Creating an operational database for Ecosystems Services Mapping and Assessment Methods

Fernando Santos-Martin[‡], Arto Viinikka[§], Laura Mononen[§], Luke M Brander[|], Petteri Vihervaara[§], Inge Liekens[¶], Marion Potschin-Young[#]

‡ Autonomous University of Madrid, Madrid, Spain
§ Finnish Environment Institute, Helsinki, Finland
| Institute for Environmental Studies, VU University Amsterdam, Amsterdam, Netherlands
¶ Flemish Institute for Technological Research VITO, Mol, Belgium
# Fabis Consulting Ltd., Nottingham, United Kingdom

Corresponding author: Fernando Santos-Martin (fernando.santos@urjc.es), Arto Viinikka (arto.viinikka@ymparisto.fi), Laura Mononen (laura.mononen@ymparisto.fi), Luke M Brander (lukebrander@gmail.com), Petteri Vihervaara (petteri.vihervaara@ymparisto.fi), Inge Liekens (inge.liekens@vito.be), Marion Potschin-Young (marion.potschin@fabisconsulting.com)

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Abstract

Identifying and applying the appropriate method for ecosystem services mapping and assessment is not trivial. To provide guidance in this task, this paper describes 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. This database, therefore, forms the basis for an online ecosystem service 'methods finder'. Our results 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. This work helps identify the main gaps and opportunities for alignment and development of commonalities in analytical approach amongst the individual Member States. The results illustrate the different conditions, dimensions and geographical contexts in Europe, information that can be used as background to help the development of a flexible methodology for mapping and assessing ecosystem services in Europe. The paper concludes with a discussion on how the typology of methods can be used in initiatives that aim to integrate ecosystems and their services in decision-making and planning. This work highlights some challenges for future activities on mapping and assessment of ecosystem services in the EU.

Keywords

Methods classification, ecosystem services, biophysical, social, economic, Europe

Introduction

Mapping and assessing ecosystems and their services (ES) is core to the EU Biodiversity (BD) Strategy 2020 (Maes et al. 2016). Specifically, Action 5 of the Strategy's Target 2 sets the requirement for an EU-wide knowledge base developed by Member States designed to be: "a primary data source for developing Europe's green infrastructure; a resource to identify areas for ecosystem restoration; and, a baseline against which the goal of 'no net loss of BD and ES' can be evaluated" (Burkhard et al. 2018).

In response to these requirements, ESMERALDA (Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking) aims to deliver a flexible methodology to provide the building blocks for pan-European and regional assessment. The work supports the timely delivery of EU Member States in relation to Action 5 of the BD Strategy and the needs of assessments in relation to the requirements for planning, agriculture, climate, water and nature policy. While other overviews of ecosystem services methods classification exist (Harrison et al. 2018), the focus in this paper is on how these methods have been applied for mapping and assessing studies rather than adding a new classification. The creation of a database for existing studies is considered an essential step in finding the method most suited to a specific issue or problem where mapping and assessing ecosystems is at the core (ESMERALDA 2017). The 'method finder' that has been developed is an online tool which is described in Reichel and Klug (this volume). The ESMERALDA database and method identification described here focuses instead on the ongoing activities in Europe such as MAES (https://biodiversity.europa.eu/maes), OpenNESS (http://www.openness-project.eu/), OPPLA (https://oppla.eu/) and other national studies such as UK NEA (http://uknea.unep-wcmc.org/) or Spanish NEA (http://www.ecomilenio.es/). The methods for mapping and assessing ecosystems and their services described here are enhanced by the creation of this operational database which integrates biophysical, social and economic mapping and assessment methods for ES. The results will be useful for designing specific case study applications for ecosystems and to identify gaps in mapping and assessment activities of ES in Europe.

Methods

Step 1. Database consultation and development process

The development of the database (finalised in April 2018) is a result of a long consultation process within the ESMERALDA consortium (Fig. 1). The ESMERALDA database, as described here, comprises of 883 entries. Only studies that described a method analysing ecosystems and their services were included.

Step 2. Collecting data

The development of the ESMERALDA database began in 2015 with the analysis of fact sheets from Member States (Kopperoinen et al. 2018). Based on the analysis, the first

version of the database template was created; this provided the framework for the systematic review of the first 370 scientific studies. The initial results and structure of the database were presented at a second workshop in April 2016 ('Nottingham-Workshop'). All project partners were asked to enter examples of methods used in their own case studies on to posters (Fig. 2). During this workshop, 138 examples from within the consortium were collected and later transcribed into an Excel spreadsheet.

