Scientific research on mapping and assessment of ecosystems and their services in the EU Overseas

Acronym: MOVE

Title: MAPPING AND ASSESSING THE STATE OF ECOSYSTEMS AND THEIR SERVICES IN THE OUTERMOST REGIONS AND OVERSEAS COUNTRIES AND TERRITORIES: ESTABLISHING LINKS AND POOLING RESOURCES

Grant Agreement n° 07.027735/2018/776517/SUB/ENV.D2

Activity Name: Knowledge sharing and information repository - Activity 3.
Task Name: Scoping and analyzing existing and ongoing studies related to mapping and assessing ecosystems and their services in EU OCTs and ORs – Task 3.
Deliverable Name: Deliverable D.3.1 - Scientific research on mapping and assessment of ecosystems and their services in the EU Overseas.
Due date of deliverable: May 2019
Actual submission date: 03/04/2020

This project has received funding from the European Commission Directorate - General Environment, under the grant 07.027735/2018/776517/SUB/ENV.D2

Document information	
Document name	Deliverable D.3.1 - Scientific research on mapping and assessment of ecosystems and their services in the EU Overseas
Citation	MOVE project, European Commission Directorate General Environment Grant Agreement no. 07.027735/2018/776517/SUB/ENV.D2. Deliverable D.3.1 - Scientific research on mapping and assessment of ecosystems and their services in the EU Overseas.
Lead Authors	Sieber, I.[1], Burkhard, B.[1, 2], Santos-Martín, F.[3]
Contributing Authors	Maréchal, J.P., van Beukering, P., Hinsch, M., Geneletti, D., Adem-Esmail, B., Trégarot, E.
Dissemination level	Public

[1] Leibniz Universität Hannover, Institut für Physische Geographie und Landschaftsökologie, Schneiderberg 50, 30167 Hannover, Germany

[2] Leibniz Centre for Agricultural Landscape Research ZALF, Müncheberg, Germany

[3] Universitdad Autonoma de Madrid, Spain

Contacts: Institute for Physical Geography and Landscape Ecology. Leibniz Universität Hannover. sieber@phygeo.uni-hannover.de; burkhard@phygeo.uni-hannover.de

History			
Version	**Date**	**Modification**	**Author(s)/Entity**
1	03.04.2019	First draft	Sieber, I.M. (LUH)
2	05.06.2019	First draft	Maurischat, P. (LUH), Santos-Martín, F. (UAM)
3	30.07.2019	First draft	Burkhard, B. (LUH), Santos-Martin, F. (UAM)
4	15.8.2019	Revision	Maréchal J.P. (NBE)
5	20.10.2019	Revision	van Beukering P. (VUA), Hinsch M. (LUH)
6	20.1.2020	Revision	Geneletti, D., Adem-Esmail, B. (UNITN)
7	30.1.2020	Final Revision	FRCT

Summary

This report presents the current state of the art of ecosystem services research, with focus on Mapping and Assessment of Ecosystems and their Services (MAES). Data collection took place through a scientific literature review (published in Sieber et al., 2018) and a consortium member survey conducted from January to June 2019 under the umbrella of the MOVE project.

Publishable Summary

This report presents the current state of the art of ecosystem services research, with focus on Mapping and Assessment of Ecosystems and their Services (MAES). Data collection took place through a scientific literature review (published in Sieber et al., 2018) and a consortium member survey conducted from January to June 2019 under the umbrella of the MOVE project.

