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 4.1. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

Mapping of ES was performed using the available spatial data sets as well as based on expert knowledge (Veidemane et al, 2017). 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.

5.1.1. 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 8.1).

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 landing 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 8.2).

5.1.2. 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 8.3).

5.1.3. 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: recreational use (survey data on 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 proximity to densely populated areas (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 8.4).

5.2. Integration of ES mapping and assessment results

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.

6. Dissemination and communication

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.

7. Implementation

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.

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.

8. References & Annexes

References

CICES v4.3 (2013). Common International Classification of ES. Available at: http://cices.eu/

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Annexes

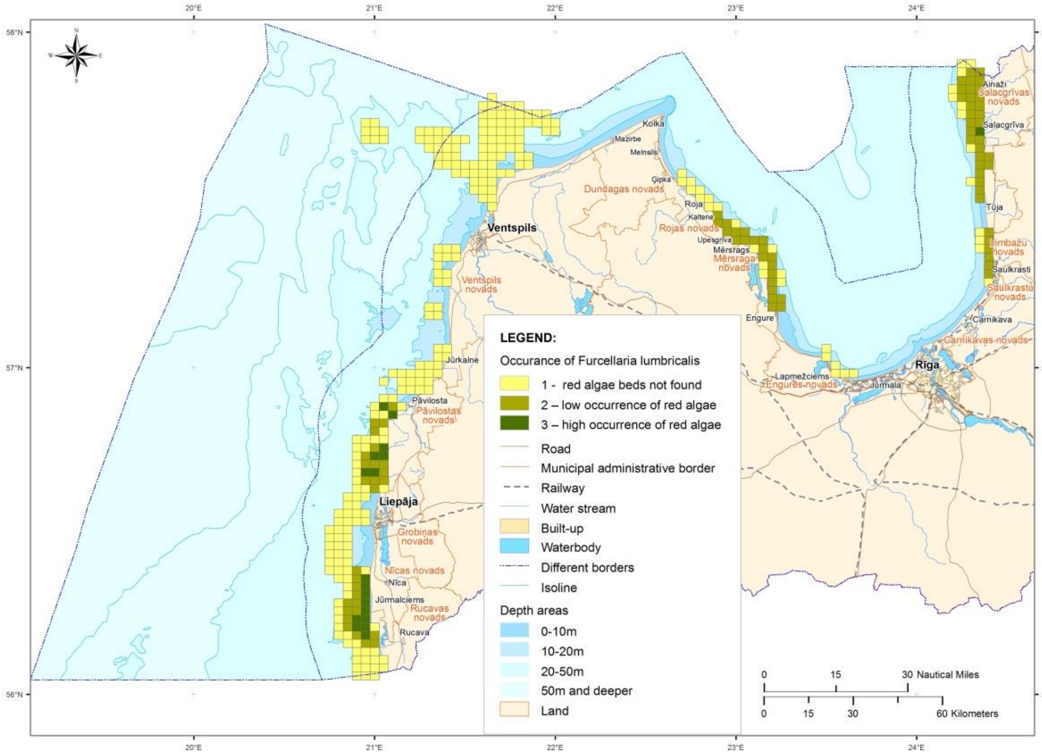


Figure 8.1. Provisioning service – algae and their outputs. Indicator: area covered by red algae Furcellaria lumbricalis. Map developed by LIAE & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

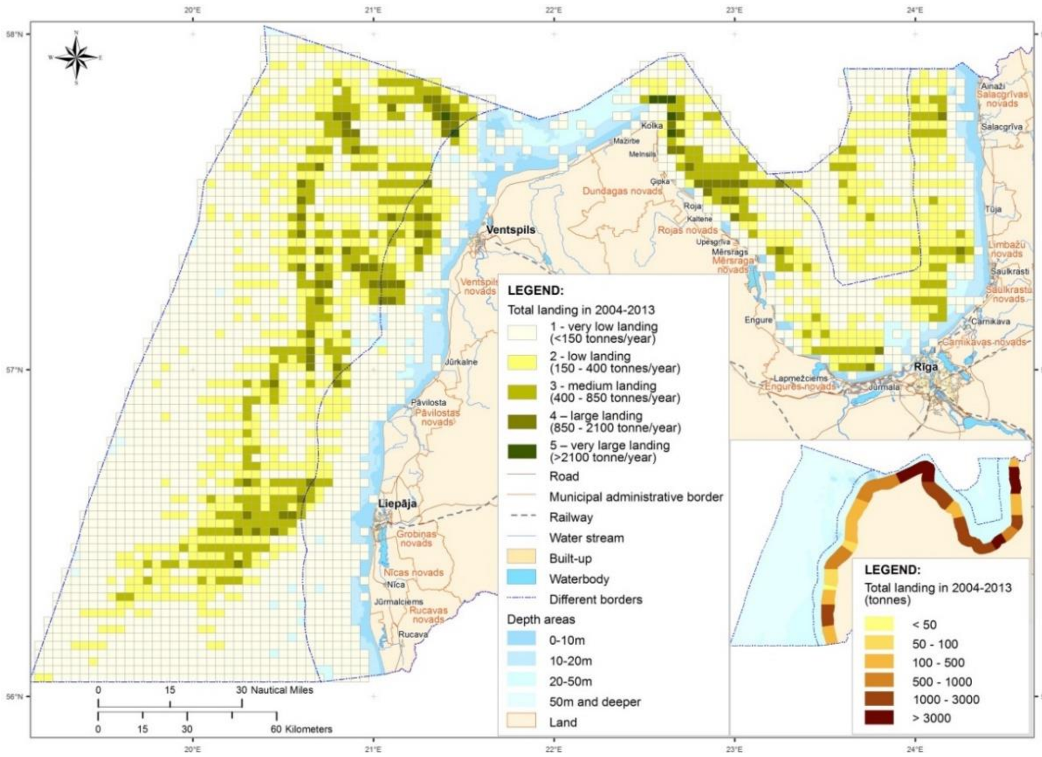


Figure 8.2. Provisioning service – fish for food. Indicator: total landing of commercially important fish species in the Open sea in the Gulf of Riga and Baltic proper (>20 m depth) and total landing from coastal fishery. Map developed by BIOR. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia.

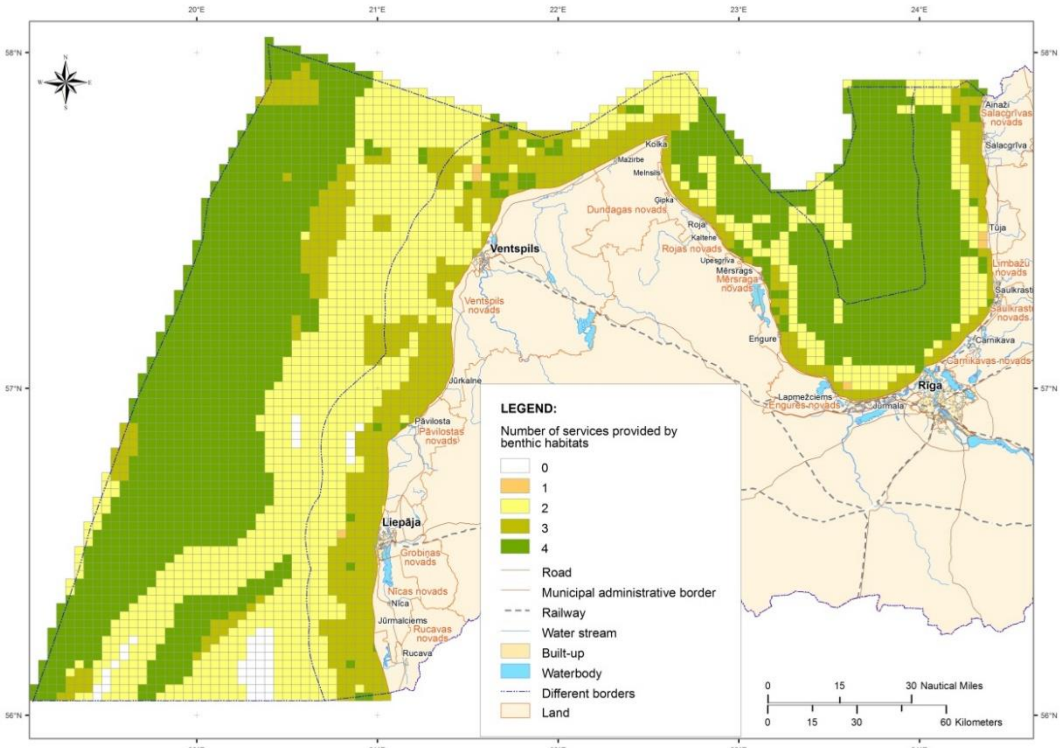


Figure 8.3. Number of regulating and maintenance services provided by benthic habitats. Map developed by LIAE & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

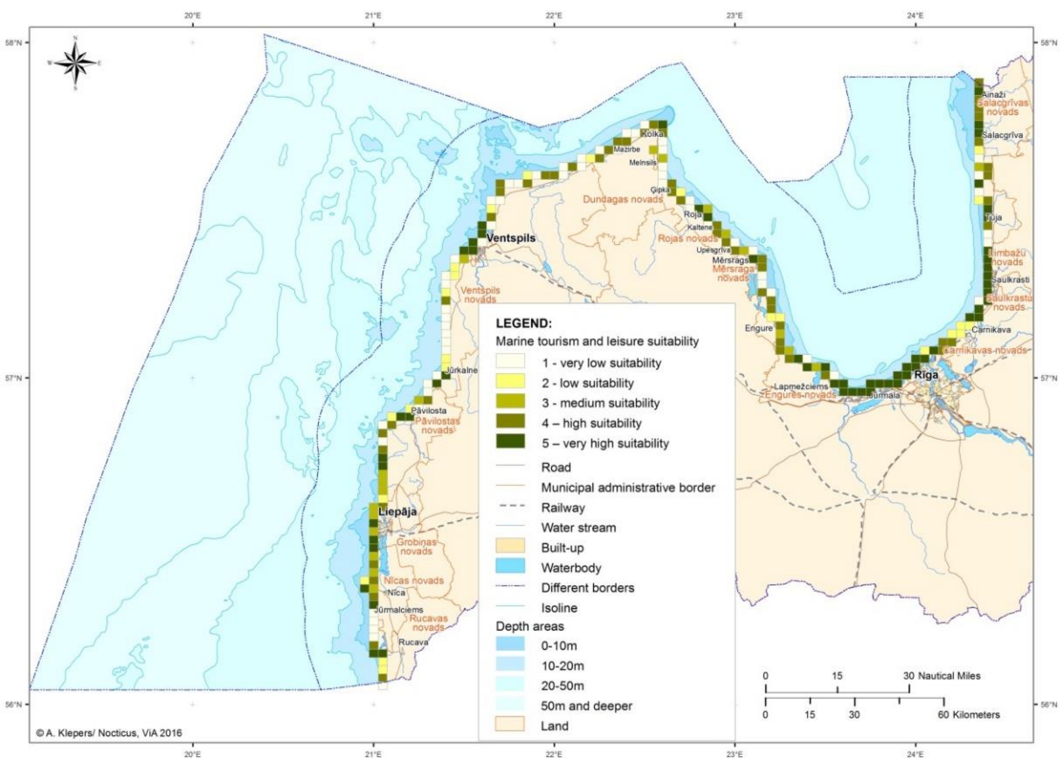


Figure 8.4. Cultural services – physical and experiential interaction. Indicator: marine tourism and leisure possibilities at the coast. Map developed by A. Klepers & BEF. Source: Ministry of the Environmental Protection and Regional Development of the Republic of Latvia, 2016.

METHOD APPLICATION CARD: SPATIAL PROXY METHOD **Applied to: Wild plants, algae and their outputs (1.1.1.3)**	
CASE STUDY	LATVIA: Mapping marine ES in Latvia
SCALE	National
TYPE	Biophysical
TIER	2

DESCRIPTION

SPATIAL PROXY METHODS 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 have been observed so far; 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 information*	• 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 information*	• 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
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	
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.
6. EXAMPLES OF POLICY QUESTION	
• What is the distribution area of red algae *Furcellaria lumbricalis* and potential of its exploitation for commercial purpose by the food industry? • Are there significant impacts expected from the sea use solutions proposed by the Maritime Spatial Plan or other development plans and projects on distribution and condition of red algae habitats?	
Suggested Citation: Ruskule, A., Veidemane, K., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD applied to "Wild plants, algae and their outputs (1.1.1.3)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: SPATIAL PROXY METHOD (SPREADSHEET) Applied to: Maintaining nursery populations and habitats (2.3.1.2)	
CASE STUDY	LATVIA: Mapping marine ES in 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
6. EXAMPLES OF POLICY QUESTION	
• What is the distribution area of fish nursery and spawning habitats? • Are there significant impacts expected from the sea use solutions proposed by the Maritime Spatial Plan or other development plans and projects on fish nursery and spawning habitats?	
Suggested Citation: Ruskule, A., Veidemane, K., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD (SPREADSHEET) applied to “Maintaining nursery populations and habitats (2.3.1.2)”. ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: STATE & TRANSITION MODEL Applied to: Maintaining nursery populations and habitats (2.3.1.2)	
CASE STUDY	LATVIA: Mapping marine ES in Latvia
SCALE	National
TYPE	Biophysical
TIER	2

DESCRIPTION	
State and transition models (STM) assume there are a number of states in which a system can exist, but there are specific conditions that can drive the system between states. The main focus of these models is the threshold point that separates one state from another and marks the transition between them. STMs are developed using information from a combination of sources including expert knowledge, historical observations, monitoring, and controlled experiments. The formulation of a state and transition model involves identifying the vegetation states, determining which of the states are linked and describing the transitions.	
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
Socio-cultural	• Implementation of the model as a BBN, can facilitate communication and makes uncertainty explicit
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
6. EXAMPLES OF POLICY QUESTION	
• What ecosystem states are the most appropriate to sustain the nursery function? • What areas should be put under protection regime in order to preserve the nursery functions?	
Suggested Citation: Nedkov, S., Ruskule, A., Veidemane, K., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: STATE & TRANSITION MODEL applied to "Maintaining nursery populations and habitats (2.3.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (MULTI-CRITERIA ES ASSESSMENT 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: Mapping marine ES in Latvia
SCALE	National
TYPE	Biophysical
TIER	2
DESCRIPTION	
The method involves ES assessment based on biophysical criteria, often in combination with social and economic data. In the case study, the method was applied to analyse empirical data on marine and coastal tourism in Latvia in combination with expert knowledge. First, relevant factors were selected characterising marine tourism and leisure possibilities at the coast. The assessment value of each grid cell was 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 were presented 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) • **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	
Local	• Do not make sense at local scale (at least in this case study the habitat areas were too coarse)
Regional	• Appropriate
National	• Appropriate
Pan European	• Most likely not
6. EXAMPLES OF POLICY QUESTION	
• Where are located the areas with priority for development of marine and coastal tourism? • Are there significant impacts expected from the sea use solutions proposed by the Maritime Spatial Plan or other development plans and projects on areas important for tourism development?	

Suggested Citation: Ruskule, A., Veidemane, K., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (MULTI-CRITERIA ES ASSESSMENT MODEL) applied to "Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (InVEST)
Applied to: Physical use of landscapes /seascapes in different environmental settings (3.1.1.2)

CASE STUDY	LATVIA: Mapping marine ES in 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 (ArcGIS 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	• Possible link to Scenic quality provision module of InVEST
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
6. EXAMPLES OF POLICY QUESTION	
• What are the places with high recreation potential?	
Suggested Citation: Nedkov, S., Ruskule, A., Veidemane, K., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (InVEST) applied to "Experiential interactions + Physical use of landscapes /seascapes in different environmental settings (3.1.1.1+3.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

CASE STUDY BOOKLET

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

June 2018

ESMERALDA partner: Institute of Applied Sciences, MCAST

Case Study Coordinators: Mario Balzan

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Balzan, M., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: ASSESSING AND MAPPING ES IN THE MOSAIC LANDSCAPES OF THE MALTESE ISLANDS prepared for “WS4 - Testing the methods across themes” held in Amsterdam, Netherlands, 09-11 January 2017. ESMERALDA EC H2020 Grant Agreement no. 642007.

CASE STUDY FACTSHEET

Mapping ES in Malta WS4_cs3

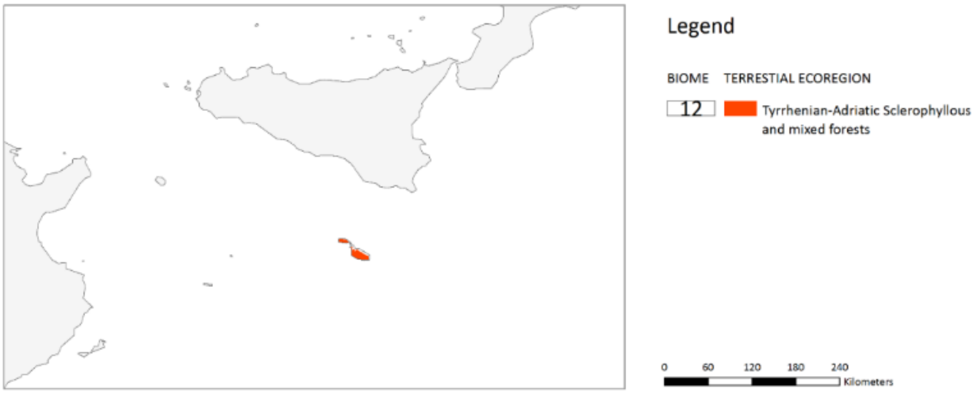
NAME AND LOCATION OF STUDY AREA	Maltese Islands
COUNTRY	Malta

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

1. Overview of the study area

The Maltese archipelago is a group of low-lying, small islands situated in the Central Mediterranean Sea at 96 km south of Sicily, almost 300 km east of Tunisia and some 350 km north of the Libyan coast. The archipelago is made up of three inhabited islands (Malta, Gozo and Comino) and several uninhabited islets, with a total land area of 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.

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).

2. Questions and Themes

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 analysing 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.

3. Stakeholders' Involvement

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.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 4.1).

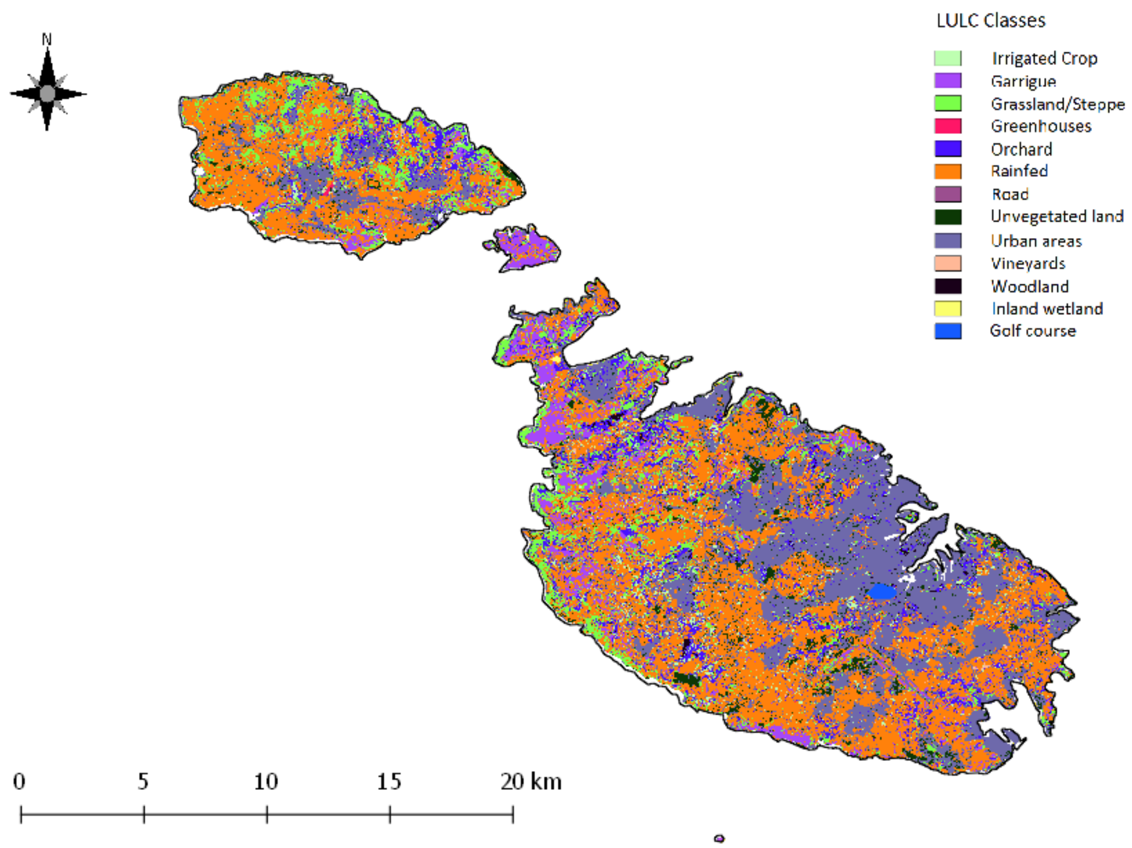


Figure 4.1. A land use land cover map of Malta was developed using Sentinel 2 satellite images.

4.2. 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 4.2)
- pollinator diversity in key habitats
- area of irrigated agricultural land

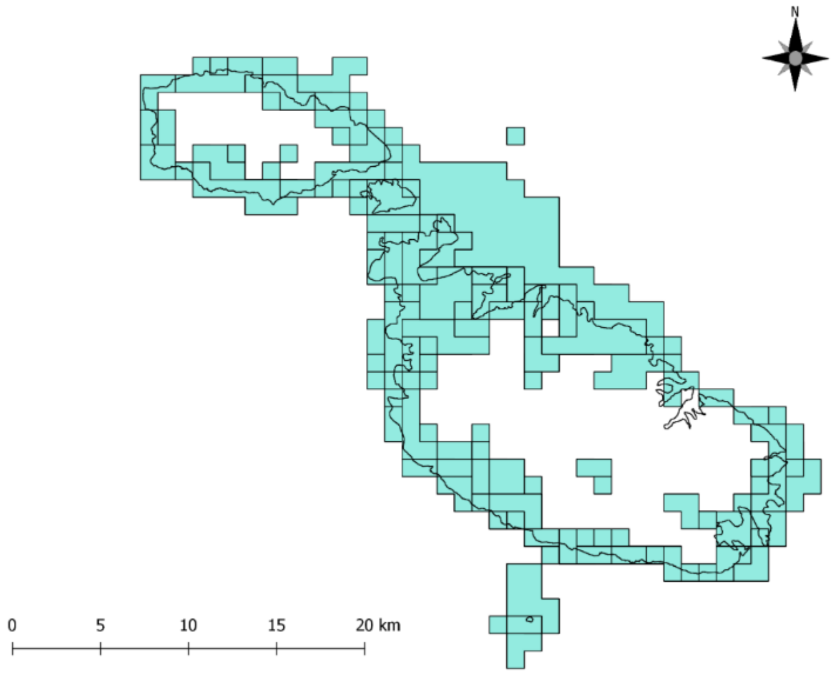


Figure 4.2. Shaded areas representing Annex I habitats' range in 1 km^2 cells (Art. 17, Habitats Directive).