The development and collection of case studies from both scientific and grey literature took place in parallel. Both activities had slightly different aims and, as a result, the recorded attributes for the planned merged database needed to be harmonised. During the merging exercise, it became clear that a few headings were inconsistent. This resulted in a new consultation with the whole consortium and a 'clean' excel spreadsheet with 413 entries. On the basis of the updated template, a call for more examples was made during workshop No. 5 in Madrid (April 2017). For this call, an updated Guideline Document (ESMERALDA 2017) was produced, which provided information and examples of what was expected for each entry, including the final list of methods.

Step 3. Creating the database

During the third workshop in Prague (September 2016), the first version of the database was presented (Fig. 3). Within the consortium, a total of 52 social, 39 biophysical and 47 economic studies were identified. The information was then turned into an online Google spreadsheet. All consortium partners were asked to check their entries and add more entries. The first Excel database resulted in over 155 entries from project partners.

Step 4. Harmonisation and validation of data

An online consultation*[1] started in April 2017 and resulted in about 500 further entries. An editorial process identified very few duplicates; before deletion, these were used as an additional quality check. This ensured that the guidelines were clear and understandable for all.

The next step in the database development was to clean the entries (by harmonising the author name spellings, links working, coding correct and updated etc.). Through several consultations, technical issues were clarified and the database changed accordingly. At the end of the project (July 2018), the ESMERALDA database contained 883 entries, identifying methods for mapping and assessing ecosystems and their services and the context in which they were used. It needs to be noted that one entry in the database represents a single method described in its context. If a case study (or publication) described a set of methods, each method was captured in a single entry. As a result, the total number of scientific studies was 370 which gave rise to the identification of 883 methods. This is taken into account in the results section of this paper and statistics referring to the methods refer to the 883 entries while others use the 370 individual studies. This was a technical necessity for the online method finder which required the facility for filtering according to specific information needs.

Step 5. Final methods identification and classification

The database developed over the course of three years, as did the final classification of methods. The original list of 37 methods was identified and presented as a draft 'methods compendium for the Nottingham workshop (Fig. 1). At the end of the project, 49 broad groups of methods were identified, comprising 15 broad categories of biophysical, 22 economic and 10 social methods (Table 1).

Step 6. Output

A final presentation of the database took place during the workshop in Trento (WS no. 7) and the material was then passed on to the developers of the online method finder tool (Fig. 4). To pass the material on, the preliminary database was frozen at 883 entries, so that the technical team had enough time to finalise the online method finder within the project lifetime (February 2015-July 2018). However, the option to add further case studies after the project finishes is available and the online questionnaire remains open for another two years.

Results and applications

Geographical distribution and ecosystem types

Altogether, 28 countries within Europe were part of the database (this included 2 Baltic and 2 western Balkan countries, linked via regional hubs). The analysis indicated that ES mapping and assessments have been conducted in 26 countries (Fig. 5). Several ES studies have been undertaken in the United Kingdom (47 method examples), Germany (36), Poland (32) and Spain (31). It is evident that most case studies come from countries for which a National Ecosystem Assessment has been already performed (e.g. UK NEA, Spanish NEA, NEA-D).

The examples included in the database cover all ecosystem types as indentified in MAES (Maes et al. 2014). While 'Woodland and Forest' examples dominate (16%), it is fair to say that all ecosystem types are included and well-studied. Again, multiple entries were possible.

Of the 370 studies included in the database, 351 were written in English. However, we also encouraged national studies and hence the remaining 19 are written in Dutch (6), Polish (4), Slovenian (3), Hebrew (3), Swedish (2) and French (1). Most have an English abstract. We wanted to leave the opportunity open for national case studies to also be available for EU members states and the national MAES project. The variation in the language, however, does not reflect any bias but only reflects the background of the consortium members whohave submitted material.

Spatial Scales and sources of data

Most of the method applications (91%) focused on one scale in their study only, while 9% studies covered multiple scales. In total, the 'Regional scale' (43%) was the most commonly used (Fig. 6). Local studies (27%) were also well represented.