Table of Contents

LIST OF ABBREVIATIONS

BEST	Voluntary Scheme for Biodiversity and Ecosystem Services in Territories of European Overseas
BISE	Biodiversity Information System
CICES	Common International Classification of Ecosystem Services
EC	European Commission
ES	Ecosystem Service
EEZ	Exclusive Economic Zone
ESMERALDA	Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking
EU	European Union
IRD	Institut de Recherche pour le Développement, FRANCE
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MA	Millennium Ecosystem Assessment
MAES	Mapping and Assessment of Ecosystems and their Services
MOVE	Mapping and Assessing the State of Ecosystems and their Services in the Outermost Regions and Overseas Countries and Territories: Establishing links and pooling resources
(M)PA	(Marine) Protected Area
OPPLA	Open Platform Project
OR	Outermost Region
OCT	Overseas Countries and Territories
PGIS	Participatory GIS
TEV	Total Economic Value
TFEU	Treaty on the Functioning of the European Union

LIST OF FIGURES

[1] https://biodiversity.europa.eu/maes
[2] ESMERALDA MAES Explorer: http://www.maes-explorer.eu/

LIST OF TABLES

LIST OF BOXES

Preface

Mapping and Assessment of Ecosystems and their Services (MAES) are core components to the EU Biodiversity (BD) Strategy 2020. Within this strategy to protect biodiversity and halt the loss of species, Action 5 of the strategy's 2nd target foresees each EU Member State to map and assess the ecosystems and their services (ES) in their national territories, creating an EU-wide knowledge base. This is important for the advancement of biodiversity objectives, the creation of informed policies on, for instance, agriculture, water, climate and landscape planning[3]. Furthermore, it is 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.

The Outermost Regions (ORs) and Overseas Countries & Territories (OCTs) of the European Union are scattered around the globe, presenting hotspots of biodiversity and ecosystem services. They host more than 70% of EUs biodiversity, 20% of global coral reefs and lagoons and 6% of endangered and red-listed species globally, and contain diverse and unique ecosystems from coral reefs to mountains and tropical rainforests. Based on the high variety of ecosystems with exceptionally high biodiversity in these territories, multiple ecosystem services are provided. There have been collective efforts from all EU Member States under the umbrella of the EU Project ESMERALDA[4] and EU BEST but the European Overseas still fall behind to map and assess the ecosystems and their services in their territories.

The MOVE (**facilitating MAES to support regional policy in Overseas Europe, mobilizing stakeholders and pooling resources**) project supports the implementation of MAES within the participating overseas regions. In response to the requirements of Action 5, the **MOVE** pilot project intends to fill the gaps in MAES implementation between continental and Overseas EU Member States. MOVE involves policy makers, researchers and the civil society in the development of methodologies for mapping and assessing the condition of ecosystems and their services, and tested throughout case studies across the ORs and OCTs. It advocates a coordinated and synergistic bottom-up approach (Fig. 1) to turn the geographical, political and knowledge fragmentation of these entities into useful units. Through pooling resources and building robust participatory tools for informed decision-making, it will contribute to safeguarding the provision of ecosystem services in the EU Overseas.

[3] Http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

[4] http://www.esmeralda-project.eu/

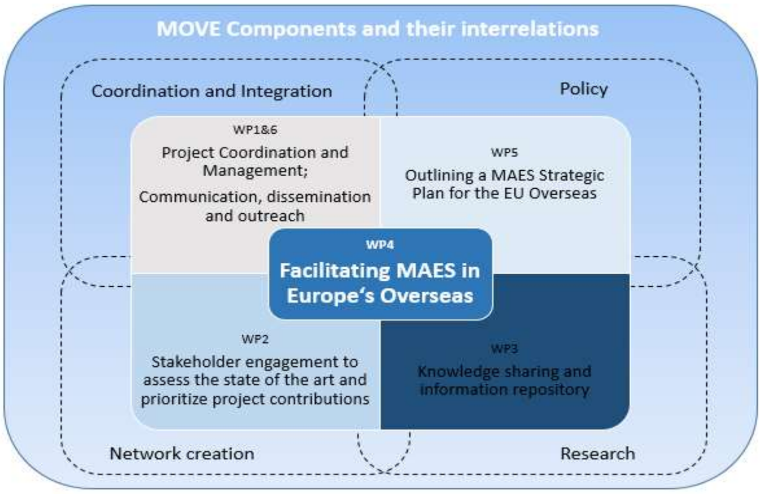


Fig. 1: Building Blocks and Work packages (WP) of the MOVE Project

MOVE **Activity 3** (Knowledge sharing and information repository, coordinated by Leibniz Universität Hannover (LUH)) aims to assess the gap between the MAES[5] implementation levels of the EU mainland and the EU Overseas by investigating the current state of the art on ES research in the EU Overseas. Through integrating this information, redundancies can be avoided. Activity 3 aims to create synergies and highlight current efforts and available resources.