4.3. Selecting Ecosystem Services

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 11 lists the selected ES in the case study, classified using the CICES v4.3 (2013) classification, and the related assessment method categories.

Table 4.1. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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).

5.1.1. 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

5.1.2. 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 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 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 5.1).

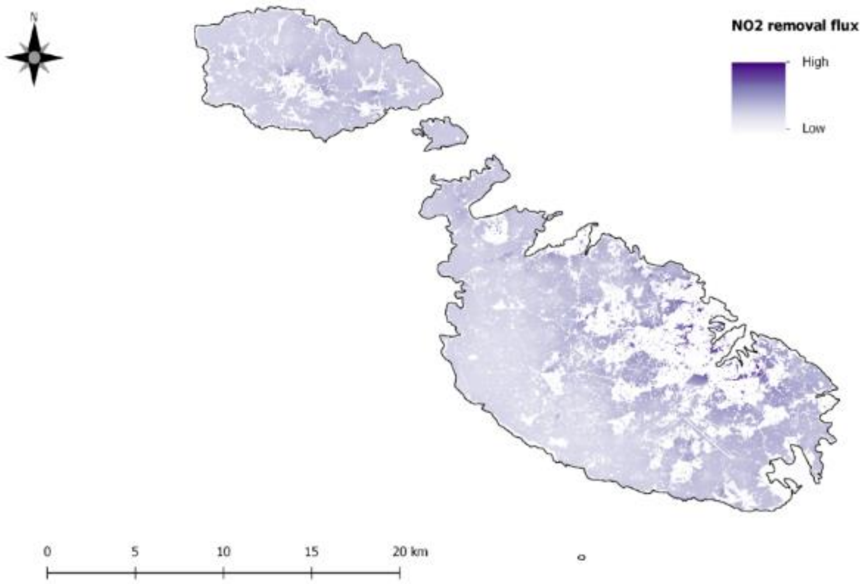


Figure 5.1. Removal of NO2 flux

5.1.3. Mapping of cultural services

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.

5.2. Socio cultural methods for ES mapping and assessment

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.

5.2.1. 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 5.2).

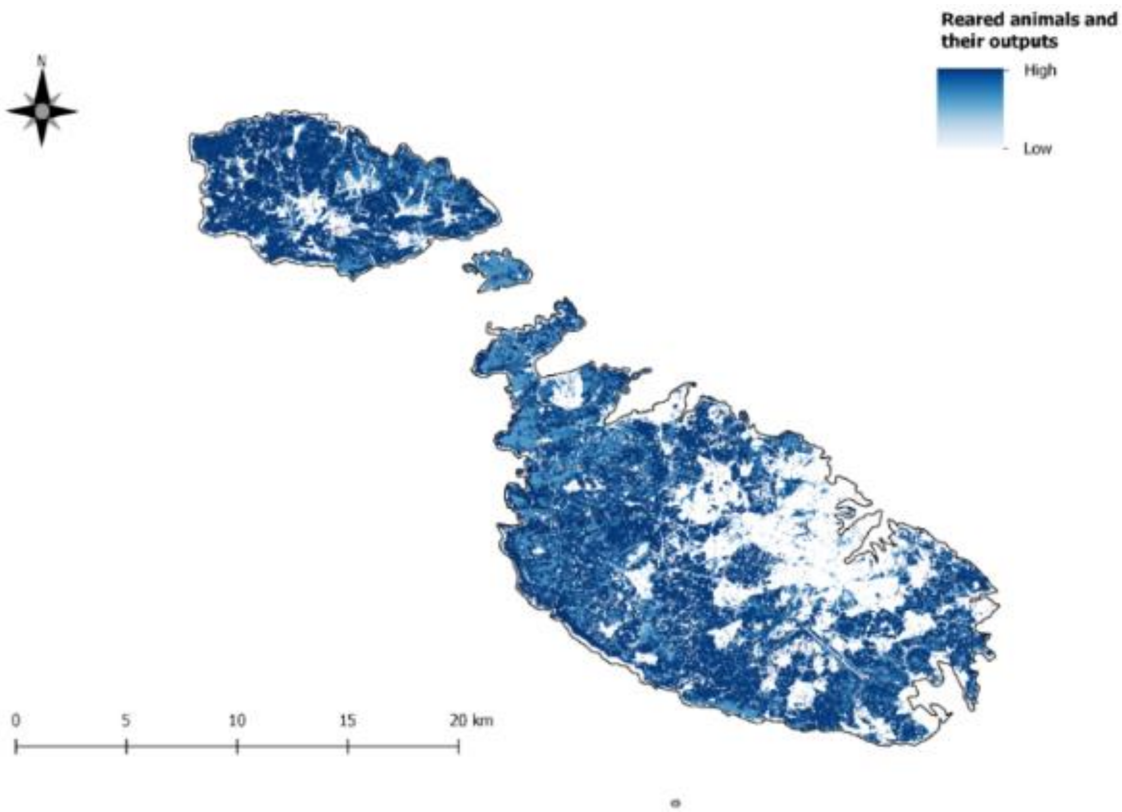


Figure 5.2. Map based on preference assessment for beekeeping and honey production.

5.2.2. Mapping of cultural services

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.

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5.3. Integration of ES mapping and assessment results

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. Dissemination and communication

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.

7. 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.

METHOD APPLICATION CARD: PREFERENCE ASSESSMENT Applied to: Reared animals and their outputs (1.1.1.2)	
CASE STUDY	MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands
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	
Local	• Highly. This exercise is considered 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 small size of the landscape units.
Regional	• Highly. 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?

Suggested Citation: Balzan, B., Ostergard, H., Inghe, O., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PREFERENCE ASSESSMENT applied to "Reared animals and their outputs (1.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.

METHOD APPLICATION CARD: SPATIAL PROXY METHODS + FIELD DATA
Applied to: Pollination and seed dispersal (2.3.1.1)

CASE STUDY	MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Islands
SCALE	Local
TYPE	Biophysical
TIER	2

DESCRIPTION

SPATIAL PROXY METHODS 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?
Suggested Citation: Balzan, B., Ostergard, H., Inghe, O., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHODS + FIELD DATA applied to "Pollination and seed dispersal (2.3.1.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: SPATIAL PROXY METHODS (SPREADSHEET METHOD) Applied to: Pollination and seed dispersal (2.3.1.1)	
CASE STUDY	MALTA: Assessing and mapping ES in the mosaic landscapes of the Maltese Island
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.	
Suggested Citation: Ostergard, H., Inghe, O., Balzan, B., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHODS (SPREADSHEET METHOD) applied to "Reared animals and their outputs (1.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

CASE STUDY BOOKLET

ES-based coastal defence in the Netherlands

June 2018

ESMERALDA partner: VU University, Amsterdam (VU)
Case Study Coordinators: Pieter van Beukering

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: van Beukering, P., D., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: ES-BASED COASTAL DEFENSE IN THE NETHERLANDS prepared for “WS4 - Testing the methods across themes” held in Amsterdam, Netherlands, 09-11 January 2017. ESMERALDA EC H2020 Grant Agreement no. 642007.

Disclaimer: This document is the final version of the Case Study Booklet produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/overview_of_esmeralda_case_studies).

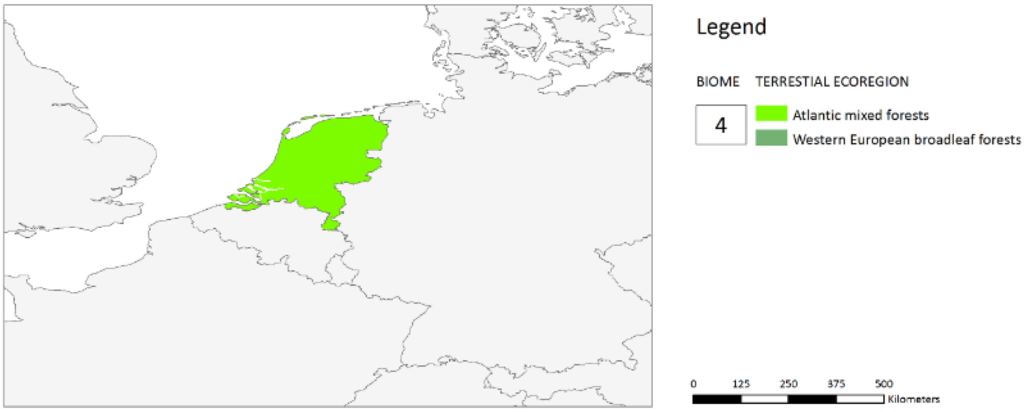
CASE STUDY FACTSHEET

ES-based coastal defence 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

1. Overview of the study area

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.

2. Question and Themes

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 2.1). 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?*

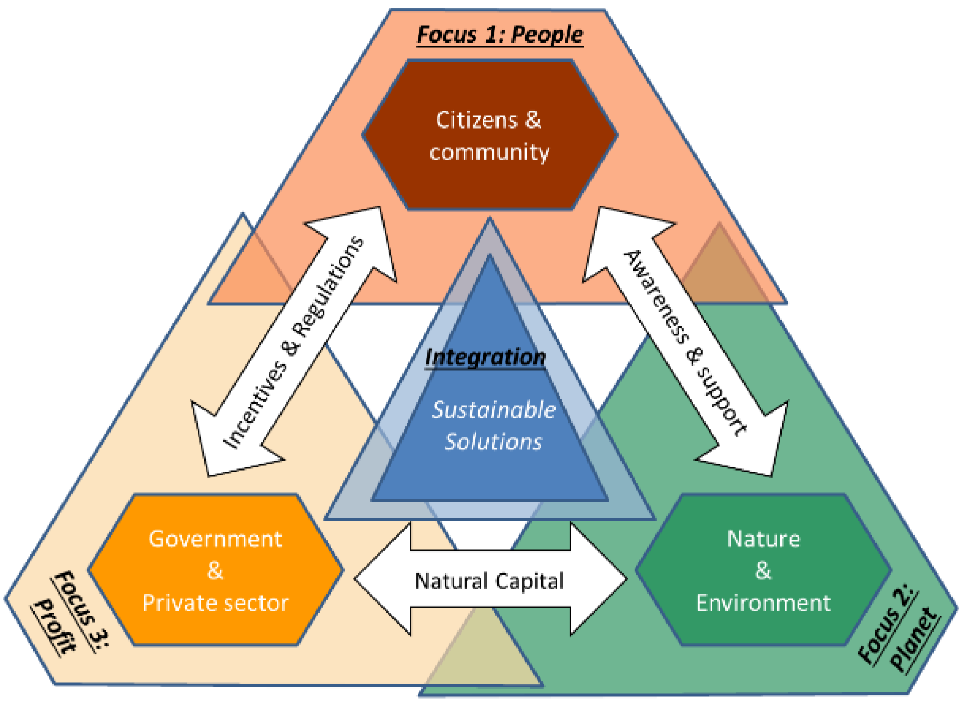


Figure 2.1. Conceptual framework of the "new" study assessing and mapping ES of the Haringvliet.

3. Stakeholders' Involvement

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. Initiating Mapping and Assessment

4.1. 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 4.1). For the scenario situation it was assumed that structures of the historically open Haringvliet will re-establish. 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.

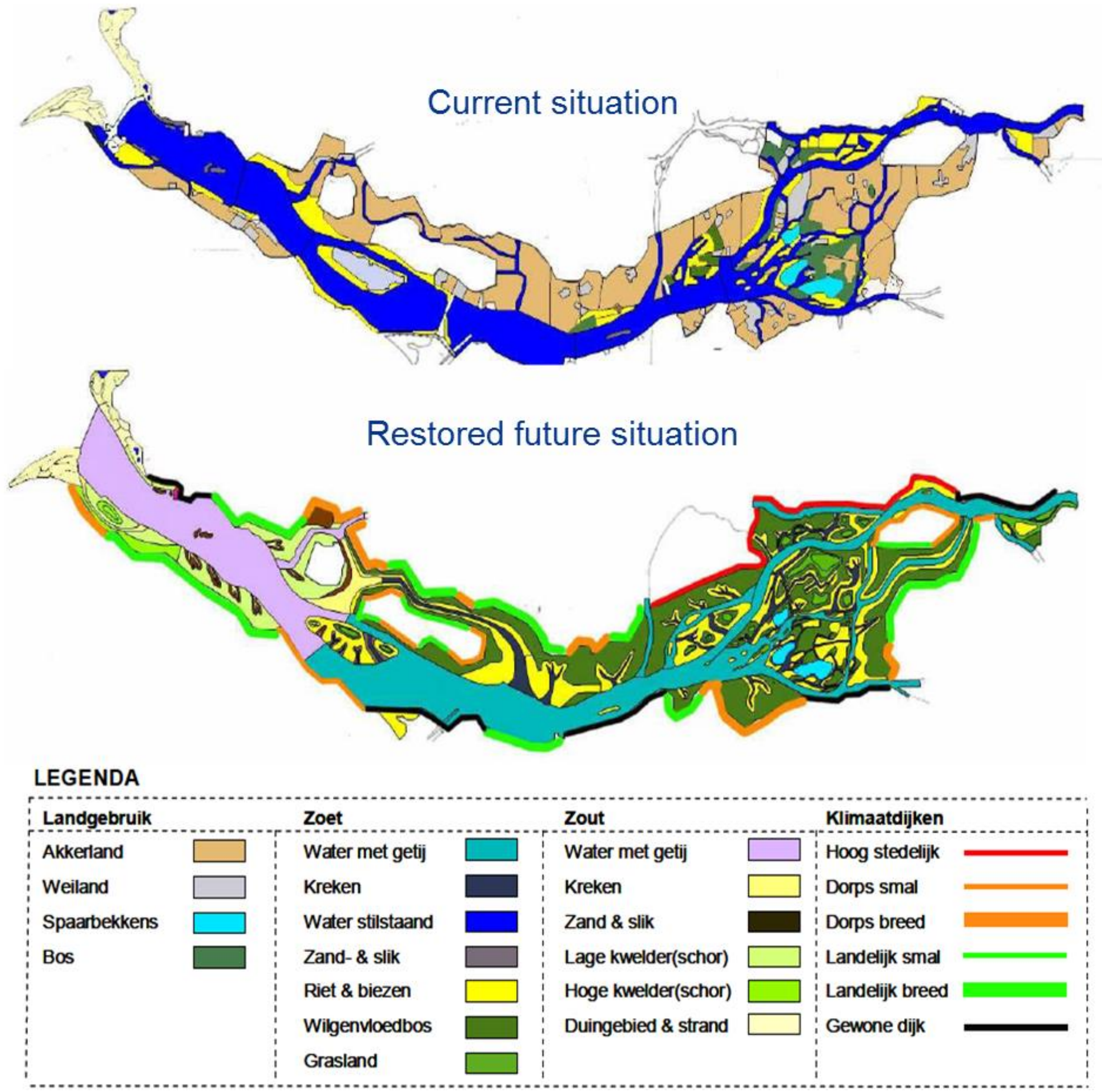


Figure 4.1. Ecosystem maps of the Haringvliet for current and potential "restored" future situation

4.2. 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 4.1 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 centre 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.

4.3. Selecting Ecosystem Services

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: Annexes

Table 7.1).

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”. Annexes
Table 7.1 in the Annex shows the ES considered in the case study.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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 5.1 illustrates how the biophysical methods will be integrated in an overall assessment of future scenarios of the Haringvliet.

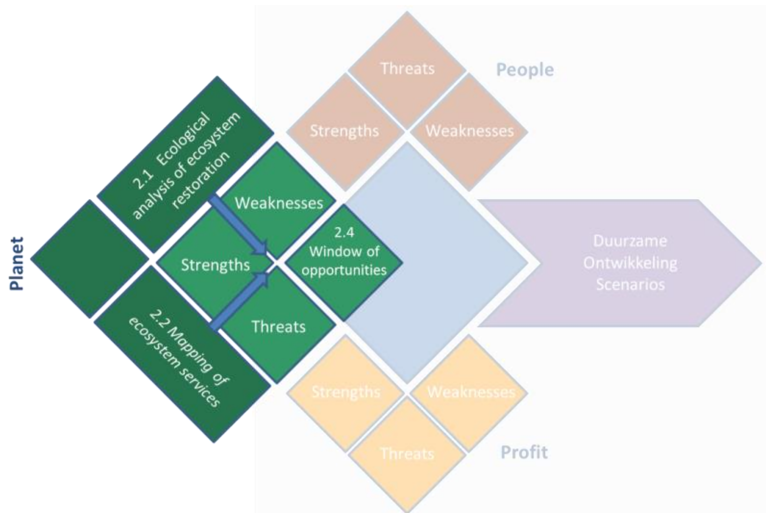


Figure 5.1. Biophysical methods for mapping and assessment of ES in the new Haringvliet study.

5.2. Socio-cultural methods for ES mapping and assessment

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 5.2 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.

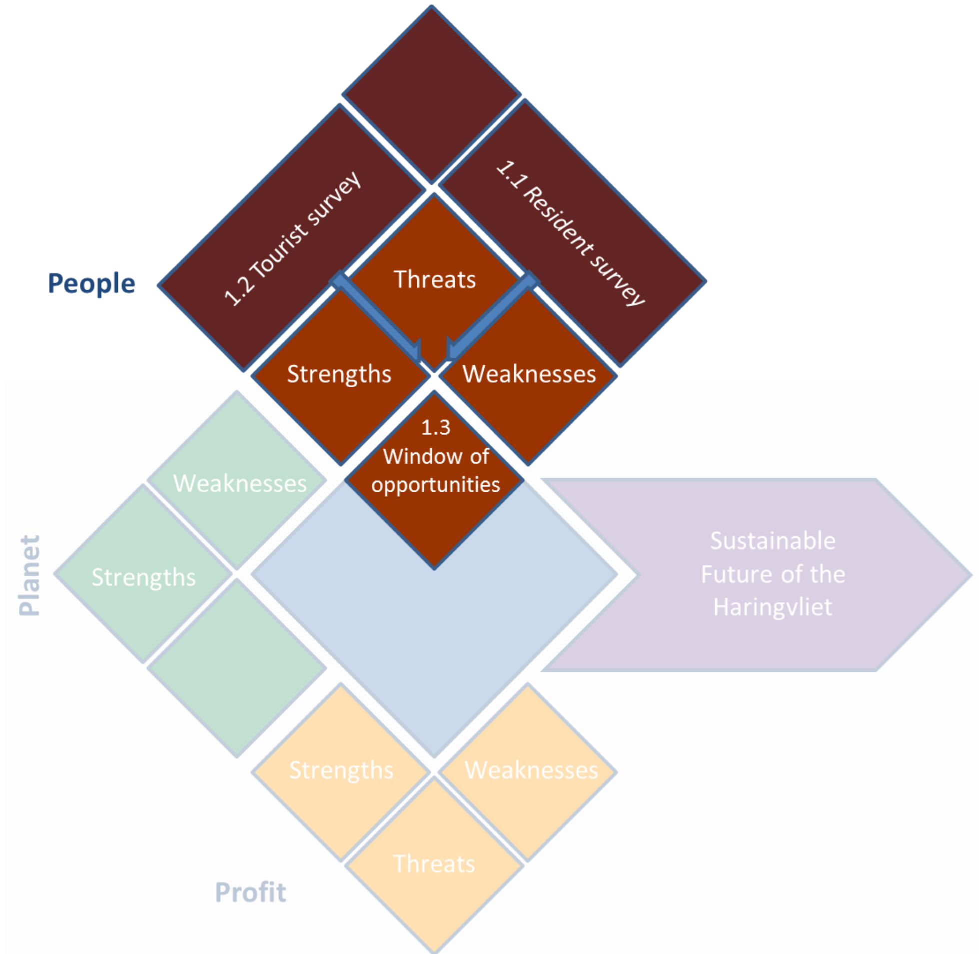


Figure 5.2. Socio-cultural methods for mapping and assessment of ES in the new Haringvliet study.

5.3. Economic methods for ES mapping and assessment

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 5.3. 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 7.2).

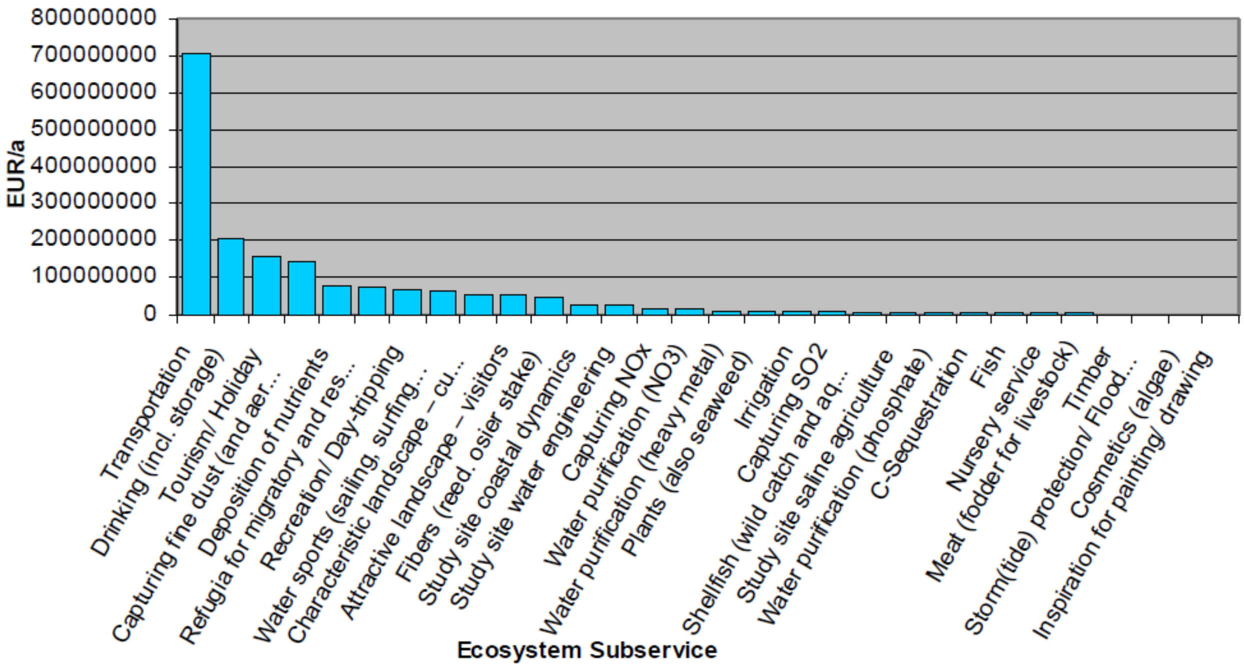


Figure 5.3. ES value of the Haringvliet for potential "restored" future situation (€/year).

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.

5.4. Integration of ES mapping and assessment results

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.

6. Dissemination and communication

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.

7. References & Annexes

Annexes

Table 7.1. 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	• fibre (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 7.1. 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.