Regarding the nature of studies, 44% were classified as assessment, while 31% were purely focused on mapping. 'Mapping' stands for the spatial delineation of ecosystems as well as the quantification of their condition and the services they supply, while 'assessing' refers to the translation of scientific evidence into information that is understandable for policy and decision-making. Based on these definitions, 25% of the studies used a combination of mapping and assessment methods (Fig. 7).

The majority of sources of the database come from published scientific papers (292), 41 came from grey literature (reports) and 37 from case studies. It should be noted that, if a case study was written up as a scientific paper, it was coded as 'scientific literature' and, if it was available as a report on a website, then it was coded as 'grey literature'. Hence, the coding followed the easiest access to the information and so avoided double counting.

Responders to the online questionnaire were also asked which data were used and how these data are available. In most examples, GIS data formed the basis for the investigation, followed by statistical data (Fig. 8).

Mapping and assessment methods and ES classification systems

When looking at the 'Domains of the method', studies were classified into 'biophysical'*[2], 'social'*[3] and 'economic'*[4]; multiple options were also possible. As a result, 53% of the studies worked only within the biophysical domain, while those with social (18%) and economic (19%) accounted for less than half of the studies (Fig. 9). Further examination of the results shows that biophysical methods are the most common methods used (i.e. spatial proxy methods), followed by economic methods (i.e. choice modelling or value transfer) and social methods are still the least used types of methods (i.e. preference assessment) (Fig. 10).

Another question and requirement to describe the entry was 'which ecosystem service classification system' was used? While the adopted framework was described in MAES and in ESMERALDA CICES version 4.3. , we did not want to exclude valid information that used methods linked to different classification systems. As Figure 10 shows, a slight majority of entries is based on the MA classification, followed by CICES (77) and TEEB (40). While 40 used a different or slightly adjusted system, in 120 cases, no information was provided on the system usedor they simply did not know (hence it was not possible for the transcriber of the study to answer this question).

The transcribers were asked to identify which of the CICES classes (version 4.3,Haines-Young and Potschin 2013) were covered by the study, so that the online method finder could make the link between specific methods and ecosystem service types. All 47 CICES ecosystem services are covered in the database. While the CICES version 4.3 does not officially include the abiotic services, for the benefit of completeness, we provided the transcribers with ways of including them. This also makes it possible for future studies which use CICES (version 5.1, Haines-Young and Potschin 2018) to be included (Fig. 11).

We also asked if the method described was used for the demand or supply side of the ecosystem service investigation; 433 examples link a method to the supply side, 303

examples reflected on both – the supply and demand side - whereas so far only 83 described the demand (or actual use) of the ecosystem services. This again might simply be a reflection of development in the ecosystem service research and its available publication. The studies of the earlier years all concentrated on the supply side, where more recent work tended to look at the demand side.

Policy and business applications

As the aim of ESMERALDA is to support the MAES initiative, we were also interested to see if studies considered questions relevant to the policy and business sectors (Fig. 12). While 24 examples consider both, it was interesting to note that over 200 examples mainly had policy questions in mind.

Based on the questions in the database and the questions collected within ESMERALDA and the MAES process, we made a classification to enable users to easily find relevant information for different policy questions (Maes et al. 2018. For policy questions, we classified the cases based on the relevant policy domain and the objective of the policy question. The business questions were classified according to the objective of the question (Table 2).

Discussion and recomendations

The development of the database on ecosystem service mapping and assessment applications was a key element running through the entire lifetime of the ESMERALDA project, including all workshops. The process of developing the database created much debate and forced us to be clear about terminology which helped expand the project glossary (Potschin-Young et al. 2018). It also enabled us to develop the method classification by building on work in OpenNESS and OPERA (Potschin-Young et al. 2018)

One aspect to be noted is that, although the database reflects what has been done in the ecosystem service community, it does not include any prioritisation nor recommendations. While a method may have been used many times to analyse a certain issue, no expert opinion is included in the database to help the user decide if this is right or wrong. The number times a method was used does not reflect any indication that it is best; it is just a matter of how many people wrote about it. It is also important to note that entries can reflect ideas that are currently in fashion. For example, although participatory GIS was *in vogue* for a while, this does not mean that this is the perfect method or that others could not be used to establish a value for a service or to aid prioritisation.