This report presents a first assessment of MAES-related literature and applications within the EU Overseas. The data collection was obtained through a literature review as well as a survey amongst stakeholders, scientists and practitioners in the EU Overseas regions. A comprehensive overview of this scientific work has been integrated into the open access online ESMERALDA MAES Explorer[6].

The report is structured into five chapters. Chapter 1 briefly introduced the state-of-the-art of mapping and assessment of ecosystems services in mainland Europe and in EU Overseas regions highlighting critical knowledge gaps. Chapter 2 presents the methodological steps for collecting data. Chapter 3, the core of the report, summarizes the identified ES mapping and assessment studies in the EU Overseas, distinguishing between seven biogeographic regions of global importance, i.e. Macaronesia, The Caribbean, Amazonia, South Atlantic, Indian Ocean, Pacific and Polar and Subpolar regions. It concludes with a SWOT analysis helping to highlight knowledge gaps, research and case study needs for MAES in the study biogeographic regions. Chapter 4 is a comparative analysis of MAES studies in mainland versus overseas EU in terms of types of studies, ecosystems, ES, and applied methods. Last, Chapter 5 concludes, highlighting a large potential for comprehensive ecosystem assessments in the EU ORs and OCTs, and suggesting a 7-Step potential for the MAES process in the EU Overseas based on the review of scientific literature.

5 http://www.maes-explorer.eu/
6 http://database.esmeralda-project.eu/database

1. INTRODUCTION

1.1 Ecosystem Services

"Ecosystem services (ES) are the benefits people obtain from ecosystem" (MEA, 2005). Their provision and flow are dependent on the ecological structures, functions and condition of ecosystems. Healthy ecosystems are essential for ecosystem functioning and the long-term provision of ES such as food, clean drinking water, building materials as timber, regulating land degradation or regulating global climate through carbon storage and sequestration. This implies that human well-being strongly depends on biodiversity, well-functioning ecosystems and natural capital (Fig. 2). Thus, healthy ecosystems form the base for a continuous flow of ES from nature to society (Burkhard & Maes, 2017). Not surprisingly, the ES concept has strong potential as a policy and decision-making tool on various levels and different temporal and spatial scales.