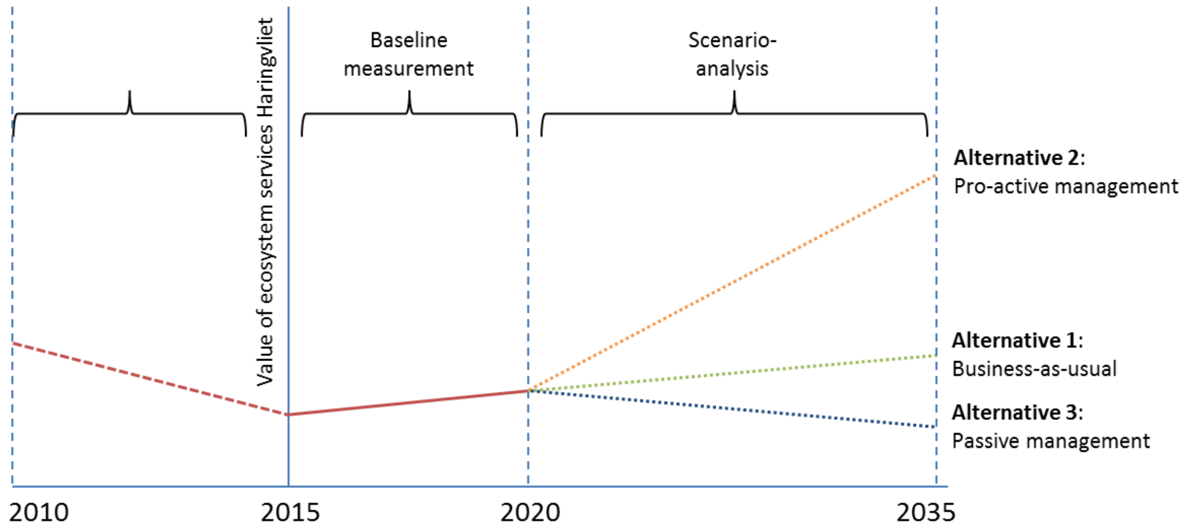


Figure 7.1. Time frames for measuring the values of the current situation and different scenarios for the Haringvliet.

Table 7.2. 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

METHOD APPLICATION CARD: PROCESS BASED MODELLING (KINEROS FLOOD MODELLING) Applied to: Flood protection (2.2.2.2)	
CASE STUDY	NETHERLANDS: ES-based coastal defense (based on experience in Bulgaria)
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[18]. 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
5. SPATIAL SCALE OF APPLICATION	
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
6. EXAMPLES OF POLICY QUESTION	
• What are the areas with high capacity for flood regulation? • What measures have to be applied to preserve the flood regulation functions of these ecosystems?	
Suggested Citation: Nedkov, S., van Beukering, P., Weibel, B., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PROCESS BASED MODELLING (KINEROS FLOOD MODELLING) applied to "Flood protection (2.2.2.2)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

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

METHOD APPLICATION CARD: SPATIAL PROXY METHOD (RECREATION BASED ON GREEN TYPOLOGY) **Applied to: Experiential use of plants, animals and land- / seascapes in different environmental settings (3.1.1.1)**	
CASE STUDY	NETHERLANDS: ES-based coastal defense (based on Recreation in Schlieren, Switzerland)
SCALE	local
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	
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?	
Suggested Citation: Weibel, B., van Beukering, P., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD (RECREATION BASED ON GREEN TYPOLOGY applied to "Experiential use of plants, animals and land- /seascapes in different environmental settings (3.1.1.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

CASE STUDY BOOKLET

ES in Polish urban areas

June 2018

ESMERALDA partner: Adam Mickiewicz University in Poznan (UPOZ)

Case Study Coordinators: Andrzej Mizgajski, Damian Łowicki

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Mizgajski, A., Lowicki, D., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D, (2018). Case Study Booklet: ES IN POLISH URBAN AREAS prepared for "WS3 - Testing the methods across Europe" held in Prague, Czechia, 26-29 September 2016. ESMERALDA EC H2020 Grant Agreement no. 642007.

Acknowledgement: In this booklet, were used the results of the study entitled: Urban MAES - Ecosystem Services in Urban Areas, financial supported by the Polish Ministry of the Environment according to the agreement No.DLP/4/2015 of 23 March 2015. We would like to thank the authors of above-mentioned study, especially Iwona Zwierzchowska, Małgorzata Stępniewska and Piotr Lupa for help in preparation of this booklet.

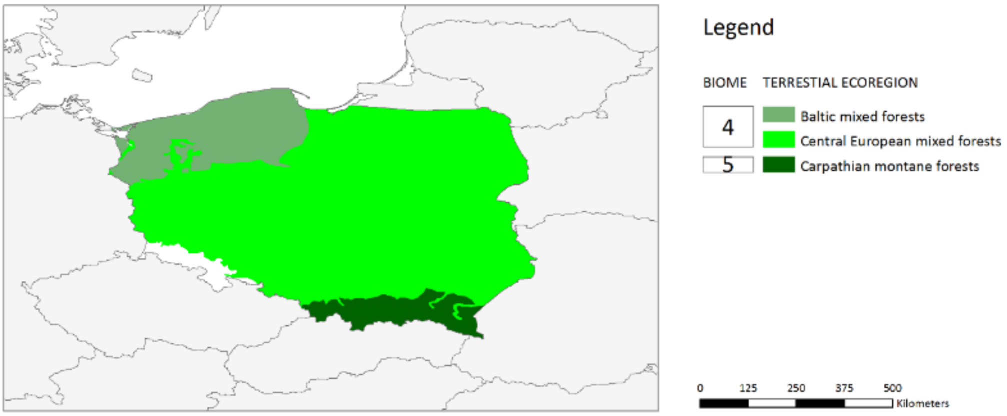
CASE STUDY FACTSHEET

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 EU 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 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

1. Overview of the study area

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 *3.13* and Table 1.1).

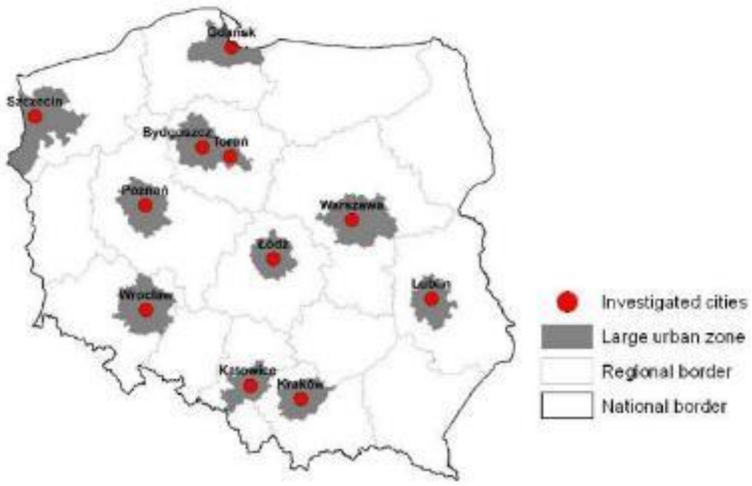


Figure 1.1. Polish agglomerations covered by analysis.

Table 1.1. 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*

2. Questions and Themes

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 1.1 and Figure *3.13*). 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.

3. Stakeholders' Involvement

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.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 4.1)

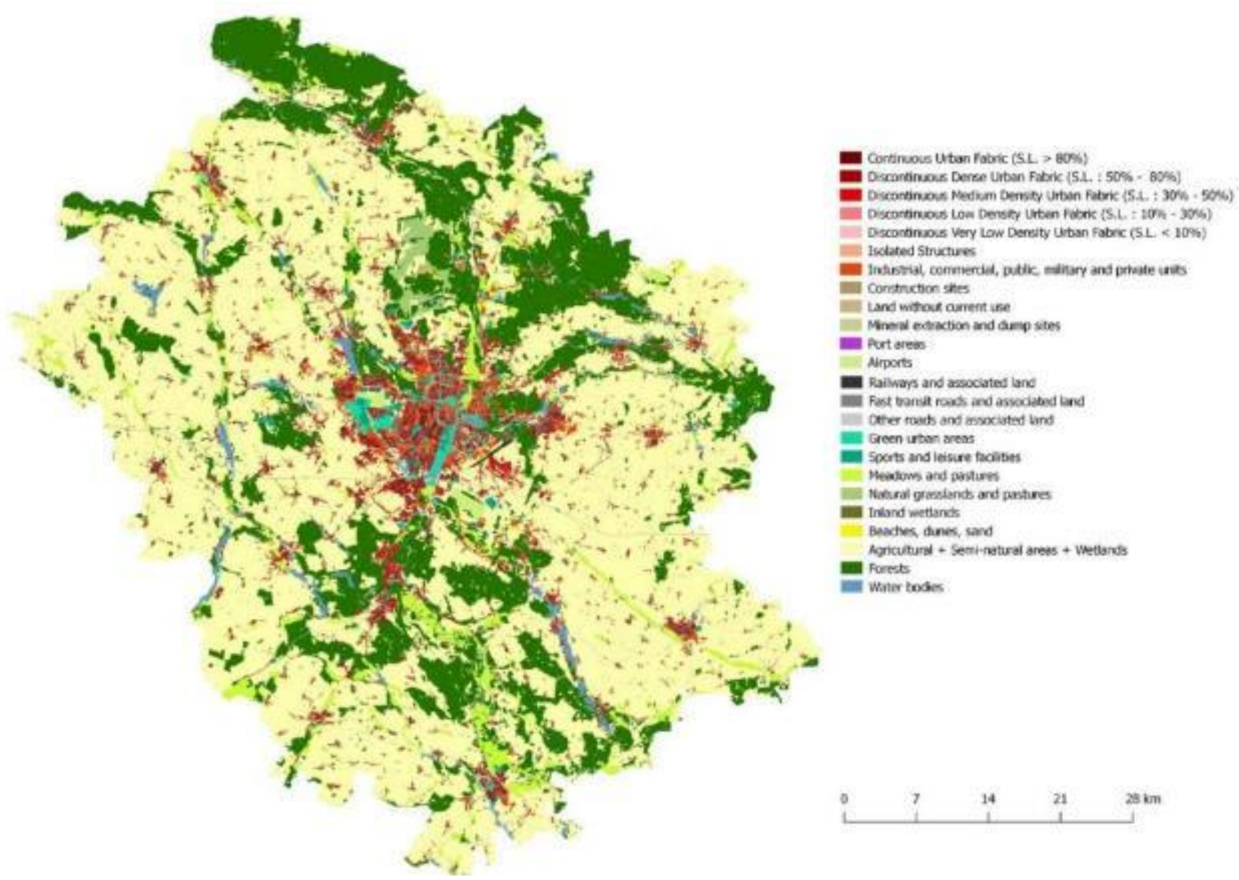


Figure 4.1. An example of ecosystem mapping for Poznan agglomeration

4.2. 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.

4.3. Selecting Ecosystem Services

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 4.1). In addition, several other ES and their spatial composition was described in preliminary research on Poznań urbanized area.

Table 4.1. 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. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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.

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

Agglomerations	Share of green infrastructure [%]	Mean patch area [ha]	Patch density [amount/ha]	Euclidean nearest neighbour 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

As shown in Figure 5.1 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 Neighbour Distance) and contrast of usage intensity between neighbouring patches (Mean Edge Contrast Index).

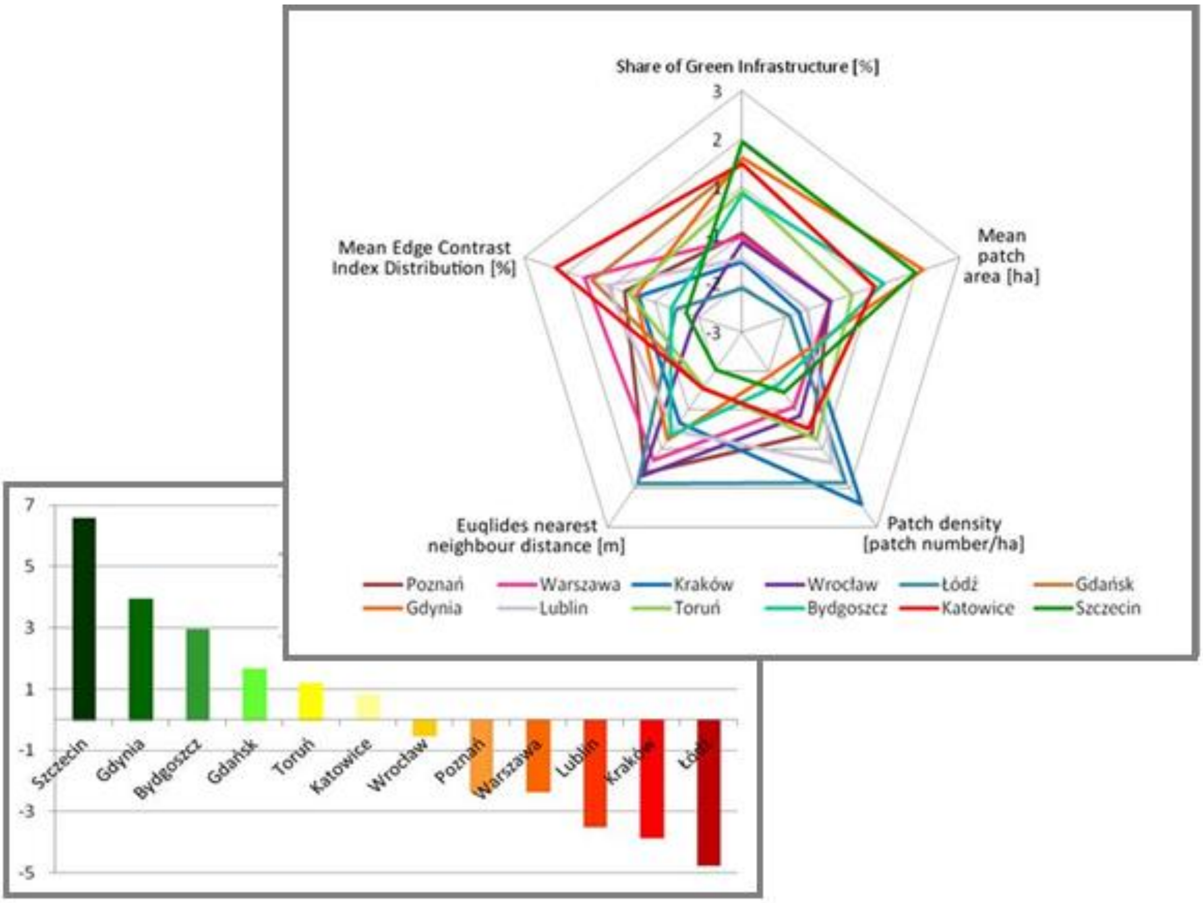


Figure 5.1. Spatial parameters of green infrastructure in the core cities according to standardized landscape metrics

5.1.1. Mapping of regulating and maintenance services

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.

5.1.2. Mapping of cultural services

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.

5.2. Integration of ES mapping and assessment results

The study aimed to show the ES in urban areas and compare Polish cities in terms of the level of services. It was considered that at this stage the use of only a biophysical method is sufficient. Although social and economic methods have not been included, the demand of services has been taken into account, esp. in the context of accessibility of green infrastructure.

6. Dissemination and communication

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: (i) Mapping and Assessment of Ecosystems and their Services, EEA Grants/European Conference, Trondheim/Norway, May 2015; (ii) ECOSERV 2016, 4th Polish National Symposium on ES in transdisciplinary approach, Poznań/Poland, September 2016; (iii) European ES Conference, Antwerp/Belgium, 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, 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.

7. Implementation

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.

8. References & Annexes

References

CLC 2012 - http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012

Geneletti D., Adem Esmail B. (2016). Selection of suitable case studies for testing the methodology for mapping and assessment of ES, Milestone 23 EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007.

Geneletti D., Adem Esmail B. (2016). Interim report illustrating the themes and regions selected for testing the methods across Europe and across themes. Deliverable D5.1 EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007.

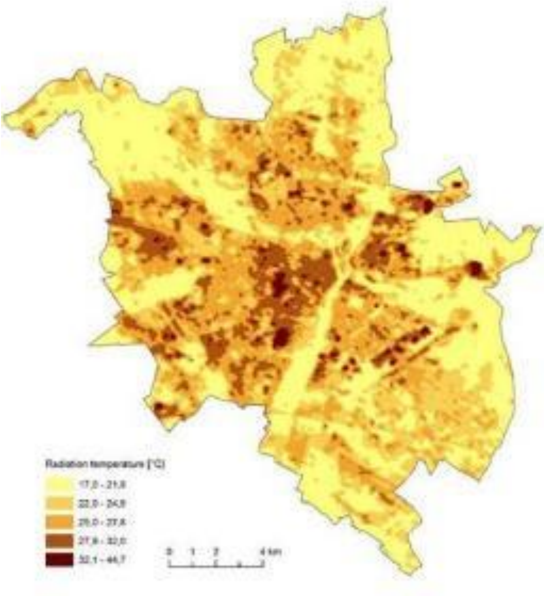
Mapping and assessment of ecosystems and their services in Poland (synthesis) - http://es-partnership.org/wp-content/uploads/2016/06/MAES-for-Poland-synthesis_Poland-introduction_objectives.pdf

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 8.1. Local climate regulation.

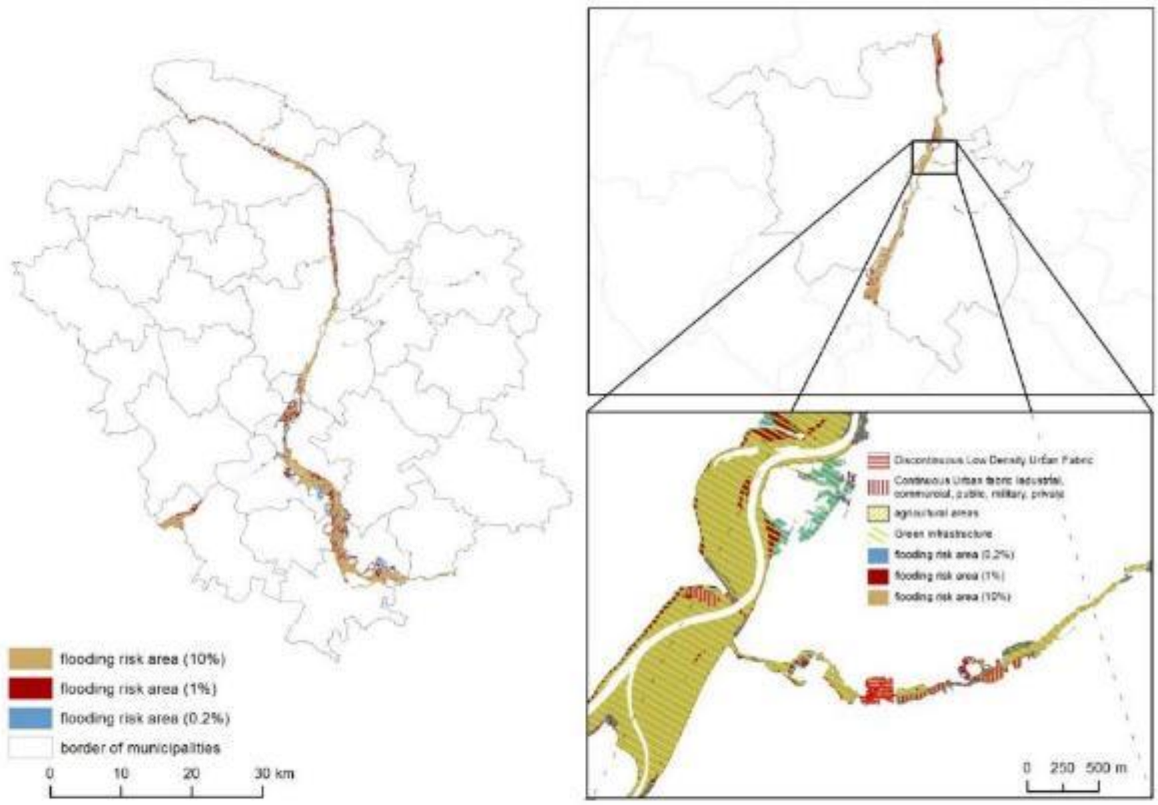


Figure 8.2. Mitigating the flow of matter on the example of mitigation of flood wave.

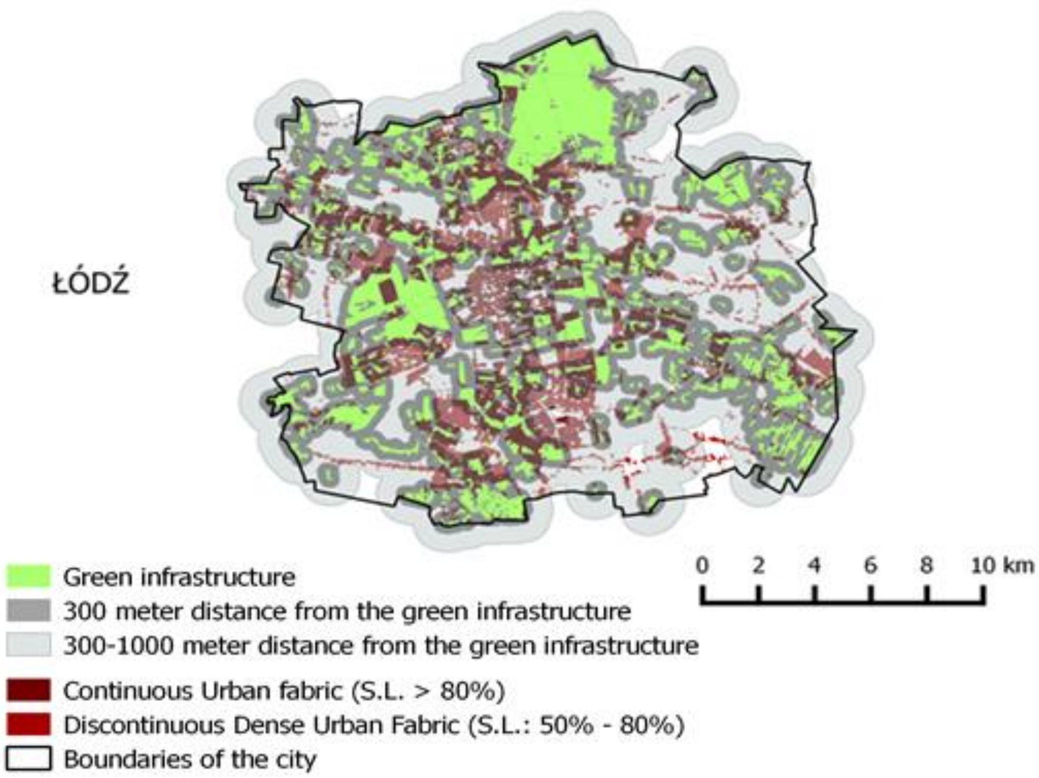


Figure 8.3. Availability of ES in the city of Lodz.