As usual with the creation of reviews such as these, a common understanding of the information asked is needed to avoid different answers to the same question. This was done here through several quality assurance methods within the consortium. However, it needs to be noted that, so far, the database is an ESMERALDA internal product and its usefulness has yet to be reviewed outside the consortium.

Based on the work described here, the following can be concluded:

- A detailed list of methods that have been used in different studies in Europe can help in the implementation of Action 5 of the EU Biodiversity Strategy.
- Methods need to be classified in relation to a set of individual variables (i.e. study dimension, scales, ecosystems or ecosystem services) in order to be appliedto other applications.
- It is important to identify how methods are being used in scientific and policy environments in order to help identify knowledge gaps and provide guidance.
- The presentation of these results provides a base line for Member States to stimulate the process of developing the flexible methodology for mapping and assessment activities.
- One advantage of this practical classification of methods is that it shows that it is possible to capture the different perceptions of ecosystems and their services, according to specific use or non-use of that ecosystem/service. However, as this brings also a level of complexity, a practical guide for selecting methods according to the resources is therefore required.

Acknowledgements

The authors wish to thank the whole ESMERALDA consortium for their discussion and inputs during workshop in creating the structure and their entries into the database. Special thanks to the additional ESMERALDA Executive Board members for intense debate on structure, expected outcomes etc. Entries are acknowledged in the database through their citation.

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Conflicts of interest

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Endnotes

*1 *1

*1 The online consultation is available at: https://www.webropolsurveys.com/S/85E71B9D58A30304.par

*2 Biophysical = An assessment of the biological and physical element s of an ecosystem, including geology, topography, hydrology and soils.

*3 *3

*3 Social = Different methods that analyse human preferences (as well as people's cognitive, emotional, ethical responses to nature) towards ecosystem services in non-monetary term

*4

*4 *4 *4 Economic = The process of expressing a value for a particular service in a certain context (e.g. of decision-making) in monetary terms.

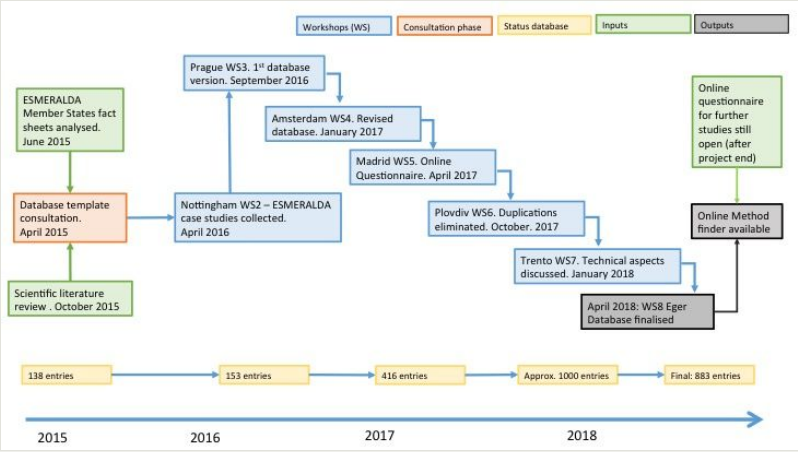

Figure 1.

Process of database development and consultation within ESMERALDA consortium partners.

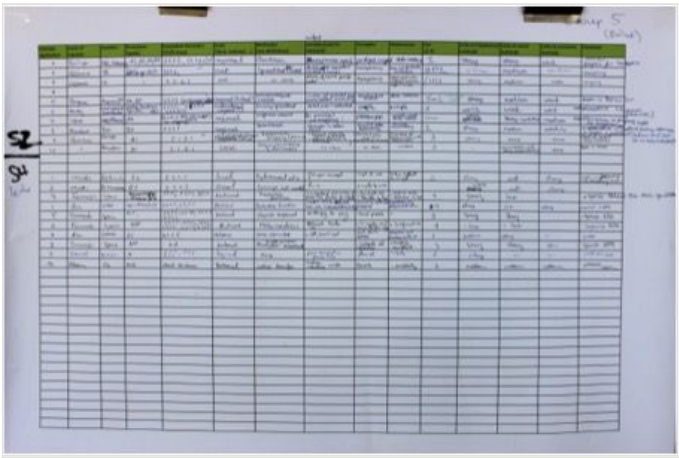

Figure 2.