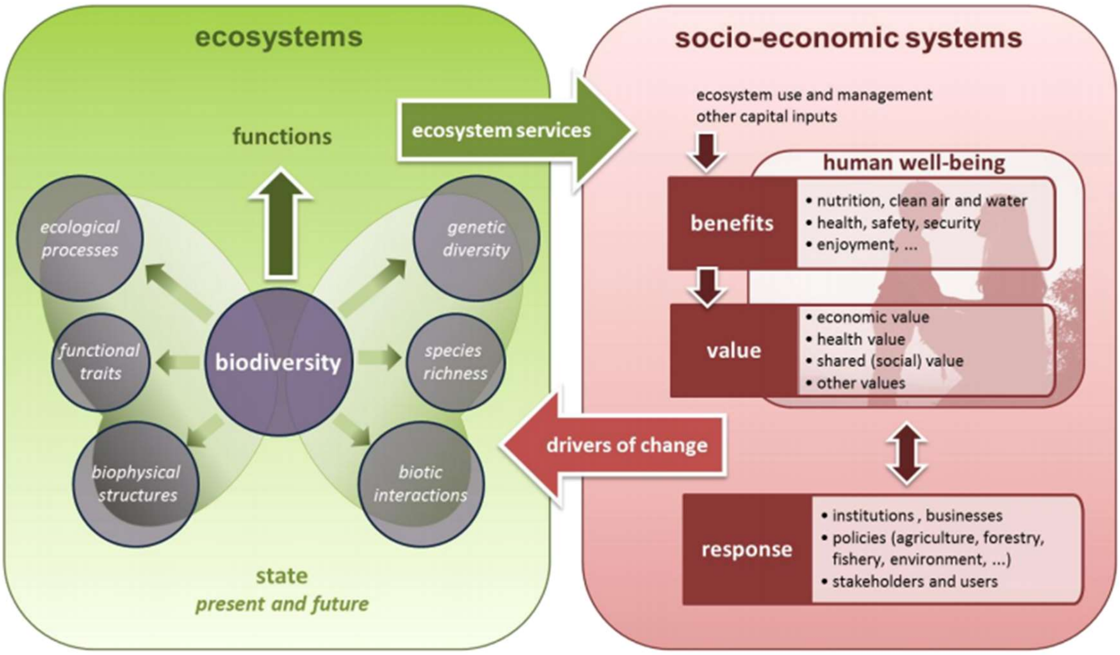


Fig. 2: MAES conceptual framework for EU wide ecosystem assessments[7].

1.2 MAES

Mapping and assessment of ecosystems and their services (MAES) are core components to the EU Biodiversity (BD) Strategy to 2020. Action 5 foresees each Member state to map and assess the ecosystems and their services in their national territories, creating an EU-wide knowledge base, important for the advancement of biodiversity objectives, the creation of informed policies on agriculture, water, climate and landscape planning[8]. Furthermore, it is 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.

To achieve this goal, the European Commission established a working group on MAES, which meets twice a year to inform and update each other on progress and new developments

[7] https://biodiversity.europa.eu/maes

[8] Http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

within EU member states. Next to various technical reports and assessment frameworks, the working group adopted the ES classification CICES[9] to allow harmonized use throughout the EU (see Box 1).

Box 2: The Common International Classification of Ecosystem Services (CICES)

CICES

The Common International Classification of Ecosystem Services (CICES) was developed from the work on environmental accounting undertaken by the European Environment Agency (EEA). CICES recognizes that the main categories of ecosystem outputs to be provisioning, regulating & maintenance and cultural services. The hierarchical structure is designed to include issues of scale and accommodate geographical differences in the kinds of ecosystem output that are recognized by society as a service.

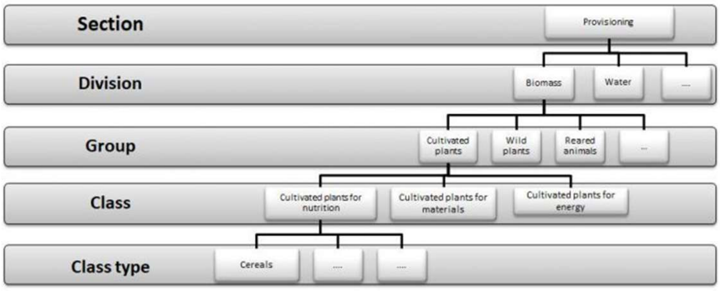


Fig. 3: Structure of CICES (Haines-Young & Potschin, 2018).

A key finding of this MAES process was that ES mapping is already being practiced in most of the EU member states, but that there were disparities in the level of implementation.

The MAES process can be subdivided into 7 steps (based on the ESMERALDA project; Fig. 4). The starting point would be the identification of a relevant policy question (1) that can effectively guide the work of relevant stakeholders (2). Next, network creating and active involvement of stakeholders are needed (3). Thereafter, the actual mapping and assessment process (4) can take place, drawing on a multiplicity of methods from environmental sciences (biophysical approaches), economic and social scientific domains. These methods can be tested and applied in exemplary case studies (5). Communication and dissemination (6) of the results is utterly important to bridge the gap between stakeholders and science. As last step, the actual implementation, the uptake of results in decision-making, for example, in sustainable land use planning to safeguard the provision of ES, takes place (7).