METHOD APPLICATION CARD: SPATIAL PROXY METHOD Applied to: Filtration/sequestration/storage/accumulation by ecosystems (2.1.2.1)	
CASE STUDY	POLAND: Ecosystem services in Polish urban areas
SCALE	Regional, local
TYPE	Biophysical
TIER	2

DESCRIPTION

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.

Operational main steps: 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.

Outputs: 1) Maps showing spatial distribution of ecosystems potential to filtration of surface pollution

1. DATA REQUIREMENT

Qualitative	• Literature
Quantitative	• Required: ○ 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. ○ 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). • Desirable: ○ Land use/land cover (LULC) vector data – current detailed data in scale 1:10 000 or larger with open access (free). ○ 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?
Suggested Citation: Mizgajski, A., Lowicki, D., Liekens, I., Broekx, S., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD applied to "Filtration/sequestration/ storage/accumulation by ecosystems (2.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: REPLACEMENT COST (MARGINAL ABATEMENT COSTS) **Applied to: Filtration, sequestration/storage/accumulation by ecosystems (2.1.2.1)**	
CASE STUDY	POLAND: Ecosystem services in Polish urban areas (based on applications in Belgium, Flanders region).
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	• Low (if based on literature review) • High(if cost efficiency model need to build)
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	• low
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 used.
6. EXAMPLES OF POLICY QUESTION	
• Where is the demand for nutrient retention the highest? • Where the ecosystem provide the service of nutrient retention? • How is the ecosystem service of nutrient retention valued?	
Suggested Citation: Liekens, I., Broekx, S., Mizgajski, A., Lowicki, D., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: REPLACEMENT COST (MARGINAL ABATEMENT COSTS) applied to "Filtration/sequestration/ storage/accumulation by ecosystems (2.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: SPATIAL PROXY METHOD Applied to: Physical use of land- /seascapes in different environmental settings (3.1.1.2)	
CASE STUDY	POLAND: Ecosystem services in Polish urban areas
SCALE	Regional, Local
TYPE	Biophysical
TIER	2
DESCRIPTION	
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. Operational main steps: 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. Outputs: 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.	

1. DATA REQUIREMENT	
Qualitative	• Required: 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. • Desirable: Location and number of residential housing or addresses points with assign number and profile of residents.
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?	
Suggested Citation: Mizgajski, A., Łowicki, D., Liekens, I., Broekx, S., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: SPATIAL PROXY METHOD applied to “Physical use of land / seascapes in different environmental settings (3.1.1.2)”. ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

METHOD APPLICATION CARD: CHOICE MODELLING Applied to: Physical use of land- /seascapes in different environmental settings (3.1.1.2)	
CASE STUDY	POLAND: Ecosystem services in Polish urban areas (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 surveys or focus groups or 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 # 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 available in every country. Could be asked within the preceding questions of the choice experiment. • Willingness to pay data: : based on surveys or focus groups or literature
2. RESOURCES REQUIREMENT	
Time	• High: very time consuming • Lower if you do not perform an own pre-studies, but use literature.
Cost	• High: depends on how the surveys are done: face to face or through internet
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 (distribute visits based on the results of the choice model)
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
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	
• What is the attractiveness of an area for walking and biking? • Which landscape characteristics are most preferred in the area? • Which areas are most preferred for recreation? And why? • If applied in distribution model, how many visitors can we expect?	

Suggested Citation: Liekens, I., Broekx, S., Mizgajski, A., Łowicki, D., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: CHOICE MODELLING applied to "Physical use of land / seascapes in different environmental settings (3.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

CASE STUDY BOOKLET

BALA - Biodiversity of Arthropods from the Laurisilva of Azores, Portugal

June 2018

ESMERALDA partner: Azorean Biodiversity Group - Centre for Ecology, Evolution and Environmental Change (GBA-cE3c) – University of Azores & Instituto Superior Técnico (IST)

Case Study Coordinators: Paulo A.V, Borges, Ana Picanço & Artur Gil

ESMERALDA

Enhancing ecosystem services mapping for policy and decision making

Suggested Citation: Borges, Paulo A.V., Picanço, A., Gil, A., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: BALA - BIODIVERSITY OF ARTHROPODS FROM THE LAURISILVA OF AZORES, PORTUGAL prepared for "WS 5 - Testing the methods across biomes and regions" Madrid, Spain, 04-07 April 2017. ESMERALDA EC H2020 Grant Agreement no. 642007.

CASE STUDY FACTSHEET

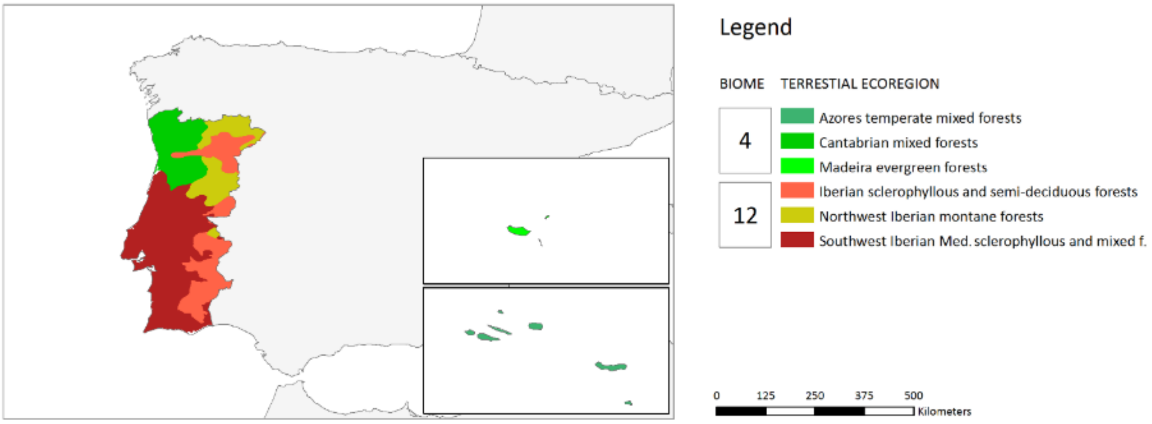
Biodiversity of Arthropods from the Laurisilva of Azores WS5_cs2

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

1. Overview of the study area

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).

2. Questions and Themes

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[19]. 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[20]. 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[21].

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

3. Stakeholders' Involvement

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[22] 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.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 4.1).

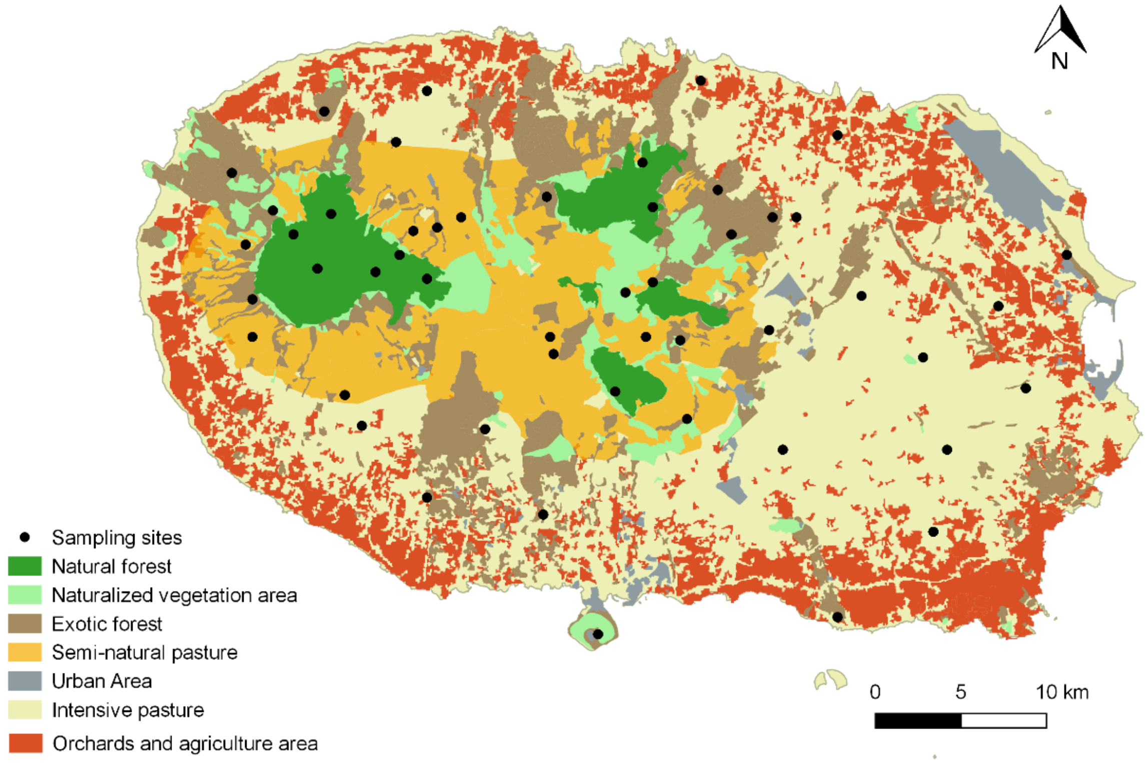


Figure 4.1. A land use land cover map of Terceira was available from DROTRH (2008) adapted by our purposes and with addition of new data for natural forests from Gaspar et al. (2008). Black points are sampled points for the pollinator assessment (see Picanço et al. (2017a, b).

4.2. 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

[22] http://gba.uac.pt/fotos/noticias/1435657919.pdf

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 6.17). 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).

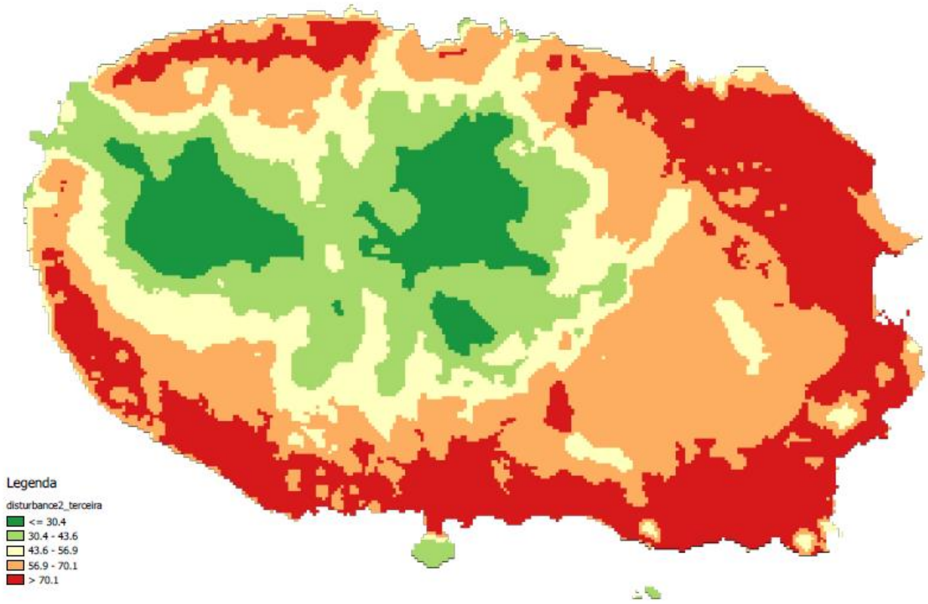


Figure 4.2. Maps of Terceira Island with value of landscape disturbance according to Cardoso et al. (2013). Values of landscape disturbance are represented in a gradient from green for lowest values to red for highest values.

4.3. Selecting Ecosystem Services

We selected two ES for which data was available based on macro-ecological studies (see Table 4.1). 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 4.1. 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

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 4.1). 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 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 created thresholds values for the different classes are specified in Table 5.1.

Table 5.1. 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 5.1 to Figure 5.6.

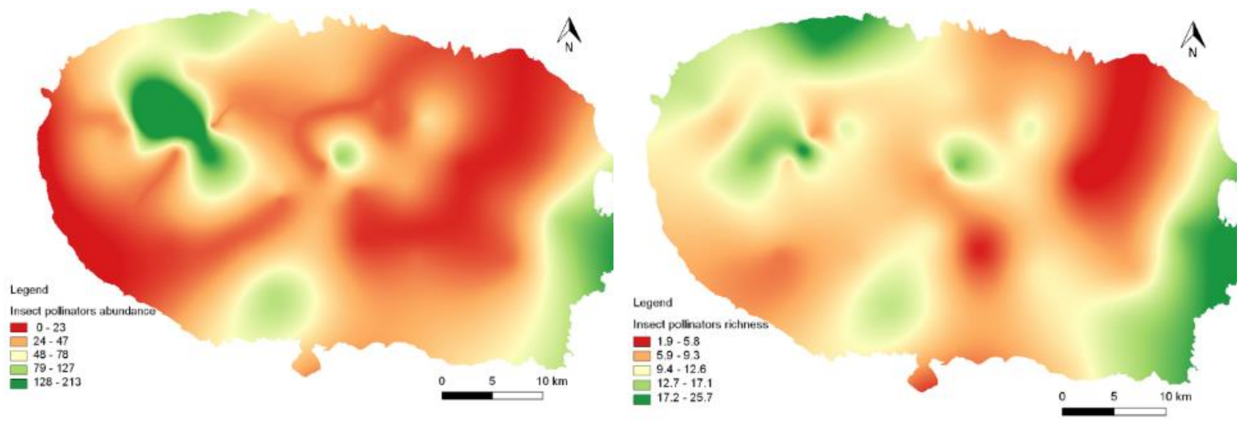


Figure 5.1. Map based on insect pollinator abundance (left) and richness (right) in Terceira Island.

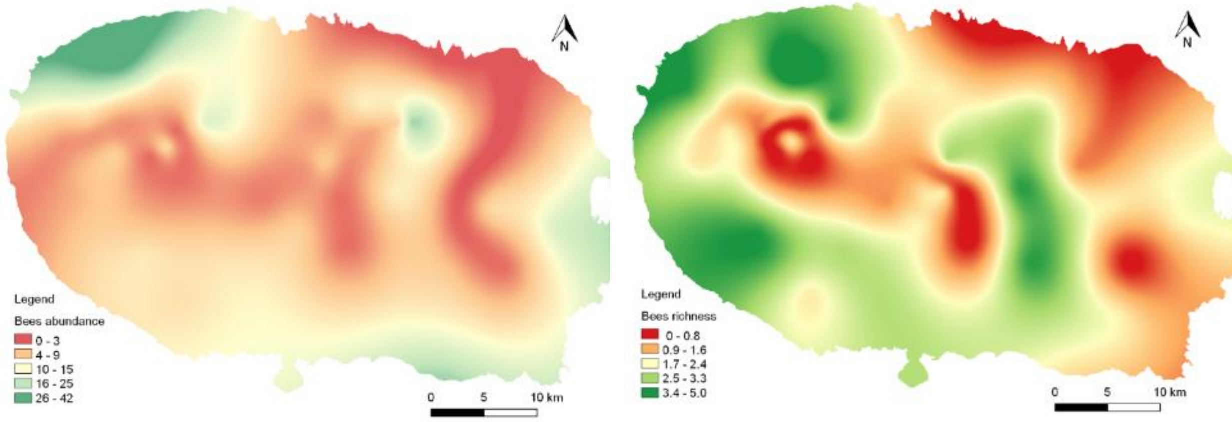


Figure 5.2. Map based on bees' *abundance (left) and richness (right) in Terceira Island.*

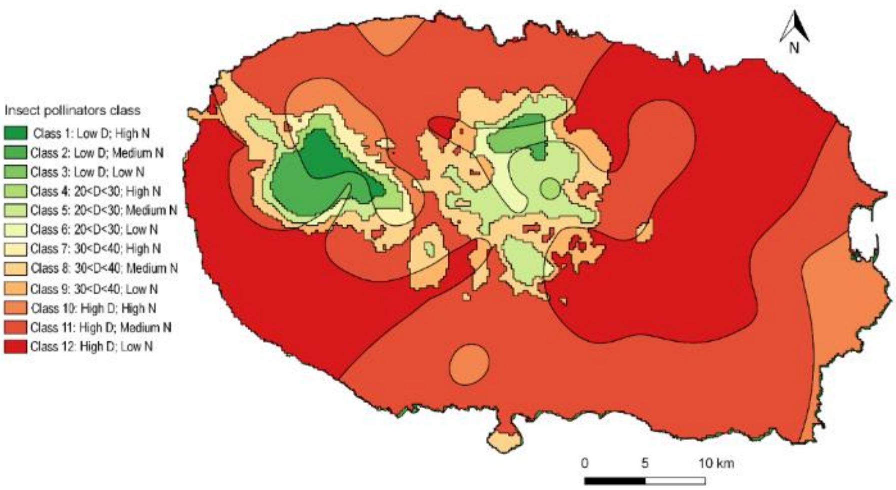


Figure 5.3. Map based on Disturbance and insect pollinator abundance in Terceira Island. Classes 1, 4, 7 and 10 have the highest potential to support pollination, despite the high disturbance on Classes 7 and 10.

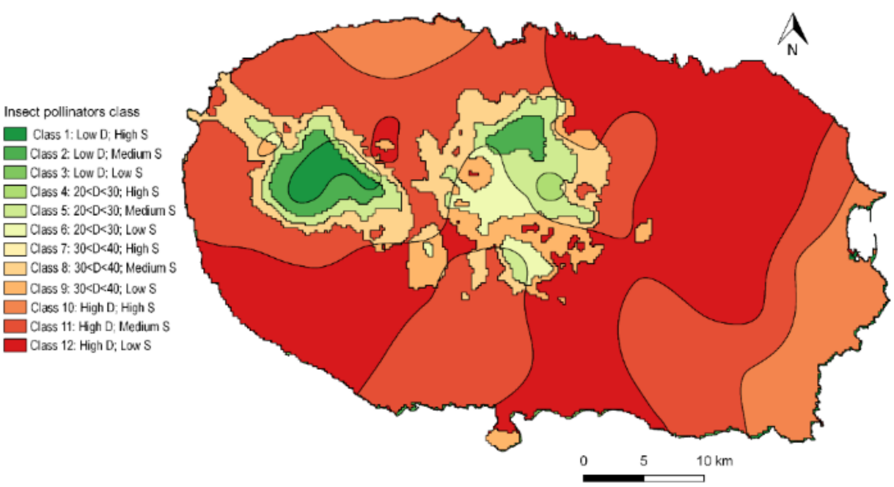


Figure 5.4. Map based on Disturbance and insect pollinator richness in Terceira Island. Classes 1, 4, 7 and 10 have the highest potential to support pollination, despite the high disturbance on Classes 7 and 10.

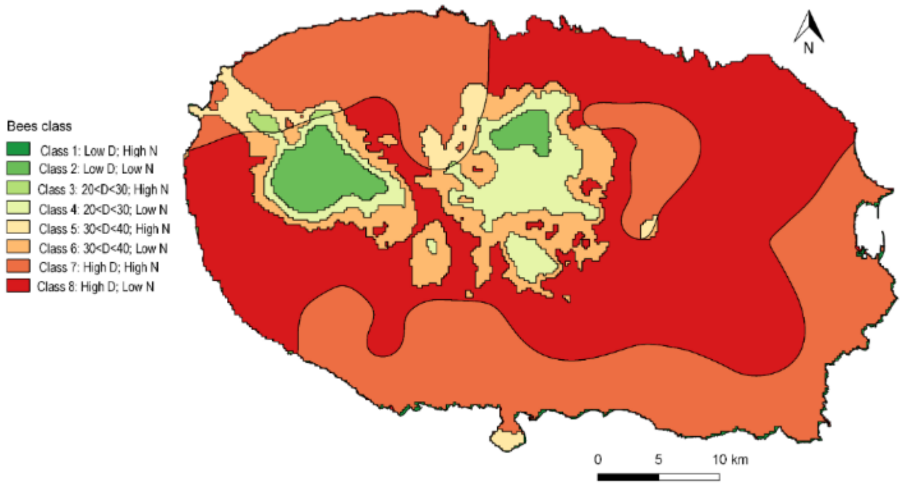


Figure 5.5. Map based on Disturbance and bees' abundance in Terceira Island. Classes 1, 3 and 6 have the highest potential to support pollination, despite the high disturbance on Class 6.

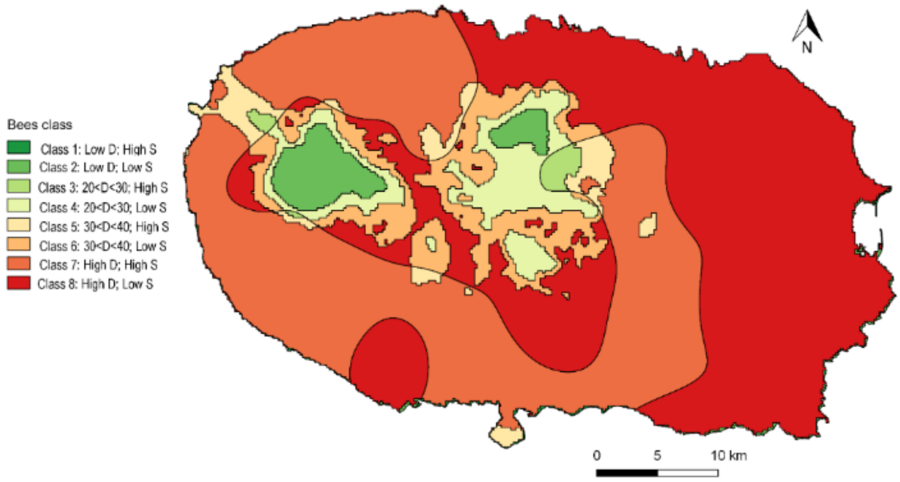


Figure 5.6. Map based on Disturbance and bees' richness in Terceira Island. Classes 1, 3 and 6 have the highest potential to support pollination, despite the high disturbance on Class 6.

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 5.2 lists the 12 classes obtained for thresholds values between the disturbance index (D) and the proportion of endemic arthropods.

Table 5.2. 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 5.7 and Figure 5.8 are two examples of mapping the ES “Nursery populations and Habitats”.