Example of internal document collecting ecosystem service method related studies within the ESMERALDA consortium (‘Nottingham workshop’, April 2016).

Figure 3.

Developing the first version of ESMERALDA database, which included scientific and grey literature from ecosystem service mapping and assessment methods.

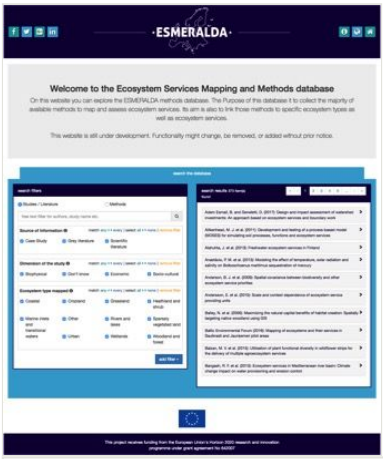

Figure 4.

Developing the first version of ESMERALDA database, which included scientific and grey literature from ecosystem service mapping and assessment methods.

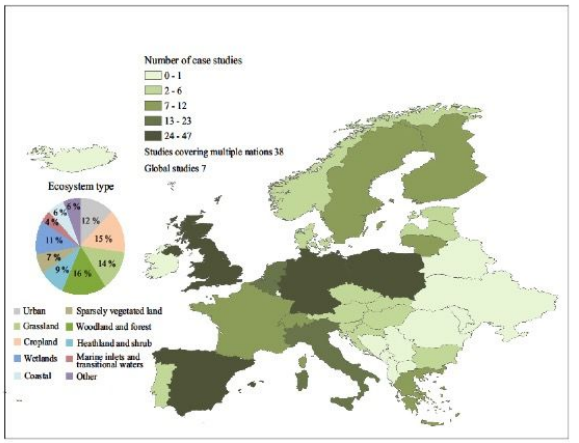

Figure 5.

Spatial distribution of case study locations by country and type of ecosystem, in which the mapping and assessment methods were applied.

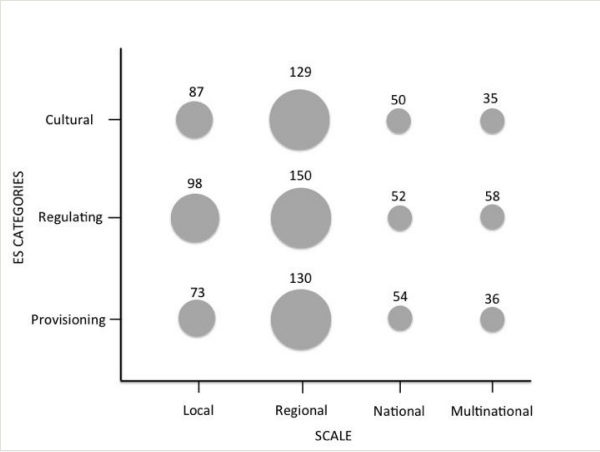

Figure 6.

Spatial scales used in ESMERALDA at which mapping and assessment methods could be applied in relation to ES categories.

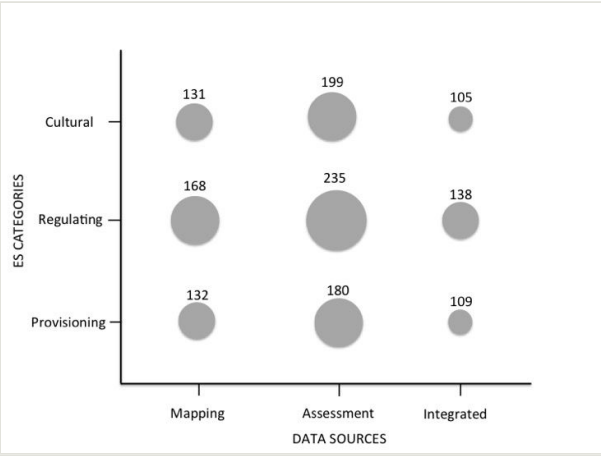

Figure 7.

Main sources of data categorised by mapping, assessment and integrated (combinations of both) that could be applied in relation to ES categories.