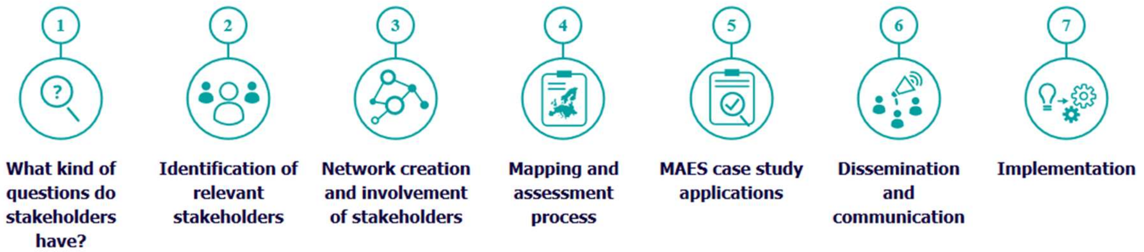


Fig. 4: The seven steps of MAES implementation as identified by ESMERALDA [10].

[9] Common International Classification of Ecosystem Services: http://cices.eu/

[10] ESMERALDA MAES Explorer: http://www.maes-explorer.eu/

1.3 The EU Overseas and their importance for the European Union

There are 34 entities associated with the EU: 9 Outermost Regions (ORs) and 25 Overseas Countries and Territories (OCTs). These entities are scattered throughout the globe and can be grouped into 7 biogeographic regions of global importance: the Polar and Subpolar regions, Macaronesia, Amazonia, the Caribbean, South Atlantic, Pacific and the Indian Ocean. These biogeographic regions significantly contribute to the EU's biodiversity: including ecosystems from polar seas, wetlands, coral reefs and volcanic islands to tropical forests (Petit and Prudent 2008). These areas harbour over 70% of all EU biodiversity, including 20% of the world's coral reefs and lagoons (Petit and Prudent 2008). They provide ecosystem services from local to global importance.

These territories have close bonds to the EU member states France, the United Kingdom, Portugal, Spain, the Netherlands and Denmark. Based on their status, they experience different levels of EU involvement and thus application of EU law: 1) the Outermost Region (OR) status, Overseas provinces of the EU member states, 2) the Overseas Countries and Territory Status - associated with the European Union (OCT) and 3) a group of territories *sui generis,* that do not fall in the two aforementioned groups (i.e. Faroe, Guernsey, Isle of Man, Gibraltar) (Kochenov, 2012). Articles 349 and 355 of the Treaty on the Functioning of the European Union specify the individual level of EU involvement in these three groups[11]. Simplified, the starting assumption for ORs is that EU acquis fully applies unless stated otherwise. This is, in reverse, the case for the OCTs (Kochenov, 2012). Despite their status, these areas contribute significantly to the extension of the European Exclusive Economic Zone (EEZ), making it the world's largest and most diverse EEZ (Fig. 5)[12].