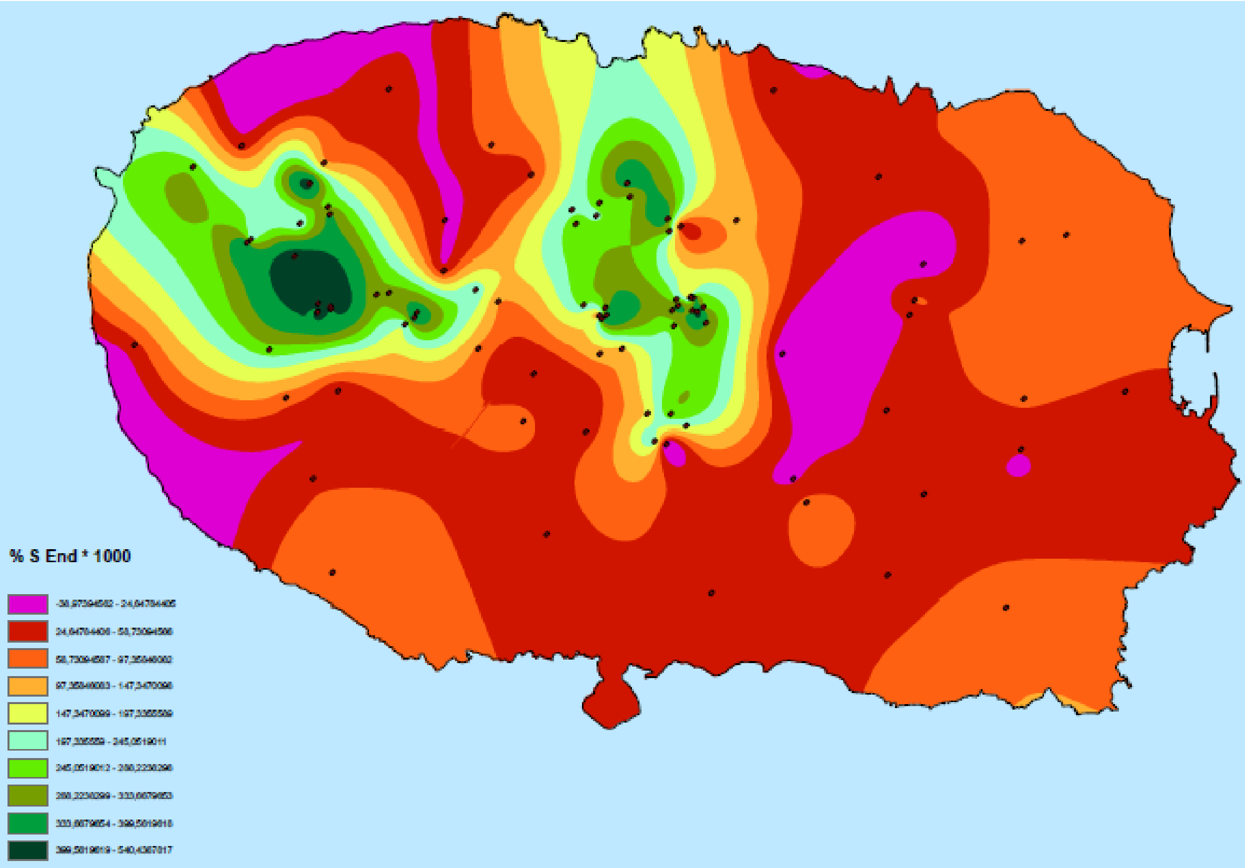


Figure 5.7. Map based on the proportion of arthropod endemic species in Terceira Island.

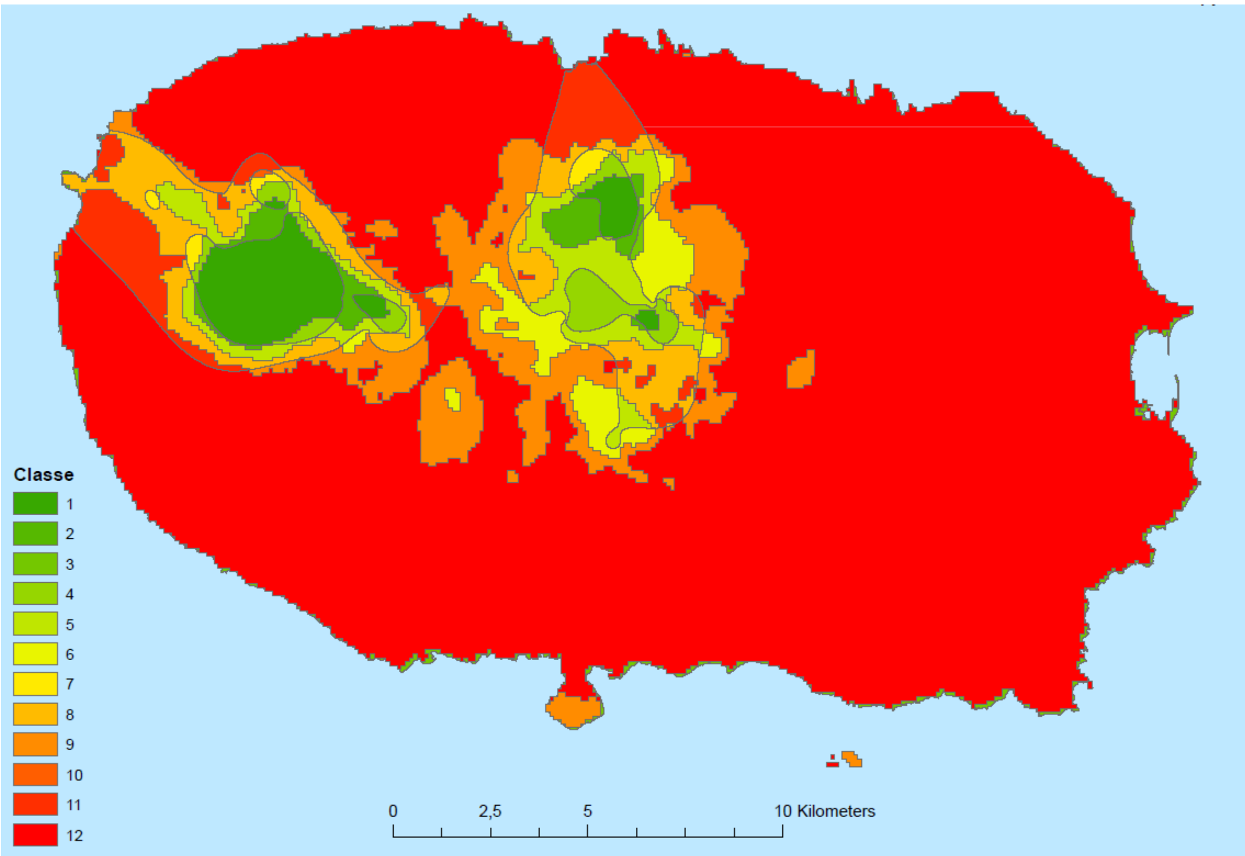


Figure 5.8. Map based on Disturbance and the proportion of arthropod endemic species in Terceira Island. Classes 1, 4 and 7 have the highest potential to support endemic species, despite the high disturbance in Class 7.

5.2. Integration of ES mapping and assessment results

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 5.8).

6. Dissemination and communication

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[23] traps (see). The same data was influential in the development of Ecosystem Assessment Profiles within BEST III project for Macaronesia[24] 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.

6.1. Implementation

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. The results obtained for Maintaining nursery populations and habitats, published by Gaspar et al. (2011) and Picanço et al. (2017a), were already used to implement an 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 traps. Similarly, the results obtained for Pollination and seed dispersal can be used to identify key ES for Azorean agro-ecosystems.

[23] http://gba.uac.pt/research/projects/ver.php?id=18
[24] http://www.azores.gov.pt/Gra/BEST_III_Macaronesia/conteudos/noticias/2016/Maio/NOTICIAS_BEST_27-05-2016.htm

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METHOD APPLICATION CARD: MACRO-ECOLOGICAL MODELLING Applied to: Maintaining nursery populations and habitats (2.3.1.2)	
CASE STUDY	PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores
SCALE	Local/Regional
TYPE	Biophysical
TIER	2

DESCRIPTION

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.

References:
Cardoso, P., Rigal, F., Fattorini, S., Terzopoulou, S. & Borges, P.A.V. (2013). Integrating Landscape Disturbance and Indicator Species in Conservation Studies. PLoS ONE, 8: e63294.

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 maps (Cardoso et al. 2013).
Quantitative	• 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 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. 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?
- How can we identify islands or mainland regions that are more susceptible to biodiversity loss in the coming decade, and what are the most efficient and cost-effective methods (i.e. policy; education; research; management) for safeguarding their biodiversity?
- What are the best strategies for in situ conservation of nursery populations impacted by non-native species?
- How can we best implement long-term monitoring schemes on nursery populations to provide quantitative evidence of changes within island ecological systems?
- How can nursery populations and habitats conservation interest best be integrated with other island stakeholder interests (particularly tourism and agriculture) on populated islands?

For additional related questions see our recent exercises for islands at:

-Borges, P.A.V., Cardoso, P., Gabriel, R., Ah-Peng, C. & Emerson, B.C. (2016). Challenges, advances and perspectives in Island Biogeography. Frontiers of Biogeography, 8: e29136
-Patiño, J., Whittaker, R.J., Borges P.A.V., Fernández-Palacios, J.M., Ah-Peng, C., Araújo, M., Ávila, S., Cardoso, P., Cornuault, J., Boer, E. de, Nascimento, Lea de, Gil, A., Gonzáalez, A., Gruner, D.S., Heleno, R., Hortal, J., Illera, J.C., Kaiser-Bunbury, C., Matthews, T., Papadopoulou, A., Pettorelli, N., Price, J., Santos, A.M.C., Steinbauer, M., Triantis, K.A., Valente, L., Vargas, P., Weigelt, P. & Emerson, B.C. (2017). A roadmap for island biology: 50 fundamental questions after 50 years of The Theory of Island Biogeography. Journal of Biogeography, 44: 963–983.

Suggested Citation: Borges, P.A.V., Picanço, A., Gil, A., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: MACRO-ECOLOGICAL MODELS applied to "Pollination and seed dispersal (2.3.1.1)". ESMERALDA EC H2020 Grant Agreement no. 642007.

METHOD APPLICATION CARD: MACRO-ECOLOGICAL MODELLING
Applied to: Pollination and seed dispersal (2.3.1.1)

CASE STUDY	PORTUGAL, AZORES: BALA - Biodiversity of Arthropods from the Laurisilva of Azores
SCALE	Local/Regional

TYPE	Biophysical
TIER	2

DESCRIPTION

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. 2017a). 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. (2017b) 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. (2017b) for the different habitat types - natural forest, naturalized vegetation areas, exotic forest, semi-natural pasture and intensively managed pasture.

References:
Cardoso, P., Rigal, F., Fattorini, S., Terzopoulou, S. & Borges, P.A.V. (2013). Integrating Landscape Disturbance and Indicator Species in Conservation Studies. PLoS ONE, 8: e63294
Picanço, A., Rigal, F., Matthews, T.J., Cardoso, P. & Borges, P.A.V. (2017a). Impact of land-use change on flower-visiting insect communities on an oceanic island. Insect Conservation and Diversity, 10: 211-223.
Picanço, A., Gil. A., Rigal, F. & Borges, P.A.V. (2017b). Pollination services mapping and economic valuation from insect communities: a case study in the Azores (Terceira Island). Nature Conservation, 18, 1-25.

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 maps (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., 2017a,b).
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?
- How can we ensure adequate land-use management in small islands for implementing the conservation of native pollinator networks
- How can we employ plant-insect pollinator interactions as educational tools for farmers and public awareness?
- Which pollinators (native or exotic) are helping the spread of invasive plants o islands and how to manage this ecosystem disservice?
- How, if at all, do island differ from continental pollinator networks in their response to global change drivers?
- What determines anthropogenic extinction rates among island plant-insect pollinator interactions?
- How do anthropogenic changes within islands impact on the capacity of island pollinator's species to respond successfully to climate change?
- How can we identify islands that are more susceptible to pollinator biodiversity loss in the coming decades, and what are the most efficient and cost-effective methods (i.e. policy; education; research; management) for safeguarding their biodiversity?
- How can we best implement long-term monitoring schemes on islands to provide quantitative evidence of changes within island plant-insect pollinator interactions?
- What are the impacts of novel biotic interactions between and among alien and native species on island biodiversity and ecosystem functioning?
- To what extent can alien pollinator species act as functional substitutes for native pollinator species on island fruit production?
- How can protected areas native pollinator management can be integrated with crop pollination management?

For additional related questions see our recent exercise for islands at:

-Patiño, J., Whittaker, R.J., Borges P.A.V., Fernández-Palacios, J.M., Ah-Peng, C., Araújo, M., Ávila, S., Cardoso, P., Cornuault, J., Boer, E. de, Nascimento, Lea de, Gil, A., Gonzáalez, A., Gruner, D.S., Heleno, R., Hortal, J., Illera, J.C., Kaiser-Bunbury, C., Matthews, T., Papadopoulou, A., Pettorelli, N., Price, J., Santos, A.M.C., Steinbauer, M., Triantis, K.A., Valente, L., Vargas, P., Weigelt, P. & Emerson, B.C. (2017). A roadmap for island biology: 50 fundamental questions after 50 years of The Theory of Island Biogeography. Journal of Biogeography, 44: 963–983.

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Disclaimer: **This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_method).**

CASE STUDY BOOKLET

Spanish National Ecosystem Assessment

June 2018

ESMERALDA partner: Universidad Autónoma de Madrid, UAM

Case Study Coordinators: Fernando Santos Martin

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Santos, M.F., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: SPANISH NATIONAL ECOSYSTEM ASSESSMENT prepared for "WS 5 - Testing the methods across biomes and regions" Madrid, Spain, 04-07 April 2017. ESMERALDA EC H2020 Grant Agreement no. 642007.

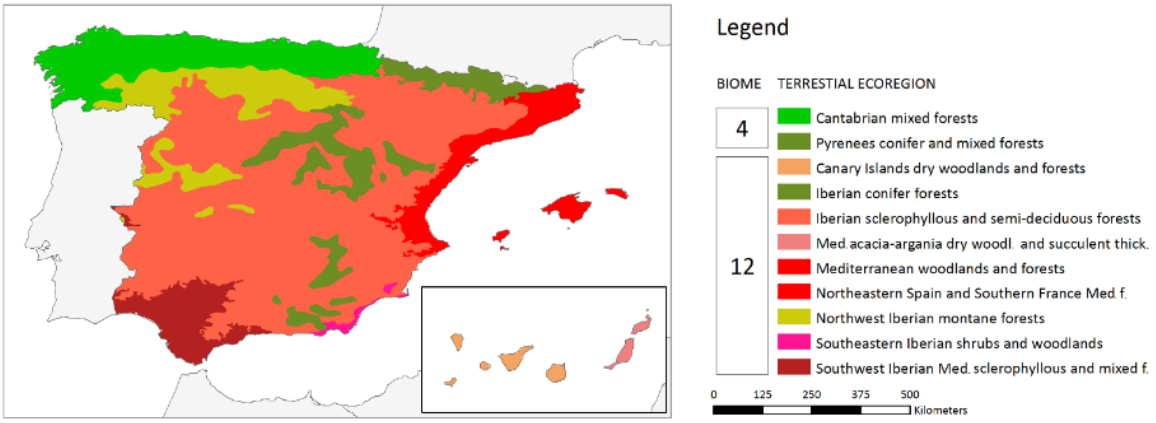
CASE STUDY FACTSHEET

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

1. Overview of the study area

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).

2. Questions and Themes

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?*

3. Stakeholders Involvement

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 centres 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 centres, 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.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

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 4.1). 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 4.1). However we made an effort to integrate national scale ecosystem classifications with the existing European level classification (Annex: Annexes

Table 7.1). 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).

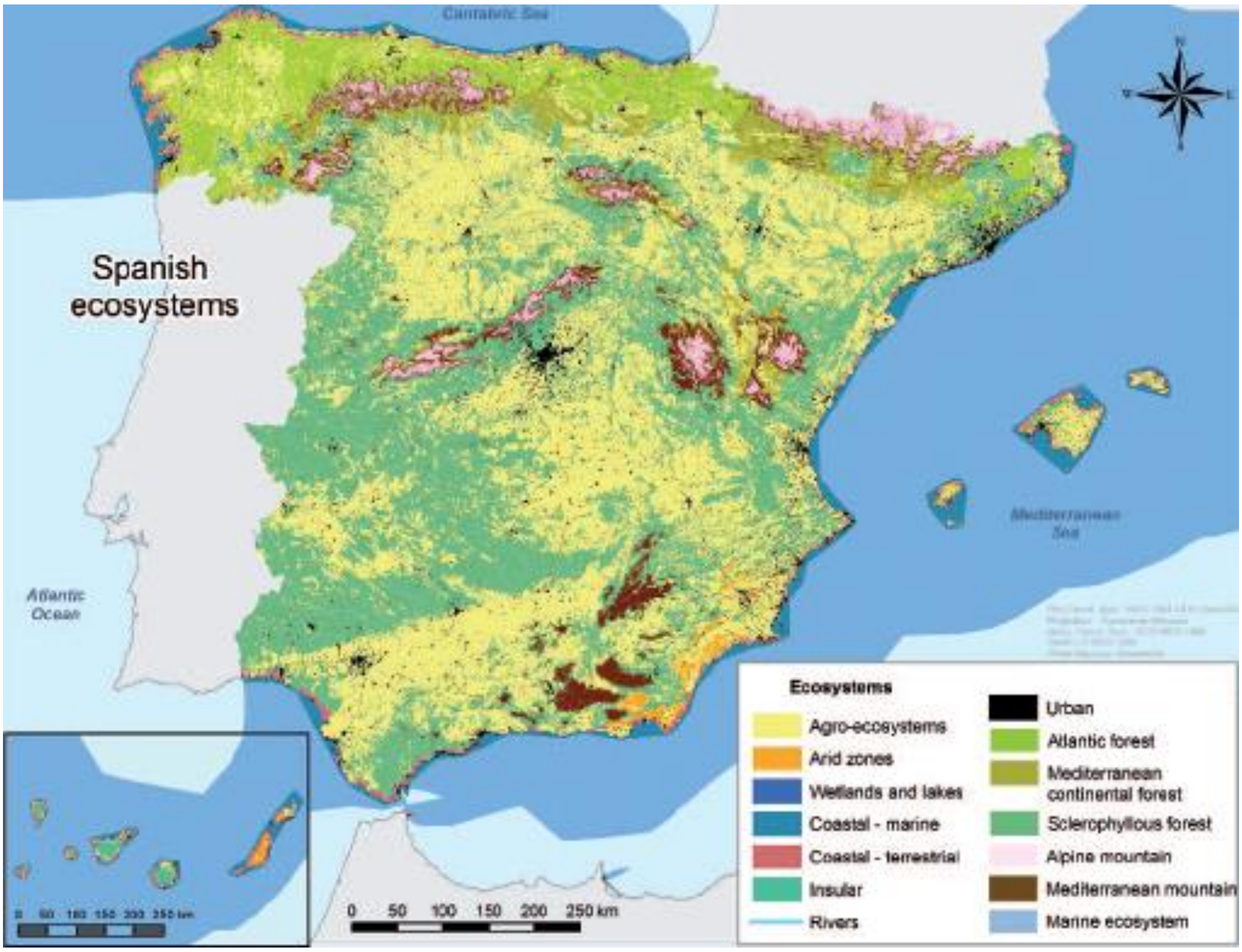


Figure 4.1. Spatial representation of the 14 Ecosystem types assessed in the Spanish NEA (Spanish NEA, 2014).

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 5.2). 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 4.1. 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.

4.2. 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.

4.3. Selecting Ecosystem Services

Under the Spanish NEA, 22 services were selected (Annex: Table 7.2) 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.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

The biophysical assessment of the status and trends of ES in Spain was performed using multiple indicators (Annex: Table 7.3). 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 5.1). In the following paragraphs we explain the methodology used for each ES.

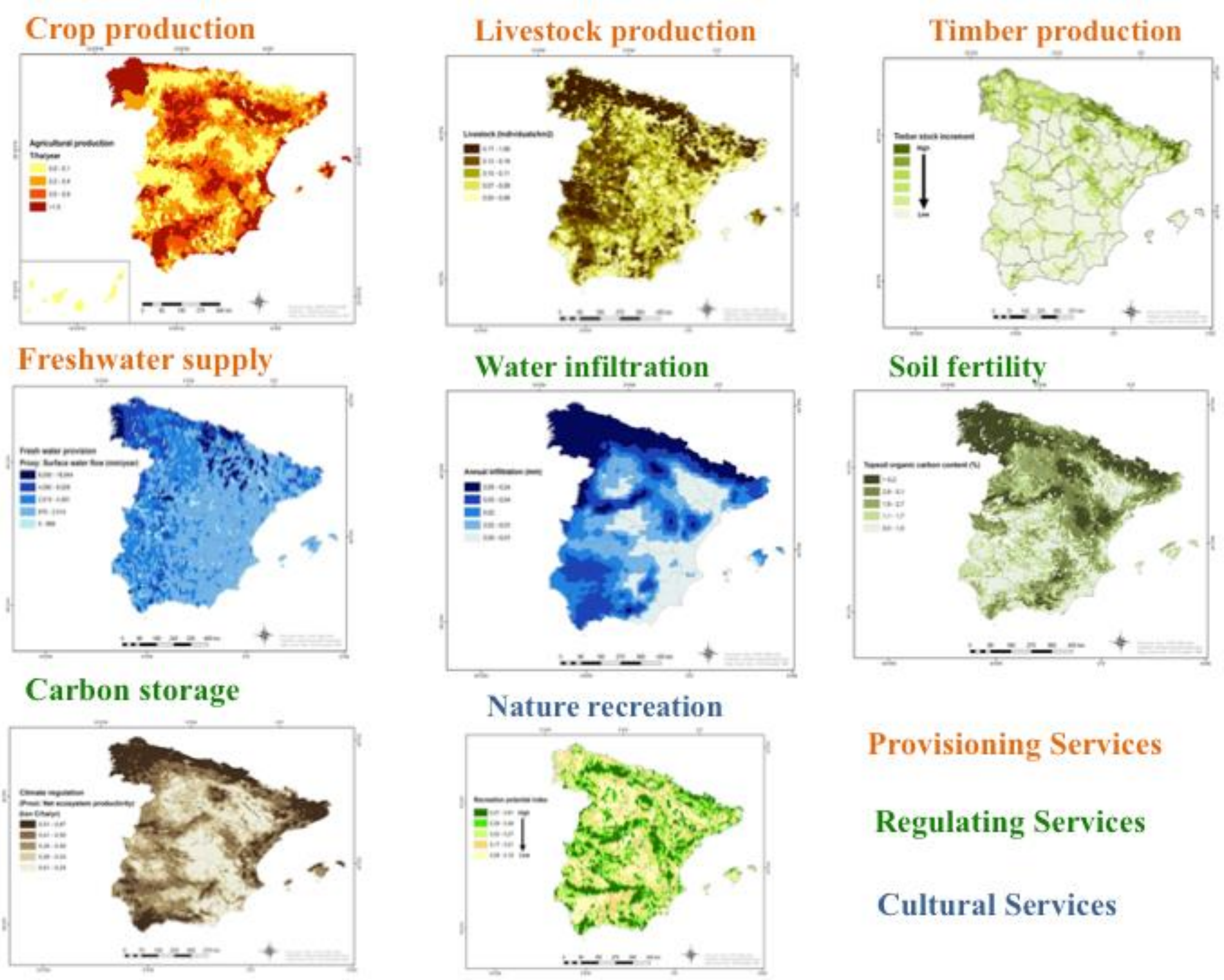


Figure 5.1. Spatial representation of mapping ES for the SNEA.

5.1.1. 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[25]). 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[26]. Based on the EFISCEN inventory, the AFOLU[27] action of the JRC produced provides aggregated statistics on the timber stock, expressed in ha and m^3 and increment (m3 year-1).

[25] http://www.fao.org/geonetwork (keyword gridded livestock)
[26] http://www.efi.int/portal/virtual_library/databases/
[27] 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 an EU 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.