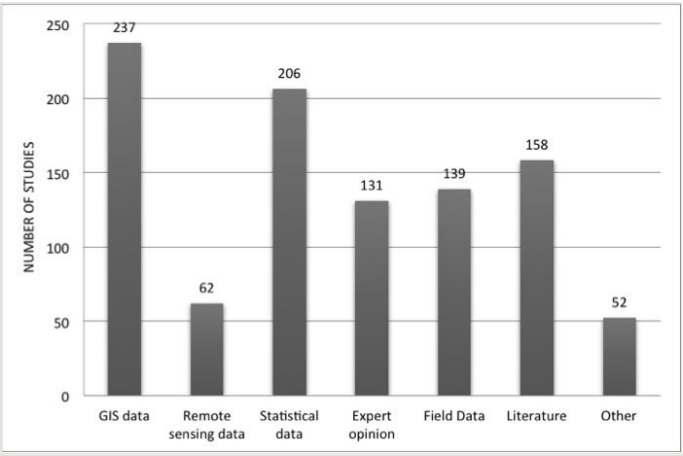

Figure 8.

Type of spatial data used and the level of details in which the mapping and assessment methods were applied.

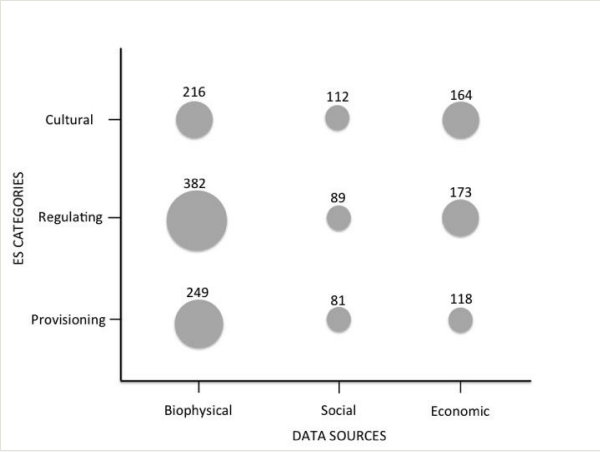

Figure 9.

Domains of the study (Biophysical, Economic or Social) at which mapping and assessment methods could be applied in relation to ES categories.

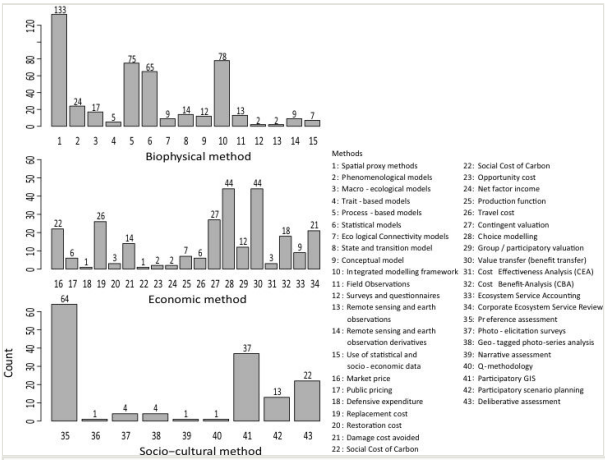

Figure 10.

Mapping and assessment methods that are applied in different studies and were part of the database.

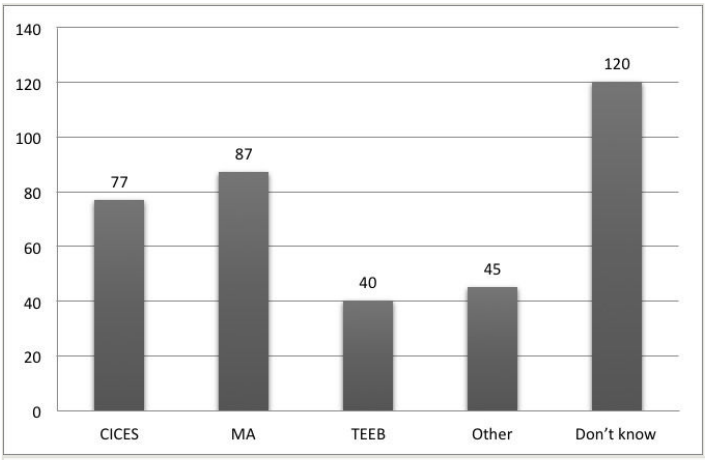

Figure 11.

Ecosystem services classifications systems in which the mapping and assessment methods were applied.