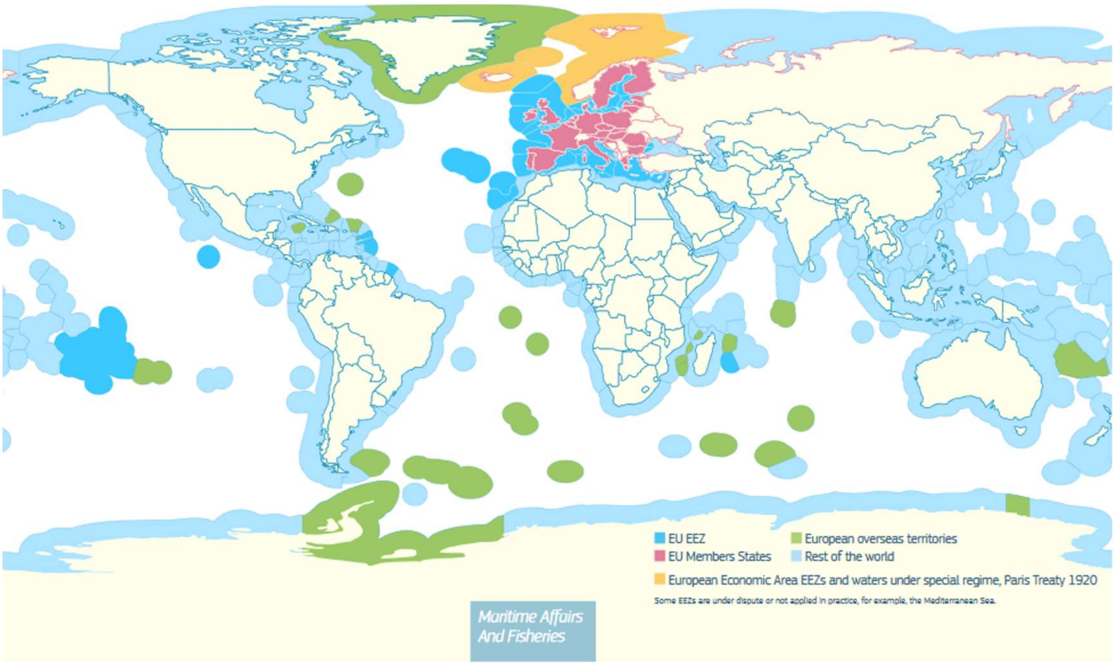


Fig. 5: The dimension of the EU EEZ and the EU Overseas (European Commission).

[11] http://www.europarl.europa.eu/factsheets/en/sheet/100/outermost-regions-ors-

[12] https://www.eesc.europa.eu/sites/default/files/resources/docs/eu-and-international-ocean-governance_en.pdf

1.4 The current status of ecosystems and their services in the EU Overseas

Since 2008, the EU has started to protect key ecosystem functions and services in terrestrial and marine overseas environments. Representatives of the EU Overseas - ORs, OCTs, EU Member States - the European Parliament and the European Commission united during the Conference "The European Union and its Overseas Entities: Strategies to counter Climate Change and Biodiversity Loss". This Conference led to the "Message from Reunion Island" (2008)[13] and "Message from Guadeloupe" (2012)[14], which called for Strategies between EU Member States and the European Commission, together with the ORs and OCTs, to establish a voluntary scheme for the protection of species and habitats (EU BEST[15]), countering Climate Change and Biodiversity Loss in the EU Overseas Entities (European Commission 2008). Ecosystems and their services stood central in this call, as demands on islands for food, clean water, fertile soils and timber are growing. Healthy ecosystems also form the foundation for wellbeing, recreation and tourism. However, for many EU Overseas territories, little is known about the impacts of anthropogenic and climatic changes on the ecosystems providing these ES. These efforts are in line with the EU Biodiversity Strategy[16], calling EU states to implement the MAES process.

Most of the ORs and all OCTs are islands. They rely heavily on natural resources - especially marine and coastal ecosystems (Wong et al. 2005, Nunes et al. 2014) or montane forests (Borges et al. 2009). These ecosystems play an important role in protecting island biodiversity, providing a variety of ES of global and regional importance (e.g. water regulation, erosion control, pollination, pest-control, food supply and recreation), which translate into a substantial but often unrecognized contribution to local island economies (Borges et al. 2009). Local island ecosystems also provide crucial contributions to the tourism sector (Wong 1993, UNEP and PAP/RAC. 2009). Especially cultural ES are of importance to the tourism sector, but highly dependent on natural diversity and healthy ecosystems (Worm et al. 2006; van Beukering et al. 2007).

1.5 The need for scientific research on MAES in the EU Overseas

The MOVE project aims to (1) build a collaborative network of local agents from a significant number of ORs and OCTs and mainland Europe teams, in order to (2) engage stakeholders in identifying local priorities for MAES and (3) collaborating in the development of case studies addressing those priorities. The project will produce an assessment of the state-of-the art of MAES in the participating regions, including an assessment of the institutional landscape. The personal links established, the communication tools created, and the guidelines provided by the Strategic Plan for the development of MAES in the European Overseas will support the sustainability of the action.