5.1.2. 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 centre. Data on soil depth, moisture capacity and organic carbon content are available via the website[28]. Soil data at the global scale are provided by the FAO[29]. 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[30]. 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[31] 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 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

[28] http://eusoils.jrc.ec.europa.eu/
[29] http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/
[30] http://cdiac.ornl.gov/epubs/ndp/ndp017/ndp017b
[31] http://geofront.vgt.vito.be/geosuccess/relay.do?dispatch=NEP_info.

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} $year^{-1}$).

5.1.3. 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: SNEA, 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 analysed. 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.

5.2. Socio cultural methods for ES mapping and assessment

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 5.1).

Table 5.1. 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 5.2, 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).

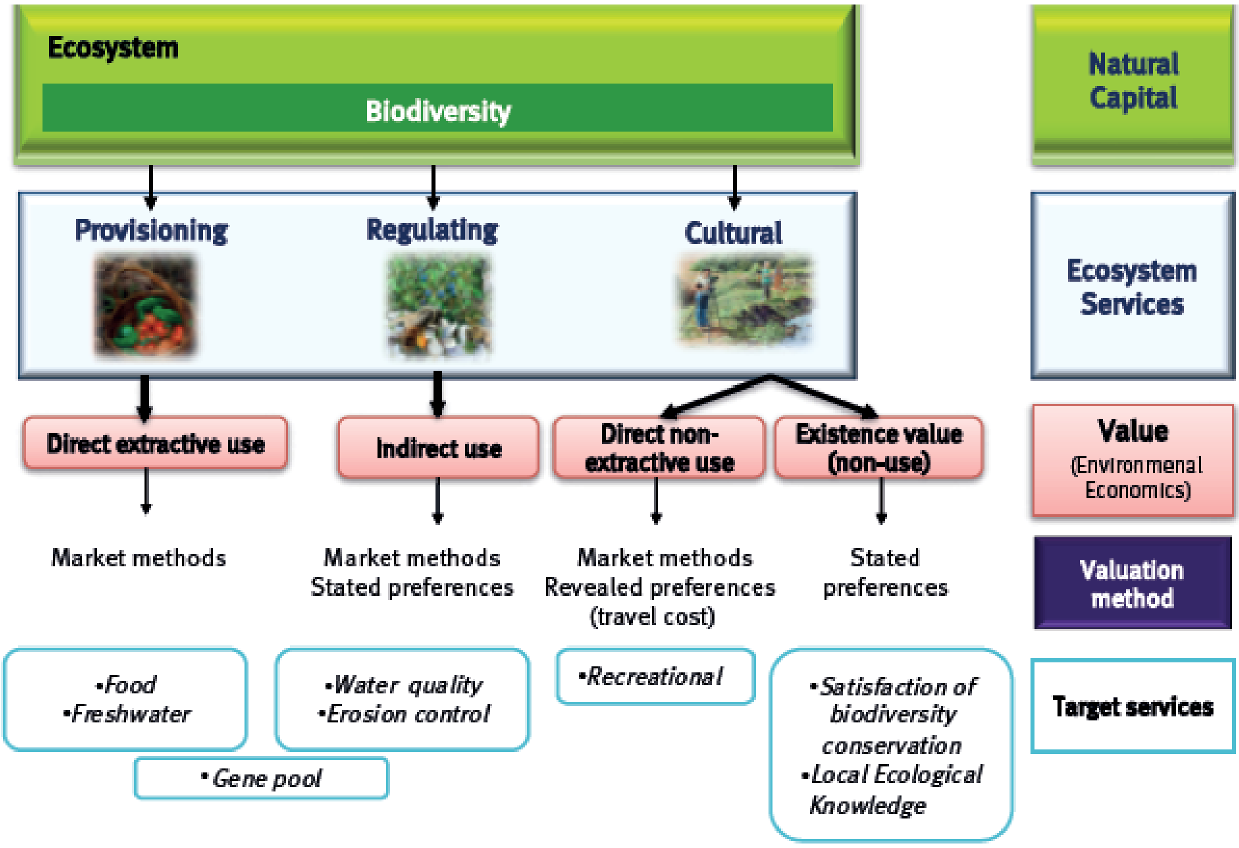


Figure 5.2. Methodological map used in the valuation of ES in Spain, in which one can see the different typologies of services derived from natural capital, and the different types of associated value according to the framework of Environmental Economy. Finally, the most appropriate methodologies for 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-Martín et al, 2016).

5.3. Integration of ES mapping and assessment results

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 5.3).

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 5.2).

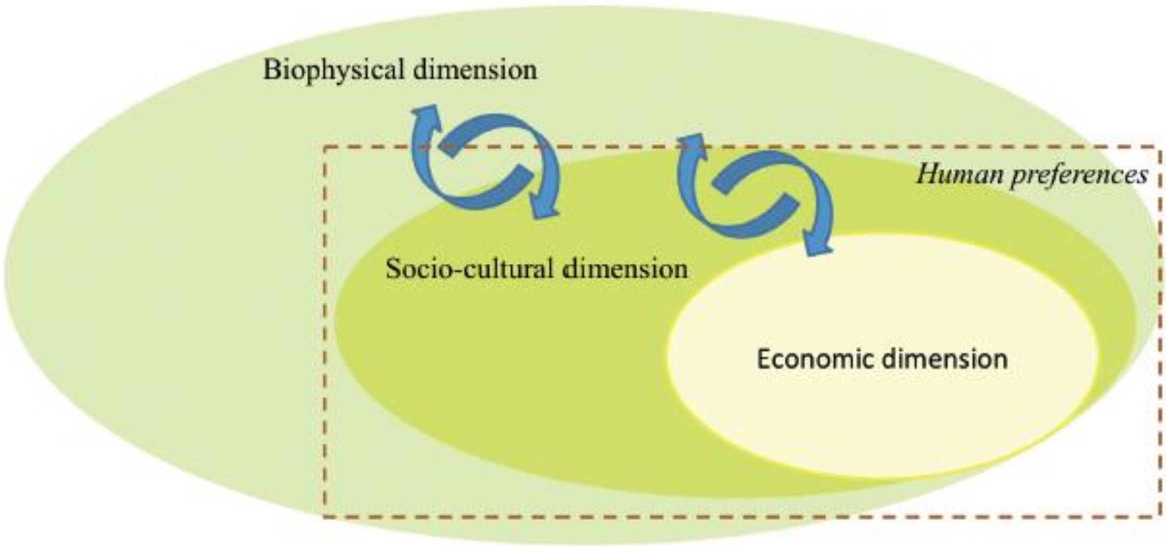


Figure 5.3. Conceptual framework of the integration of results and the concentric relationship between the three dimensions of the assessment. (Source: Santos-Martín et al, 2016).

Table 5.2. 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-Martín et al, 2016).

		Biophysical	Economic			Social	Spatial		Available in SNEA
			MAR	MA	CM		SNEA	OTHERS	
Provisioning	1. Food	X	X	X		X	X	X	
	2. Water	X	X				X	X	
	3. Raw materials	X				X		X	
	4. Gene pool	X			X				
	5. Natural medicines	X							
Regulating	7. Climate regulation	X		X		X		X	
	8. Air quality	X				X			
	9. Water regulation	X				X		X	
	10. Water treatment	X	X	X	X		X	X	
	11. Erosion control	X		X	X			X	
	12. Soil formation	X				X		X	
	13. Natural disturbances	X	X	X			X		
	14. Biological control	X		X					
	15. Pollinating potential							X	
Cultural	16. Recreational or tourism	X	X	X		X	X		
	17. Local Ecological Knowleged	X			X	X	X		
	18. Cultural identity	X				X			
	19. Scientific knowledge	X							
	20. Environmental education	X				X			
	21. Spiritual feeling and existence values	X		X	X	X			
	22. Aesthetic pleasure	X		X		X			

6. Dissemination and communication

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. References & Annexes

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Annexes

Table 7.1. 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 (> 8-10m) Lakes: deep water (> 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 7.2. . List of ecosystems services assessed in the Spanish NEA. (Source: Spanish NEA, 2014.)

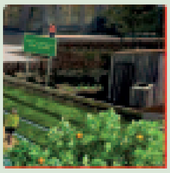
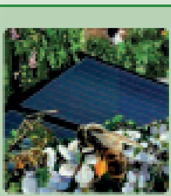
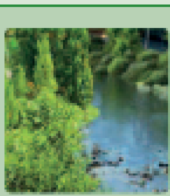
Type of services	Services	Examples
Provisioning services  	1. Food	Crops, livestock, wild plants and animals and their products, aquaculture product
	2. Water	Agriculture and domestic water use
	3. Biotic Materials	Non-food vegetal fibers
	4. Geotic Materials	Continental and marine salt
	5. Renewable 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 7.3. 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

METHOD APPLICATION CARD: MARKET PRICE METHODS Applied to: Cultivated crops (1.1.1.1)	
CASE STUDY	SPAIN: Spanish National Ecosystem Assessment
SCALE	National
TYPE	Economic
TIER	2
DESCRIPTION	
The valuation has been performed using a spatial explicit method, obtaining a mean value for crop production for the whole territory, but also a detailed map (pixel size + 5 km x 5 km) of crop production in biophysical units (tones) and monetary units (euro). It was also explored the trade-offs between the agricultural production in monetary units and the high nature value farmlands. Areas with high agricultural production and high natural value could be used as references of sustainable production systems, where a high agricultural production can be obtained while enhancing high natural value systems. We could detect that those areas correspond with traditional Mediterranean crops, like vineyards, olive trees, agroforestry systems (dehesas) and rain-fed cereals grown in areas with an appropriated climate and soil conditions to those crops.	
1. DATA REQUIREMENT	
Qualitative	•
Quantitative	• Mean productivity of each crop per municipality; • Mean price of crop per province; • Mean of the area cultivated of each crop between 1996 and 2010 in each municipality; **NB**. All the data came from the Ministry of Agriculture, Food and Environment of Spain, and was used to obtain the total annual agricultural production per municipality.
2. RESOURCES REQUIREMENT	
Time	• Medium: depending on GIS competences and data availability
Cost	• Low/medium: depending on data availability
Expertise	• GIS and databases expertise
Tools & equipment	• GIS tool
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• It is useful to combine whit other ES supply maps to create ES hotspots maps.
Socio-cultural	• Analysis were carried out using monetary values with high value farmlands and assess what was the social perception of ES and main environmental issues in those municipalities..
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Medium
Non-academic stakeholders	• Low
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Medium: This method can be applied at local scale depending on accuracy of LULC databases and other variables needed.
Regional	• Highly: This method can be applied at regional scale depending on accuracy of LULC databases and other variables needed.
National	• Highly: This method can be applied at national scale using same accuracy as local and regional scale. The only limitation is to work whit heavy databases delaying the processes.
Pan European	• Medium: This method can be applied at EU scale using same accuracy as local and regional scale. The only limitation is to work whit heavy databases that can delay the processes.
6. EXAMPLES OF POLICY QUESTION	
• Where are the most important areas for food provision supply with high values of ecological and economic terms?	

- Where are the most profitable areas for food provision supply in economic terms but with low values of ecological units?
- Where are the most valuable areas for food provision supply in ecological terms but with low values of economic units?

Suggested Citation: Santos Martin, F., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: MARKET PRICE METHODS applied to "Cultivated crop (1.1.1.1)". ESMERALDA EC H2020 Grant Agreement no. 642007.
Disclaimer: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (InVEST - Water Supply model)
Applied to: Surface water for drinking (1.1.2.1)

CASE STUDY	SPAIN: Spanish National Ecosystem Assessment (based on Project ECOGRADIENTS)
SCALE	Local
TYPE	Biophysical
TIER	3

DESCRIPTION

InVEST water supply model are used to estimate the run-off after ecosystem consumption processes.
It gives an output per pixel that shows (in mm) how much water arrives to hydrological network to be used by humans. In this case we used the output to estimate how much water is supplied by each municipality to compare it whit the demand at the same municipalities. To capture the accuracy of the database of land use and vegetation cover, we established a spatial resolution of 30x30 m per pixel.

1. DATA REQUIREMENT	
Qualitative	• **Land Use Land Cover**: Easy to find but hard to work with. In this case SIOSE database contains more than 15.900 different polygons for 2500 km^2. It is needed SQL competences to work efficiently whit this database.
Quantitative	• **Mean annual precipitation**: Easy to find in national databases. • **Average Annual Reference Evapotranspiration**: Easy to find in national databases. • **Plant Available Water Content (PAWC)**: Hard to get that variable at local scale because the poorly local information about soil properties in Spain. We used two different databases (one of them only in paper format) to estimate PAWC using soil properties at profile level. Next we estimate PAWC using kriging interpolation. • **Root restricting layer depth**: Easy to find in 1:1.000.000 scale but hard to find information at local scale. We used data from FAO and we include urban areas as areas whit total restriction. • **Z parameter**: Variable that needs more variables to be calculated. • **Watersheds and sub-watersheds**: Easy to find and to create whit SIG hydrology tools. • **Biophysical table**: It is needed data about root depth and evapotranspiration coefficient of Land Cover Land Use, it is hard to get some data at local scale in Spain. We review more than 20 papers to get the information about root depth and more than 10 to Evapotranspiration coefficients.
2. RESOURCES REQUIREMENT	
Time	• High: depending on GIS competences and data availability
Cost	• Low/medium: depending on data availability
Expertise	• GIS and databases expertise
Tools & equipment	• GIS tool • Hardware with medium/high potency, depending on accuracy of LULC and size of databases
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• It is useful to combine whit other ES supply maps to create ES hotspots maps.

Socio-cultural	• Mismatches analysis were carried out using supply from InVEST and demand from other databases. We estimated the deficit or surplus of this ES in terms of supply/demand.
Economic	•
4 COLLABORATION LEVEL	
Researchers own field	• Medium
Researchers other fields	• Medium
Non-academic stakeholders	• Low
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Highly: This method can be applied at local scale depending on accuracy of LULC databases and other variables needed.
Regional	• Highly: This method can be applied at regional scale depending on accuracy of LULC databases and other variables needed.
National	• Highly: This method can be applied at national scale using same accuracy as local and regional scale. The only limitation is to work whit heavy databases that can delay the processes.
Pan European	• Not recommended: The method can be applied at any scale. However, at this scales, we can obtain too much information to be analysed properly.
6. EXAMPLES OF POLICY QUESTION	
• Where are the most important areas for water supply? • Where we should place a forest, building or others? How can it affect water supply? • How much water is supplied in a specific area?	
Suggested Citation: Santos Martin, F., Nedkov, S., Viinikka, A., Pitkanen, K., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS (InVEST) applied to "Surface water for drinking (1.1.2.1)". ESMERALDA EC H2020 Grant Agreement no. 642007. **Disclaimer**: This document is the final version of the Method Application Cards produced within the ESMERALDA Project. (See http://maes-explorer.eu/page/ecosystem_services_and_applied_methods).	

CASE STUDY BOOKLET

ES mapping and assessment in the Vindelälven-Juhtatdahka river valley, northern Sweden

June 2018

ESMERALDA partner: Swedish Environmental Protection Agency (SEPA)

Case Study Coordinators: Johan Svensson [1)], Hannah Östergård [2)], Ola Inghe [2)]

1) Swedish University of Agricultural Sciences; 2) Swedish Environmental Protection Agency

ESMERALDA

Enhancing ES mapping for policy and decision making

Suggested Citation: Svensson, J., Östergård, H., Inghe, O.L, Adem Esmail, B., Geneletti, D., (2018). Case Study Booklet: ES MAPPING AND ASSESSMENT IN THE VINDELÄLVEN-JUHTATDAHKA RIVER VALLEY, NORTHERN SWEDEN prepared for "WS 8 - Testing the final methods in policy- and decision-making (II): businesses and citizens" held in Eger, Hungary, 19-22 March 2018. ESMERALDA EC H2020 Grant Agreement no. 642007.

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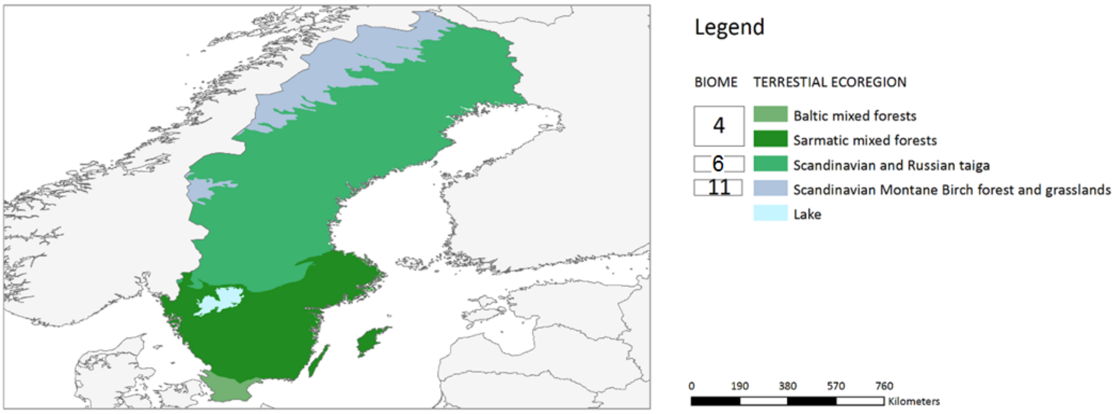
CASE STUDY FACTSHEET

ES mapping and assessment in the Vindelälven-Juhtatdahka river valley WS8_cs3

NAME AND LOCATION OF STUDY AREA	Vindelälven-Juhtatdahka river valley, northern Sweden
COUNTRY	Sweden

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	13,300 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

1. Overview of the study area

The Vindelälven-Juhtatdahka river valley stretches about 450 km from a highest point of 1,641 m in the Scandinavian mountain range watershed divide to the Gulf of Bothnia marine coast. "Älv" translates to river in Swedish and "Juhtatdahka" translates to migration route in local Sami language. The river is the southernmost one out of four national rivers in Sweden. These are large rivers in northern Sweden, which have not been developed for hydropower and have strong legal protection to remain natural. The river valley includes the contributory Laisälven mountain river that merge in the mountain foothills area, and the lower part of Umeälven river into which Vindelälven merge about 40 km from its mouth in the Umeälven Ramsar and Natura 2000 delta. "Juhtatdahka" – migration route – refers in particular to the traditional use of the river and valley for movement and migration. The annual migration of reindeer from the mountains to the coast and back – the backbone of the traditional Sami reindeer husbandry – is of specific value and importance. Before railways and roads were developed starting in the late 1800s, the river was also the main historical southeast to northwest infrastructure for humans. The river valley is also the natural ecological network for spread and migration for many species. The river valley includes territories used by seven Sami communities and is within the land of Sapmi, which encompasses indigenous peoples in northern Sweden, Norway, Finland and Northwest Russia. The area is rich in forest, minerals and other natural resources, and rich in nature conservation values. In total 32% of the area is protected, including parts of the 550.000 ha Vindelfjällen Nature Reserve which is one of the largest reserves in Europe. The Sami culture have enriched the natural values through a very long-term traditional and sustainable land use, alongside with rural settlers and small-scale farming. The human influence dates 8,000 years back.

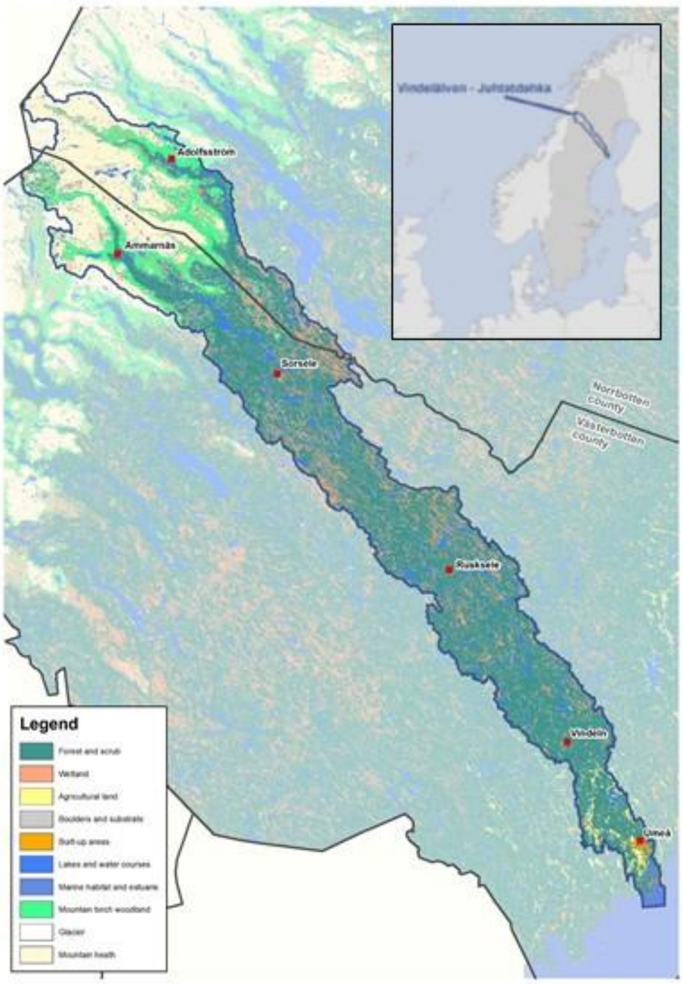


Figure 4. Location and cover types in the Vindelälven-Juhtatdahka river valley. The area stretches for latitude 63.62 to 66.25 and longitude 15.38 to 20.41. Source: Västerbotten County Administration Board.

Figure 2. Cultural influence have enriched the natural and cultural values. Source: NILS-ESS project, SLU (Svensson et al. 2017)

The river valley is a 1,330 kha alpine and boreal transition with a human population of about 110,000, of which the vast majority (93%) in the coastal zone and the city of Umeå. Umeå, the largest city in northern Sweden, host two universities (Umeå University and Swedish University of Agricultural Sciences, Faculty of Forest Sciences) with around 35,000 students and high-profile research in, e.g., natural sciences and indigenous culture. The area supports numerous long-term and project research as well as biophysical monitoring sites. The Vindelälven-Juhtatdahka river valley area is, formally, in the candidacy process for acceptance as a member reserve in the UNESCO Man and Biosphere Program[32] (Gardeström et al. 2018)

2. Questions and Themes

The mapping and assessment of ES has been put in the context of planning and implementing sustainable development across a large-scale geographic and biotic transition, that display a magnitude of economic, ecological and socio-cultural premises and that is representative for northern Sweden. With the overarching incentive of increasing the knowledge and capacity for sustainable development following the Sustainable Development Goals and Agenda 2030, the UNESCO MAB program combines natural and social aspects of economy and education for improved human livelihoods and equitable sharing of goods and benefits of natural and managed ecosystems (Gardeström et al. 2018). Accordingly, ES is included as a central component in the formal UNESCO candidacy template. The ES mapping and assessment theme thus follows the local natural and cultural identity and the premises for developing, supporting and conserving those values. In this case study, the foci are on ES associated with forest habitats, forest management and forests in a landscape context, and with the indigenous Sami culture reindeer husbandry. The Sami people with their reindeer husbandry represents a culture that ultimately is based on services and goods provided by ecosystems and landscapes (Svensson et al. 2016). In addition, a sustainable reindeer husbandry and vital Sami culture relies on continued access to ecosystem, landscapes and ES across geographical areas that reflect the natural annual and seasonal movement of the reindeer. Since reindeer husbandry occurs simultaneously with other land use – such as forestry – and irrespective of land ownership, the balancing of different and conflicting interest and views on multiple geographical scales requires, amongst others, appropriate ES data for stakeholder-informed operational landscape planning (Bjärstig et al. 2018).