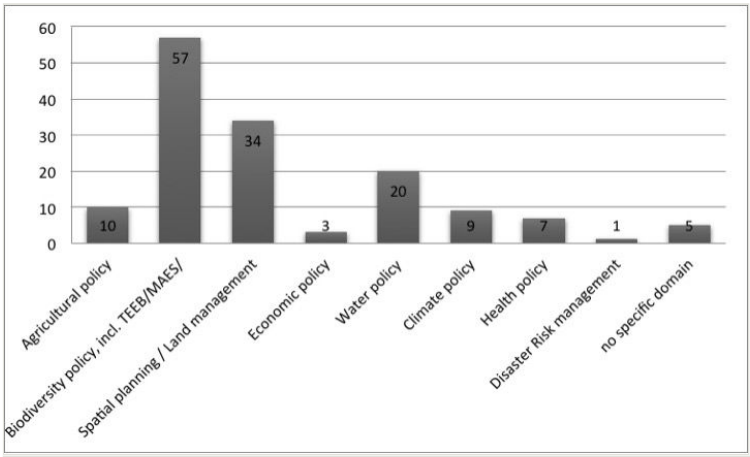

Figure 12.

Policy and business domains included in the database in which the mapping and assessment methods were applied.

Table 1.

Overview of the ecosystem service mapping and assessment methods proposed in ESMERALDA.

Method type	Method number	Method name
Biophysical	**1**	Spatial proxy methods
	2	Phenomenological models
	3	Macro-ecological models (includes habitat models)
	4	Trait-based models
	5	Process-based models (includes: landscape function models)
	6	Statistical models
	7	Ecological Connectivity models
	8	State and transition model
	9	Conceptual model
	10	Integrated modelling framework
	11	Field Observations
	12	Surveys and questionnaires
	13	Remote sensing and earth observations
	14	Remote sensing and earth observation derivatives
	15	Use of statistical and socio-economic data
Economic	**16**	Market price
	17	Public pricing
	18	Defensive expenditure
	19	Replacement cost (alternative cost method)
	20	Restoration cost
	21	Damage cost avoided
	22	Social Cost of Carbon
	23	Opportunity cost
	24	Net factor income (residual value method)
	25	Production function
	26	Hedonic pricing
	29	Travel cost
	30	Contingent valuation
	31	Choice modelling (choice experiment, discrete choice modelling)
	32	Group / participatory valuation
	33	Input-Output analysis
	34	Value transfer (benefit transfer)
	35	Cost-Effectiveness Analysis (CEA)
	36	Cost-Benefit Analysis (CBA)

	37	Ecosystem service assessment
	38	Ecosystem Service Accounting
	39	Corporate Ecosystem Service Review
Socio-cultural	**40**	Preference assessment
	41	Time-use assessment
	42	Photo-elicitation surveys
	43	Geo-tagged photo-series analysis
	44	Ecosystem service card game
	45	Narrative assessment
	46	Q-methodology
	47	Participatory GIS
	48	Participatory scenario planning
	49	Deliberative assessment

Table 2.

Policy and business objectives described in the database linked with the mapping and assessment methods.

Policy Domains	Policy objective	Business objective
1. Agricultural policy	1. Awareness raising	1. Site management (achieve and promote biodiversity-friendly management of corporate sites)
2. Biodiversity policy	2. Benchmarking and prioritisation (performance indicators to monitor evolution / benchmark/ identify priority areas)	2. Operational management (reduce costs and risks of interruption, realise efficiency gains)
3. Spatial planning / Land management	3. Policy evaluation (evaluating the impact of policies, policy actions)	3. Legal and regulatory issues (identify future legislation, reduce compliance costs and risk of fines)
4. Economic policy	4. Project evaluation (evaluating the impact of individual projects on ecosystem services)	4. Financing (reduce financing costs and increase margins, improve access to finance-attract investors)
5. Water policy	5. Accounting (measure the changes in the stock of natural capital and integrate the value of ecosystem services into accounting and reporting systems)	5. Reputational and marketing (identify revenue streams, differentiate products, improve ability to attract and retain employees)
6. Climate policy	6. Instrument design (design incentives, targeting user groups)	6. Societal (identify benefits and negative impacts to local communities, support social licence to operate)
7. Health policy	7. Litigation (damage and compensation claims, liability issues)	7. Other
8. Disaster Risk management	8. Preference assessments	
9. No specific domain	9. Other	