3. Stakeholders' Involvement

This ES mapping and assessment approach have benefitted from the process of forming and developing the formal UNESCO MAB candidacy for Vindelälven-Juhtatdahka, which is accommodated by the County Administrative Board of Västerbotten and the municipalities in the area (Gardeström et al. 2018). This process has included broad and long-term stakeholder involvement and participation – more than 160 different meetings have been held – to outline strategies for conservation, development and supporting sustainable development. ES are specifically addressed in one of the chapters in the candidacy report. With the focus on Sami people and reindeer husbandry, the final setting of the Vindelälven-Juhtatdahka river valley ESMERALDA ES mapping and assessment report was prepared in dialogue with members of

[32] The MAB-program is an intergovernmental scientific program that aims for establishing a scientific basis for advancing the relationship between people and their environment. Through the program, with the about 670 sites in 120 countries, MAB promotes innovative approaches to environmentally sustainable and socially and culturally appropriate economic development.

the Ran Sami community and incorporate some of the ES that generically and specifically are related to or generated by reindeer husbandry as a culture and land use in northern Sweden.

4. Initiating Mapping and Assessment

4.1. Identification and mapping of ecosystem type

The area represents an elongated transition from the coastal boreal to the alpine biome. Forests and woodlands are predominant and cover about 535.1 kha (52%). Other nature types, in decreasing order, are alpine and subalpine heathland (18%), peat-forming wetlands (12%), subalpine mountain birch forest (8%), water bodies (6%), agricultural land (2%), marine habitat (<1%), built areas (<1%), glaciers (<1%), estuary (<1%) and rocky and substrate land (<1%). The Vindelälven-Juhtatdahka landscape contains natural and cultural premises that support a rich pool of provisioning, regulation and maintenance and cultural ES. Furthermore, the watershed scale, from the uppermost divide in the Scandinavian mountain range and the valley hillsides to the mouth in the Gulf of Bothnia, represents a holistic landscape with a continuum of ecosystems and ecological processes. The configuration of habitat types follow natural gradients and terrain formation. Unique natural features of significant values includes for instance primary succession on post-glacial rising coastlines (the official rate 8.5 mm uplift per year along the Gulf of Bothnia coastline) and characteristic (e.g., Arctic fox) and endemic (e.g. Ammarnäs trout) species. The study area harbor 20 priority species according to the Habitats Directive, 51 priority species according to the Birds Directive, 19 species on the global IUCN priority list, and 488 species on the national red list. The river ecosystem itself, in particular with respect to its natural state, provides a range of ecological, economic and socio-cultural premises.

Land use, e.g. forestry, reindeer husbandry, agriculture, etc., have modified and affected the supply of ES in both positive and negative ways. The rich natural resources and landscape characteristics support land use and business opportunities. Nature-based tourism is well developed with facilities ranging from internationally recognized downhill skiing resorts to family-driven fishing and wildlife activities.

4.2. Assessing ecosystem conditions

Ecosystem conditions have been assessed by using public data from the County Administration Board and Municipality Boards, statistics in public databases and from sector authorities, expert knowledge by researchers that have experience from the area and by local stakeholders, biophysical national monitoring data, and local knowledge of reindeer herders. For the biophysical data the main sources were the Swedish National Forest Inventory (NFI; Fridman et al. 2014) and the National Inventory of Landscapes in Sweden (NILS; Ståhl et al. 2011). Both these program collect a large set of biophysical variables that can be used as indicators or other type of ES measures, in particular if combined with wall-to-wall remote sensing-based data (cf. Mononen 2017).

No final indicators for continued assessment and evaluation have been defined and decided at this stage. However, earlier studies by, e.g., Geijzendorffer & Roche (2013), Hansen and Malmeus (2016), Svensson et al. (2016) and Naturvårdsverket (2017) – the two latter in Swedish – indicate considerable ES assessment opportunities in particular with the NILS data. Studies are ongoing on testing cultural ES-based amenity value assessment for mountain environment by biophysical NILS variables (Hedblom et al. in prep).

4.3. Selecting Ecosystem Services

In the context of ESMERALDA, the ecosystem mapping and assessment have focused on ES associated with forests, forest management and forests in a landscape context, and with Sami community reindeer husbandry. Forests constitute the predominant land cover (Figure 4), and forest industry is a key business in the area as well as regionally and nationally. Forest ecosystems are also key biodiversity entities, alongside with open or semi-open habitats in the forest landscape. Reindeer husbandry represents an indigenous culture and sustainable, traditional land use that substantially contribute to the natural and cultural values of northern Sweden. The annual migration of reindeers from the mountain to the coast and back is a distinct feature that, ultimately, require large-distance connectivity and functional green infrastructure across different land cover types, land ownership situations and land used simultaneously for other land use. The mapping and assessment has been prepared for the following ES types (Table 1):

Table 6. Overview of the ES and related mapping and assessment methods in the Northern Sweden case study

Ecosystem Service selected for mapping and assessment	B	S	E
1.1.1.2. Reared animals and their outputs *		X	
1.1.1.3. Wild plants, algae and their outputs	X		
1.2.1.1. Fibers and other materials from plants, algae and animals for direct use and	X		
2.3.1.2. Maintaining nursery populations and habitats	X		
3.1.1.1. Experiential use of plants, animals and landscapes *		X	
3.1.1.2. Physical use of plants, animals and landscapes *	X	X	

* ES selected for further discussion during ESMERALDA workshops 8 in Eger, Hungary;
B = biophysical methods; S = socio-cultural methods; E = economic methods.

5. Methods for ES mapping and assessment

5.1. Biophysical methods for ES mapping and assessment

Biophysical methods were applied to map and assess services associated with natural forest (wild plants, algae and their outputs; 1.1.1.3), wood fiber provisioning (Fibers and other materials from plants, algae and animals for direct use or processing; 1.2.1.1), and valuable forest habitat qualities (Maintaining nursery populations and habitats; 2.3.1.2) and for physical use (Physical use of plants, animals and landscapes; 3.1.1.2). The approach was based on data from the NFI and NILS national monitoring schemes. The Swedish NFI dates back to the 1920s with a fairly consistent design since 1983. The NILS-program dates back to 2003. Thus, retrospective analyses, as well as forecasting towards selected land-use or climate change scenarios, of ES supply and accessibility can be done.

The NFI monitoring protocol includes a combined permanent and temporary field plot-based sampling of biophysical data with a 5-year sampling rotation. The NFI-based mapping applied here was performed through interpolated Inverse Distance Weighting (IDW) moving window with a 25 km search radius, where an average value was calculated from 20 field sample plots and weighted towards the center plots. The numerical values presented was based on a moving average on the 2012-2016 sampling period. The NILS monitoring protocol includes a combined field sample-plot and aerial photo interpretation within a systematic sample of 1x1 and 5x5 km sampling squares. Twelve field plots, consisting of concentric sample circles of increasing size for step-wise detail to broader resolution of biophysical data, are systematically placed within the 1x1 km square and sampled on a 5-year rotation. The mapping procedure applied here was a Species Distribution Model (SDM) that maps presence probability of a selected monitoring variable. The specific model was a Generalized Additive Model (GAM) with auxiliary wall-to-wall land-cover information (Swedish Land Cover map and Lidar data) and data on topography, ground inclination, ground moisture and climate variables (Svensson et al. 2016). The GAM-approach based on NILS-data allows for spatially explicit and high resolution scenario-based mapping of selected variables on multiple scale.

5.1.1. Mapping of provisioning services

1.1.1.3. Wild plants, algae and their outputs

Provisioning ES related to wild plants and their outputs are not outlined per se but partly implicitly reflected in ES types 1.2.1.1, 2.3.1.2 and 3.1.1.2.

1.2.1.1. Fibers and other materials from plants, algae and animals for direct use or processing
Indicators: *Areal extension (ha) of productive forest land and total forest land / Areal extension of forest age class (ha) / total volume wood biomass (m^3) and dry substance (kg) / Areal extension of dominating tree species (ha) / Distribution of forest age classes (%/ha) / Distribution of broadleaf share in coniferous forest (%/ha) / Length (m) and density (m/ha) of ditches in productive forest land.*

Growing forests contribute to wood fiber provisioning and also to regulating and maintenance services such as carbon sequestration. Out of 530.7 kha productive forest land, 23.7 kha are recent clearcuts, 120.7 kha are plant- and young forests, 214.1 kha are mature forests at thinning stage, and 172.3 kha are older, mature forest that according the forestry regulations has reached an allowed clearcutting stage (Figure 3, left panel). The total volume wood biomass in the area equals about 54 million m^3 across all forest land, whereof 51.5 million m^3 on productive forest land. According to national forestry policy, productive forest land is forest land that produces a minimum of 1 m^3 (merchantable) wood per ha and year. Only productive forest land can be used for forest management for economic purposes. The wood biomass in productive forest equals in total 21,786,999 kkg (stems and bark), 7,636,000 kkg (branches and needles) and 10,042,000 kkg (stumps and roots) dry substance. For total forest land, the comparable dry substance equals 42,863,000 kkg which equals 110% compared with productive forest land.

Different tree species provide diversity in and different premises for ES. The pre-dominant tree species in the area is Scots pine on 346.8 kha (65.5% of the productive forest land), followed by Norway spruce on 18.5%, coniferous dominated mixed forest on 15%, mixed coniferous and broadleaf forest on 7%, and broadleaf forest on 5% (Figure 3, right panel). While coniferous trees are the main source of wood fiber, broadleaf trees and broadleaf-dominated forests contribute to the range and pool of provisioning services. Drainage in forest land contribute to the tree growth site capacity and provisioning ES but has also negative effects, such as changes in physical and chemical conditions in aquatic ecosystems. In total about 55 kha (10.5% of total productive forest land) have been drained whereof the majority of the drainage systems (49 kha) are in function.

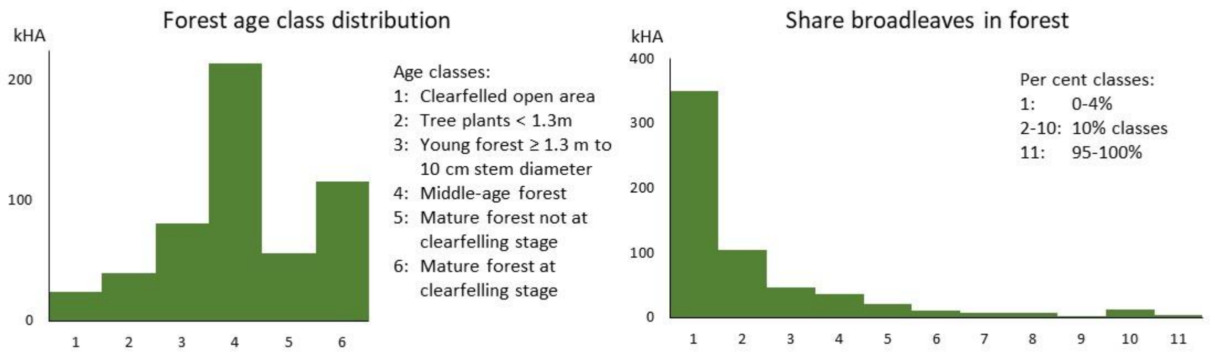


Figure 3. Forest age class distribution and the share of broadleaf trees, both on productive forest land. Data source: The Swedish National Forest Inventory for the 2012-2016 5-year monitoring rotation.

5.1.2. Mapping of regulating and maintenance services

2.3.1.2 Maintaining nursery populations and habitats

Indicators: *Areal extension and distribution (ha) of old forest (age ≥140 years) / Areal extension and distribution of old broadleaf-dominated forest (age ≥80 years) / Density (no/ha) of large trees (diameter ≥0.45 mat 1.3 m above ground) / Amount (m^3) dead wood / Areal extension and distribution of protected area (ha) / Areal extension and distribution of priority habitats and species (ha) / Numbers and types of formal protection areas.*

Old forests contribute critical biodiversity values and ES, e.g., as core forest areas with intact habitat and ecosystem characteristics, structures and processes, and as refugia for endangered species (Figure 4). The area harbors about 64 kha forest older than 140 years, which equals 12% of the productive forest land. Old broadleaf forest, which generally support a higher pool of biodiversity and ES, cover about 11 kha. Large and old trees provide essential niches for biodiversity and also contribute specific amenity, historical and cultural values. There is on average one (0.9) large tree (diameter ≥0.45 m at 1.3 m above ground) per ha in the area. Most of them are Norway spruce or Scots pine and only about 10% are broadleaves. Dead wood provides an important substrate for many species and is generally considered as a key factor for biodiversity. Assessed for productive forest land, the total volume dead wood is about 4,326,000 m^3, equal to 8.2 m^3/ha. The amount dead wood on total forest land is slightly higher, about 4,702,000 m^3, owing to the fact that low productive forest land often is more open with low volumes of trees.

Nature conservation in the form of nature reserves and other types of formal protection set aside larger areas and clusters of ecosystems and habitats that have a high degree of ecosystem functionality and biodiversity, and where the functionality can be maintained for a continued pool of provisioning, regulating and maintenance and cultural services. Thereby, mapping of protected areas is indicative for ES mapping. As well, data on identified priority natural and cultural values are indicative for ES assessment. Of the 1,330 kha Vindelälven-Juhtatdahka area, 430 kha is formally protected and another 230 km^2 voluntary protected according to certification (FSC) criterion, altogether equivalent to about 34% (Figure 5). The area encompasses about 90 different nature reserves, including parts of the 550 kha Vindelälven mountain reserve, several near-natural forest areas, river rapids, cultural landscapes, estuary and marine habitats, etc. Besides nature reserves, in total 43 formal nature conservation agreements, 120 biotope protection areas, and three Ramsar sites currently are demarcated.

The concept of green infrastructure is developed to secure long-term functionality of ecosystems at multiple spatial scales. Liquete et al. (2015) defined green infrastructure as a strategic and operational planning network of natural and semi-natural areas that specifically are designed to provide and mobilize ecological connectivity, functionality, biodiversity and services in ecosystems. Hence, a functional green infrastructure is a spatiotemporally connected configuration of habitats that sustain ecosystem processes and structures also under ongoing climate change and forest management. A large fraction of the protected area is located in the alpine region (Figure 5, 6). Recent studies (Svensson et al. in revision) have identified well-connected boreal forest green infrastructure along the mountain range foothills zone, but also a lack of connectivity in the mountain to coast northwest to southeast gradient. The possibilities to view ES in the context of green infrastructure in holistic, comprehensive planning in northwest Sweden has been further explored in the study Bjärstig et al. (2018), where it was concluded that planning strategies based on the spatial and temporal traits of different land uses combined with different intrinsic natural and cultural values associated with ecosystems and landscapes, provide premises for sustainable landscape planning.

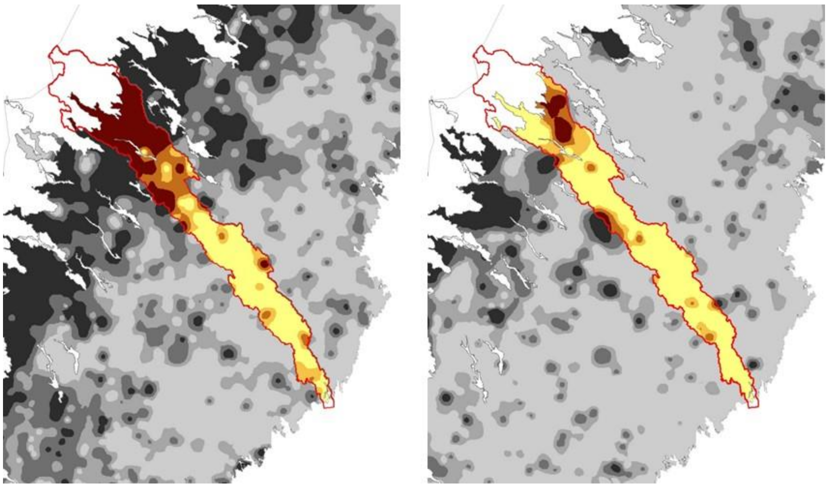


Figure 4. Distribution of old forest (age ≥140 years) to the left and old broadleaf forest (i.e. broadleaves at minimum 30% of the basal area and 80 years old) to the right. The map shows the Vindelälven-Juhtatdahka river valley in yellow to red colors and the surrounding areas in grey to black colors. Data: The Swedish National Forest Inventory for the 2012-2016 5-year monitoring rotation. Source: Västerbotten County Administration Board.

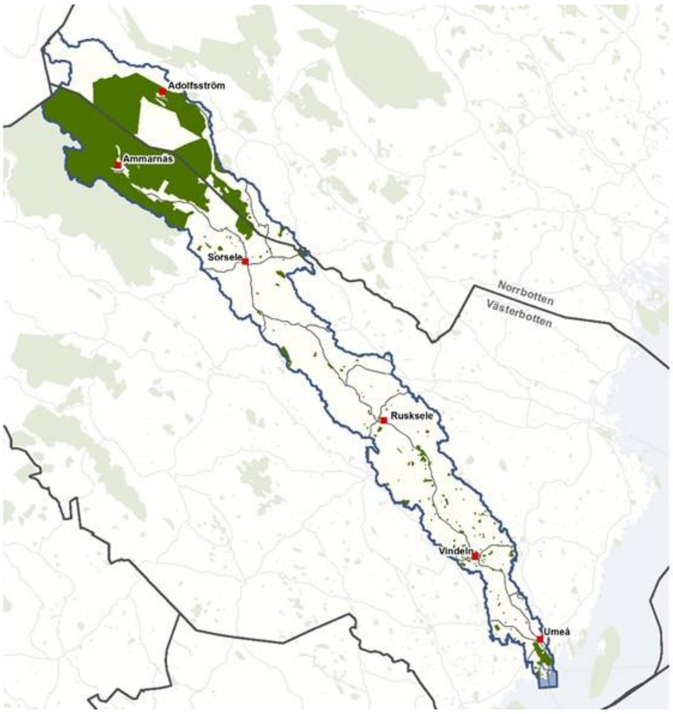


Figure 5. Formally protected areas in the Vindelälven-Juhtatdahka river valley. Source: Västerbotten County Administration Board.

Figure 6. A large fraction of the protected area is in the alpine region. Source: NILS ESS project (Svensson et al. 2016).

5.1.3. Mapping of cultural services

3.1.1.1 Experiential use of plants, animals and landscapes
3.1.1.2 Physical use of plants, animals and landscapes
Indicators: *Distribution (ha) and cover (%) of forest floor lichen / Distribution (ha) and cover (%) of edible berries / Distribution (ha) and cover (%) of ptarmigan habitats.*

With the rich natural resources and landscape features, the long-term rural land-use history and associated socio-cultural influence have enriched the total supply of ES in the Vindelälven-Juhtatdahka river valley. Here, the reindeer husbandry and the Sami culture explicitly provide unique values. A large enough reindeer population is a prerequisite not only for the economic life of indigenous people and the local economic and business societal opportunities, but also for maintaining a grazed, open mountain landscape (Sandström et al. 2016). The open, magnificent mountain landscape provides highly appreciated amenity values and prerequisites for a range of cultural services, goods and benefits alongside with provisioning and regulating and maintenance ES (Blicharska et al. 2017). Grazing is a natural disturbance mechanism in boreal ecosystems. It is well established that the availability of forest floor lichens as a natural reindeer food during winter, is a limiting factor determining the reindeer population size (Sandström et. al. 2016). Forest floor lichen and also epiphytic lichen favor open to semi-open forests. In a landscape dominated by forest, open and semi-open areas generally contribute to the landscape diversity and the ES supply. Such open and semi-open forest exists in a natural network on drier and wetter sites, e.g. as poor Scots pine forests on sandy eskers and ridges in the northwest-to-southeast direction of the river valley. These forests and woodlands represent essential grazing and resting areas for reindeers. Thus, their abundance is a regulating factor for reindeer husbandry and the ecosystems services associated with reindeer and the Sami culture. A maintained green infrastructure of such open and semi-open habitats is critical for natural reindeer movement and reindeer herding as a land-use culture. The study by Sandström et al. (2016) showed that such forests are decreasing rapidly at a rate of about 70% over a 50-year period.

Figure 7 illustrates forest floor lichen cover through probability modelling based on NILS data. The total area of lichen rich (> 25% forest floor lichen cover) forests in the area is about 48 kha (NFI data), equal to 9% of the productive forest land. Figure 7 also illustrates the probability of occurrence and cover of bilberry in the coastal zone and ptarmigan habitats in the mountain zone. Berry picking, both as business for industrial purposes and for household purposes, is common in the area. The annual production of bilberry and lingonberry has been estimated to around 24,000 kkg and 13,700 kkg, respectively (NFI data; Note that the sample for this estimate is small and that the figures may overestimate the production potential). Also small-game hunting of ptarmigan is common and a typical activity in the mountain environment, both for household hunting and for hunting tourism. With climate change, the shrub-dominated alpine habitats preferred by ptarmigans is at risk to transform into tree-dominated through upward movement of the alpine tree line.

The cultural ES mapping and assessment examples provided here also contribute to other ES, such as wild plants, algae and their outputs (1.1.1.3) and experiential use of plants, animals and landscapes (3.1.1.1), and are also indicative for a range of regulating and maintenance ES as they exemplifies natural structures, ecosystem characteristics and species occurrence in their habitat and landscape contexts.

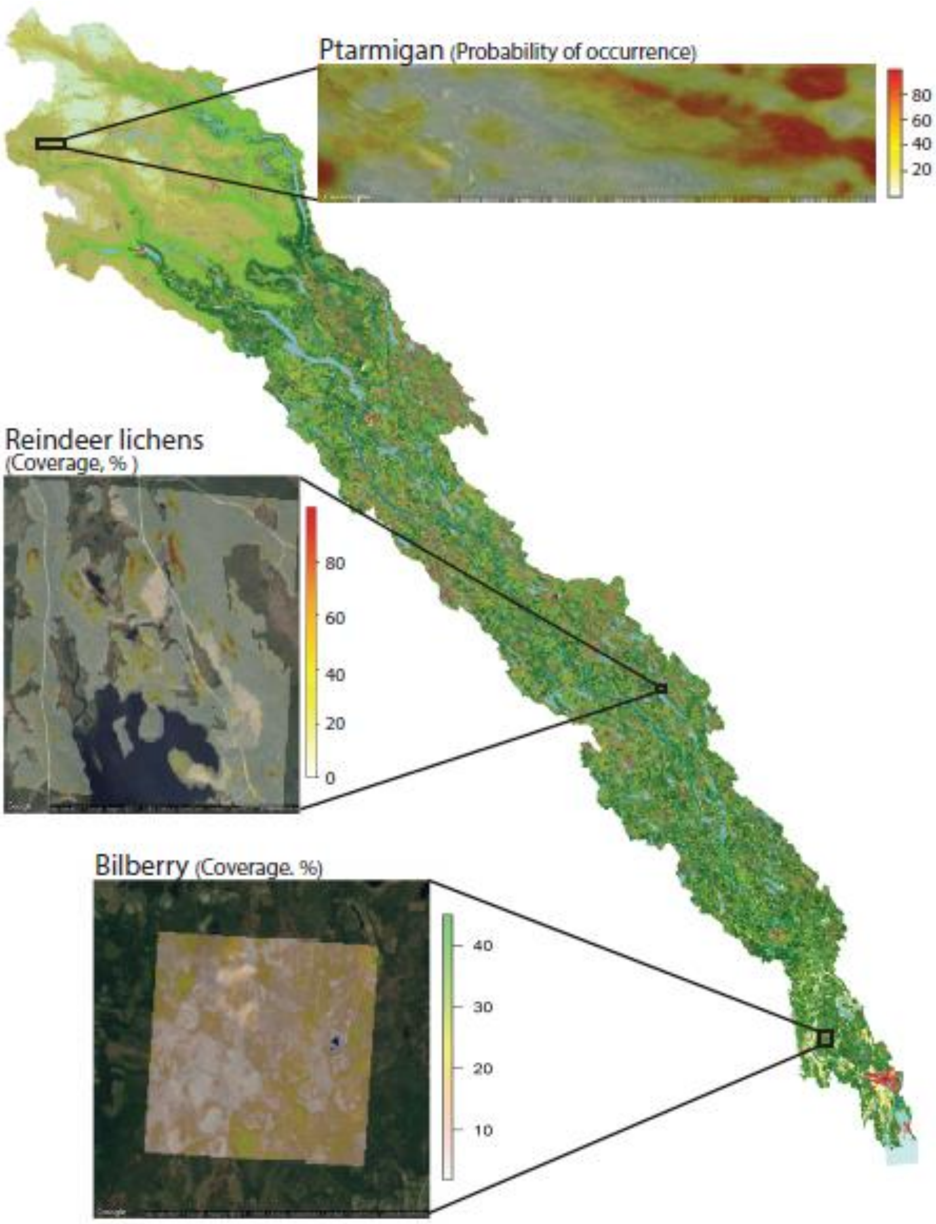


Figure 7. Mapping and assessment of occurrence of ptarmigan habitats (mountain zone), forest floor lichen cover (forest zone) and bilberry cover (coastal zone). The model is based on data from the National Inventory of Landscapes in Sweden (NILS; lichen, ptarmigan) monitoring program and the Swedish National Forest Inventory (NFI; bilberry) combined with land cover data for wall-to-wall modelling and auxiliary data. Source: Västerbotten County Administration Board.

5.2. Socio-cultural methods for ES mapping and assessment

Socio-cultural methods were applied to map and assess the premises for presence and abundance of reindeer in the landscape (Reared animals and their outputs; 1.1.1.2) and the experiential and physical presence of reindeer husbandry (Experiential use of plants, animals and landscapes; 3.1.1.1, and Physical use of plants, animals and landscapes; 3.1.1.2).

Reindeer husbandry in Sweden occurs according to legal rights on 55% of the Swedish land base, within in total 51 defined Sami community territories (Sandström 2015). Each Sami community consists of a varying number of semi-separate business enterprises. No strict land ownership is associated with the land use. Instead, reindeer husbandry occurs simultaneously with other land use on land owned by the state, private forest companies, private household forest owners, municipalities, etc. Hence, land-use conflicts do occur. The semi-domestic herding system basically reflects the natural migration behavior of the wild reindeer, which for many Sami communities means annual migration from the mountains in the early fall to the coast and back in the spring and early summer; a one-way migration distance as long as up to 400 km. To support and function for these migrations, the landscape needs to contain the necessary habitat prerequisites, and the habitats need to be accessible for the free-ranging reindeers. Hinders and barriers prevent the free-ranging behavior and force more active herding, including transporting on trucks and artificial feeding. Urban areas, roads, railways, regulated water reservoirs (for hydroelectricity), mines, and wind mill parks are examples such barriers. Also forestry land-use activities that modifies the natural habitat and landscape structures, generates hinders, for example too dense growing forests that prevent forest floor and epiphytic lichens to occur in enough quantities. In addition, predators such as the golden eagle, wolf, bear, lynx and wolverine cause impact reindeer husbandry. Connectivity and availability of suitable habitats and landscape links for grazing, resting, calving and moving are critical for the ES supply associated with the reindeer husbandry and the Sami culture. Lack of connectivity, links and availability implies a decreasing supply. The concept of green infrastructure is thus generically applicable for multiple-scale mapping, assessment of planning of those ES and supporting functions that are associated with reindeer husbandry, the Sami culture and the open, magnificent character of the Scandinavian Mountain Range.

The socio-cultural ES mapping is based on key areas, core areas, migration routes and barriers. The data has been compiled by the herders themselves based on their traditional knowledge of how the reindeer moves in the landscape and the different annual phases in the reindeer autecology. Figure 8 shows the location of the seven Sami communities that has territory within the Vindelälven-Juhtatdahka area (left panel) and key areas, core areas, migration routes and barriers specifically for the Ran Sami community (right panel).

Following a strict definition of direct or final ES, it may be argued that the reindeer itself as an animal is the provisioning service, that the immediate impact of the reindeer on ecosystems (e.g., grazing or scraping with the antlers on trees) is the regulating and maintenance service it generates, and that the human wellbeing created by experiencing the reindeer is the cultural ES. However, in practice the interfaces between services, goods and benefits are prominent. Furthermore, since the Sami indigenous culture, traditions, language, etc. are strongly associated with the natural and cultural values associated with reindeer husbandry and with the Scandinavian Mountain Range and norther boreal forest landscape characteristics, the socio-cultural mapping and assessing approach presented here has followed a wider understanding of ES (Bjärstig et al. 2018).

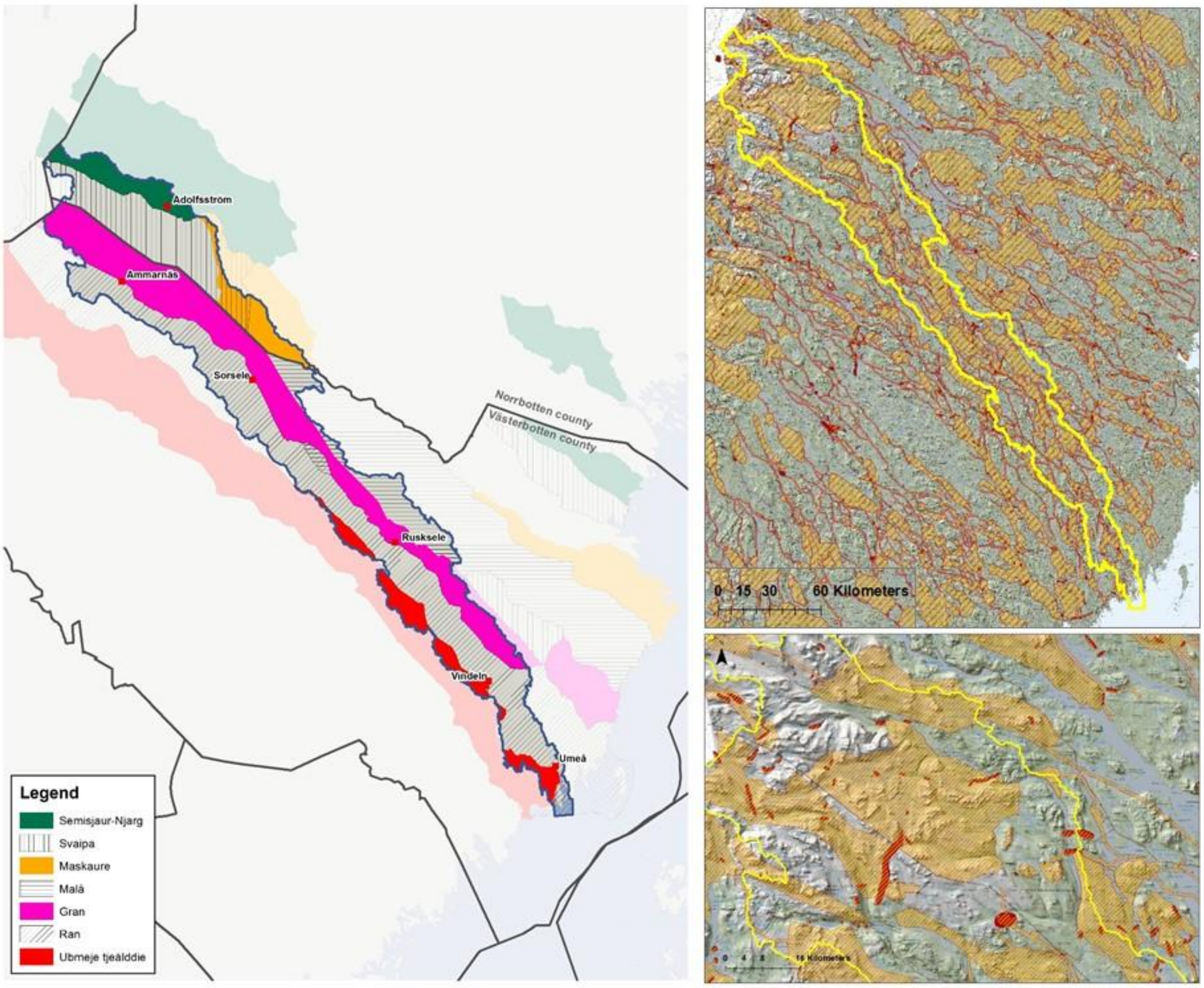


Figure 7. Location of the seven Sami communities within the Vindelälven-Juhtatdahka river valley (left panel), and key areas, core areas (brown, striped) and migration routes (red lines) and barriers (red, striped; only natural barriers such as steeps, ravines, etc., are included) for the Ran Sami community (right panel). The lower map in the right panel is a magnification of a part of the mountainous area. Source: Västerbotten County Administration Board / Ran Sami Community; Green municipal plan project (Bjärstig et al. 2018).

5.2.1. Mapping of provisioning services

1.1.1.2 Reared animals and their outputs
Indicators: Numbers of reindeer (no) / Slaughter reindeer (no/kg) / Amounts of reindeer products, such as meat, skin, bones, antlers, milk used for tools and handicraft
General indicators: Areal extension of core areas (ha), including subdivision into specific areas / Areal extension of key areas (ha), including subdivision into specific areas / Length (m) or density (m/ha) migration routes and other types of functional links between core and key areas / Migration barriers (no) / Type of migration barrier (qualitative)

Reindeer generate products that are used as food, handicraft and tools, either directly by the Sami and other local people, or for more industrial processing and sale. Processing units such as abattoirs, corals, tool and handicraft manufactures etc. structures are owned and operated within Sami communities, commonly between Sami communities, or by single herding businesses. By tradition, local use of goods and benefits are customary, either as family consumption or by local restaurants specialized in local food. However, Sami ecosystem goods and products are demanded on the national and international markets (Gardeström et al. 2018).

5.2.2. Mapping of regulating and maintenance services

Regulating and maintenance ES was not approached per se in the socio-cultural method. As noted above, however, the reindeer husbandry and Sami cultural land-use interaction with ecosystems and landscapes have generic relevance for regulating and maintenance ecosystems functions and processes and thus to a range of various ES.

5.2.3. Mapping of cultural services

3.1.1.1 Experiential use of plants, animals and landscapes
3.1.1.2 Physical use of plants, animals and landscapes
Indicators: *Numbers of reindeer (no) / Areal extension of open, grazed alpine heath (ha) / Historical remains on ecosystems and vegetation, of land use and impact that are associated with reindeer and Sami culture (no) / Type of historical remain (qualitative)*
General indicators: *Areal extension of core areas (ha), including subdivision into specific types of core areas / Areal extension of key areas (ha), including subdivision into specific types of key areas / Length (m) or density (m/ha) migration routes and other types of functional links between core and key areas / Migration barriers (no) / Type of migration barrier (qualitative)*

It is well established that a large enough population of reindeer is needed to maintain the magnificent landscape in the Swedish Mountain Range, and thus to maintain the amenity and other values that are the foundation for a vital small- and large-scale tourism business. Seeing reindeer and the remains and impact of reindeers and the Sami culture in the environment certainly is central for a range of different cultural ES. The local identity with maintained traditions and presence of Sami culture and reindeer husbandry sustain a sense of belonging that generates the intrinsic capacity for a sustainable development and economic life along the whole stretch of the Vindelälven-Juhtatdahka river valley.

5.3. Integration of ES mapping and assessment results

The ES mapping and assessment has been put in the context of planning and implementing sustainable development. The Vindelälven-Juhtatdahka river valley area is in the candidacy process for the UNESCO Man and Biosphere Program (Gardeström et al. 2018). With the overarching aim to support sustainable development following the Sustainable Development Goals and Agenda 2030, the UNESCO MAB approach to landscape planning includes a zonation of the area into core areas, buffer zones and development areas. The different zones reflect the natural, social and economic aspects of improved human livelihoods and equitable sharing of services, goods and benefits of natural and managed ecosystems. Hence, ES are outlined, described, mapped and assessed, and indicators and other measures are proposed, developed and tested, for developing, supporting and conserving the natural and cultural identity and values. The foci in the ESMERALDA ES mapping and assessment was on forest habitats, forest management and forests in a landscape context, and on the indigenous Sami culture reindeer husbandry, from detailed to local and regional scales. These foci are key ingredients in the MAB zoning approach to sustainable development. Thus, the ESMERALDA ES mapping and assessment approach will assist in balancing different and sometimes conflicting natural- and cultural value-based interest and views on multiple geographical scales following the zonation approach.

6. Dissemination and communication

For academic purposes, the approach and results presented here will be used for the continuing building of know-how on ES applications within the Swedish EPA ES research and communication programs. As a key component in the MAB-application and process, ES have been an integrated part in communication through the biosphere office stakeholder meetings, web site (http://vindelalvenjuhtatdahka.se/), newsletters, booklets, debate articles in newspapers and articles in popular journals. A research platform have been created linked to the Arctic Research Centre (Arcum) at Umeå University (http://www.arcum.umu.se/english/) with the purpose to facilitate various research activities and cooperation. Dissemination and communication has also been exercised nationally in cooperation with the Swedish MAB-committee and globally in various MAB-network meetings and conferences.

7. Implementation

With the direct anchorage with the County Administrative Board of Västerbotten and the Municipality Boards involved in the UNESCO MAB-process, the ES mapping and assessment will also contribute to regional and local ES understanding and use as input data in territorial planning. Furthermore, through the MAB-program and the following steps towards formal reserve membership for the Vindelälven-Juhtatdahka site, this also supports ES applications as a key ingredient in the global MAB-network with the Sustainable Development Goals and Agenda 2030 as a main framework. At site, for exploring and solving the conflict risks but also for elucidating integration and synergy opportunities between reindeer husbandry and other land uses as well as among other land uses, appropriate ES mapping and assessment is needed for stakeholder-informed and sustainable operational landscape planning.

8. References & Annexes

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Annexes

Annex 1: Examples of ecosystem services, use of services, business opportunities and indicators, specifically for reflecting the local natural and cultural landscape values in the Vindelälven-Juhtatdahka river valley.

Category	Examples	Use	Business	Indicators
Provisioning	Wood fiber; Fire wood; Tree bark, roots and conks; Reindeer – meat, skin, antlers and bones; Wild ungulates, birds and fish; Wild berries, fruits and mushrooms; Clean surface drinking water	Household consumption of fire wood, berries, mushrooms, meat, natural medicine and drinking water; Handicraft production based on plant and animal material.	Organized berry picking hunting and fishing; Forest management; Reindeer husbandry; Wildlife tourism; Local food and handicraft	Amount picked berries, mushrooms; Growth and harvest of trees; Amount reindeers, game and fish processed; Amount of natural drinking water consumed
Regulating and maintenance	Intact habitats, flora and fauna; Natural wetlands with peat formation; Growing forest; Natural riparian buffer areas towards water bodies; Natural forest edges	Storm protection, ventilation and transportation; Mass stabilization and erosion control; Functional ecosystems, habitats and hydrological cycles; Natural flora and fauna	Functional ecosystems for tree growth, reindeer populations, wild game and fish. Access not natural landscapes and local culture	Area formally protected nature; Density natural forest edges and riparian zones; Density natural river rapids; Density restored waterways; No. of avalanches and other mass flows; No. of wind thrown trees
Cultural	Open, lands in the mountain region, open mires and farmland. Habitat diversity on landscape scale; Biological legacy of long-term sustainable land-use culture; Large, old trees; Natural rapids and whitewater	Access to natural and cultural landscapes; A sense of naturalness, originality and belonging; Fishing places, hunting areas, bird watching. Trails, shelters, snow mobile routes, access roads;	Access to natural landscapes with cultural remains; A sense of naturalness and originality; Organized fishing places and hunting areas. Trails and shelters for hiking; Campgrounds; Handicraft, local food and products	Area open land; Density old, large trees; Density trails, shelters, camp grounds, information signs, fishing places; Numbers of research projects

METHOD APPLICATION CARD: PARTICIPATORY GIS Applied to: Reared animals and their outputs (1.1.1.2)	
CASE STUDY	SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley
SCALE	Sub-national
TYPE	Socio-cultural
TIER	2
DESCRIPTION	
The socio-cultural ES mapping is based on information about key areas, core areas, migration routes and barriers, which are applied for the reindeer herding land-use planning system. The data has been compiled in a GIS-system by the herders themselves based on their traditional knowledge of how the wild reindeer moved in the landscape and the different annual phases in the reindeer autecology. The traditional knowledge is supported by GPS-positions on collars which both add complementary data and is of benefit for the herders in following and locating the reindeer. The concurrent reindeer husbandry system is semi-nomadic with semi-domestic herds that are free-ranging across the landscape on land simultaneously used for other land-use purposes and, according to rights, irrespective of land ownership. Reindeer generate products that are used as food, handicraft and tools, either directly by the Sami and other local people, or for more industrial processing and sale. The reindeer husbandry and Sami cultural land-use interaction with ecosystems and landscapes have generic relevance for regulating and maintenance ecosystems functions and processes and thus to a range of various ES.	
1. DATA REQUIREMENT	
Qualitative	• Traditional knowledge • Reindeer autecology
Quantitative	• Land-cover and terrain maps, land ownership maps • Migration barriers • Reindeer population size, amount reindeer-generated services and goods • GPS-collar positions
2. RESOURCES REQUIREMENT	
Time	• GIS development and updating
Cost	• Free GIS-software and public data
Expertise	• GIS skills
Tools & equipment	• GIS software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Various biophysical data, generic and specifically for reindeer husbandry, are needed and supports the socio-cultural mapping and assessment method
Socio-cultural	•
Economic	• Not addressed
4 COLLABORATION LEVEL	
Researchers own field	• Multi-disciplinary
Researchers other fields	• Multi-disciplinary
Non-academic stakeholders	• Local reindeer herder and Sami people • Other land users • Policy and decision makers in landscape planning
5. SPATIAL SCALE OF APPLICATION[1]	
Local	• Yes, for herding enterprises and Sami communities
Regional	• Yes, for the total reindeer husbandry area in Sweden
National	•
Pan European	•
6. EXAMPLES OF POLICY QUESTION	
• Sustainable development • Recognizing indigenous people • Multiple-use management • Landscape planning	
Suggested Citation: Svensson, J., Östergård, H., Inghe, O., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: PARTICIPATORY GIS applied to "Reared animals and their outputs (1.1.1.2)". ESMERALDA EC H2020 Grant Agreement no. 642007.	

METHOD APPLICATION CARD: INTEGRATED MODELING FRAMEWORKS (INTEGRATED MONITORING DATA GAM-MODELLING FRAMEWORK) Applied to: Experiential/Physical use of plants, animals and landscapes (3.1.1.1 & 3.1.1.2)	
CASE STUDY	SWEDEN: ES mapping and assessment in the Vindelälven-Juhtatdahka river valley
SCALE	Sub-national
TYPE	Socio-cultural / Biophysical – Integrated modelling frameworks group
TIER	2/3
DESCRIPTION	
A model was developed based on biophysical monitoring data, which describes presence and cover of forest floor lichens, berries and ptarmigan habitats; three examples of highly valued ES. The method approach was based on data from the NILS (National Inventory of Landscapes in Sweden) and NFI (National Forest Inventory) national monitoring schemes, with a Species Distribution Model (SDM) that maps presence and probability of selected monitoring variables. The specific model was a Generalized Additive Model (GAM) with auxiliary wall-to-wall land-cover information and data on topography, ground inclination, ground moisture and climate variables. The model allows for spatially explicit and high resolution scenario-based mapping of selected variables on multiple scale. The ES mapping and assessment examples provided here also contribute to other ES, such as wild plants, algae and their outputs (1.1.1.3) and experiential use of plants, animals and landscapes (3.1.1.1), and are also indicative for a range of regulating and maintenance ES as they exemplifies natural structures, ecosystem characteristics and species occurrence in their habitat and landscape contexts.	
1. DATA REQUIREMENT	
Qualitative	• Traditional knowledge on reindeer autecology • Berry picking and small-game hunting
Quantitative	• Land-cover and terrain maps, satellite images, climate and other wall-to-wall data • Monitoring variables (biophysical) • Validation data
2. RESOURCES REQUIREMENT	
Time	• Computer modelling
Cost	• Model software and public data
Expertise	• Modelling skills
Tools & equipment	• Computer and modelling software
3. LINKS AND DEPENDENCY ON OTHER METHODS	
Biophysical	• Biophysical monitoring data in the model • Un-dependent biophysical monitoring or alternative data to validate the model
Socio-cultural	• Traditional reindeer husbandry knowledge
Economic	• Not addressed
4 COLLABORATION LEVEL	
Researchers own field	• Natural sciences; Statistical modelling
Researchers other fields	• Multi-disciplinary
Non-academic stakeholders	• Local reindeer herder and Sami people • Recreation data
5. SPATIAL SCALE OF APPLICATION	
Local	• Yes, the model provide high resolution models (maps)
Regional	• Yes, the model support multiple-scale mapping
National	• Yes, the model support multiple-scale mapping for nature supporting selected variables
Pan European	• Yes, the model approach can be applied for other variable and other premises
6. EXAMPLES OF POLICY QUESTION	

- Sustainable development
- Recognizing indigenous people
- Multiple-use management
- Landscape planning

Suggested Citation: Svensson, J., Östergård, H., Inghe, O., Nedkov, S., Adem Esmail, B., Geneletti, D., (2018): Method Application Card: INTEGRATED MODELING FRAMEWORKS applied to “Experiential (physical) use of plants, animals and landscapes (3.1.1.1 & 3.1.1.2)”. ESMERALDA EC H2020 Grant Agreement no. 642007.