MOVE Activity 3 - Knowledge sharing and information repository - is a cross-cutting activity aiming at sharing knowledge and capacities between the ORs and OCTs and Europe mainland. Information collected in the project will be analyzed, integrated, synthesized and structured to fulfil the demands of MAES implementation in all EU member states, includi ng

[13] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/message_from_reunion_island.pdf
[14] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/message__from_guadeloupe_en__2_.pdf
[15] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/BEST_Brochure_2017-brochure_complete_WEB.pdf
[16] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244

the ORs, OCTs and marine areas. Existing experience from MAES implementation in the EU member states (e.g. from the ESMERALDA project and the EU MAES Working group) will be harnessed to guarantee efficient and tailor-made processes in the project regions. Finally, MAES-relevant information on ORs and OCTs ecosystems and their services will be made available for EU level repositories such as BISE or OPPLA. Therefore, the project needs a strong interaction with relevant EU bodies.

The aim of this report is to investigate the current state-of-the-art of ES research in the EU Overseas regions. This will be obtained through a survey amongst consortium members and experts from the different overseas regions. This report presents these findings and summarizes the results for each global region.

2. METHODOLOGY

The methods to assess the current status of the MAES implementation in the EU Overseas have been twofold: First, a scientific literature review and second, a survey amongst stakeholders and MOVE partners on current activities related to ecosystem services research (with a specific focus on ES mapping and assessment).

2.1 Literature Review

A first screening of scientific publications was conducted from March 2017 to April 2018. This systematic literature review followed the PRISMA[17] statement (Moher et al, 2015). It screened scientific literature for publications, case studies and grey literature, dealing with mapping and assessment of ecosystems and their services. For this, the search engines Scopus, Web of Science and Google Scholar were selected. Over 1050 publications met the search criteria, however, a majority dealt with biodiversity, ecosystem structures and functions. Only 161 publications focused on ecosystem services and benefits.

2.2 Survey

A survey amongst MOVE consortium members and stakeholders was conducted between January and June 2019 to capture part of the ongoing work that a scientific review usually cannot easily grasp. As most ES mapping and assessment efforts take place on local and regional levels and in both scientific and governance sectors (e.g. land use planning and decision making), they might not be scientifically published or available open access. Therefore, the survey acknowledged different languages (amongst others French, Portuguese, Spanish, Dutch and Danish), spatial scales and different professional/scientific backgrounds of the respondents[18].

This survey comprised three blocks: The first block contained questions for the respondent, including background knowledge related to ES or his/her field of expertise. The survey was designed in accordance with the EU Data Protection Directive. The second block entailed information on existing studies. It comprised 25 questions per study entry - open-ended and closed-ended questions, and a range of multiple-choice questions including the ecosystem type considered, the ecosystem services according to the CICES[19] classification, including policy questions addressed within the project/report/case study. This second block allowed multiple entries of studies, publications, and reports. A third block asked respondents for any comments and questions and to enter their email if they wished updates on the results. Furthermore, they could suggest experts as additional respondents to the survey. This way, snowball sampling was possible.

The survey was distributed amongst consortium members and experts in the regions - identified through MOVE Activity 2. About 60% of the 44 respondents completed the survey (Fig. 6).

[17] PRISMA stands for 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses', a standardized method for scientific literature reviews

[18] For the European mainland, similar data has been collected within the ESMERALDA EU Project, in which EU Member states have provided their information on the state of the art of MAES implementation, including studies, projects, and scientific publications.

[19] https://cices.eu/

Respondents showed their confidence (0 = no knowledge; 5 = expert) with the topics of ecosystem services (σ = 4.41), spatial planning (σ = 4.71) and (small) island (developing) states (σ = 3.96). Each of the completed surveys provided between one to five studies, projects or reports. In addition, two respondents turned in publication lists that were added by the project staff. Therefore, 70 additional studies were obtained.

Both review and consortium member survey reach a total of 231 publications. Whilst these can cover multiple ORs and OCTs, a total of 271 assessments for the 34 ORs and OCTs is reached.

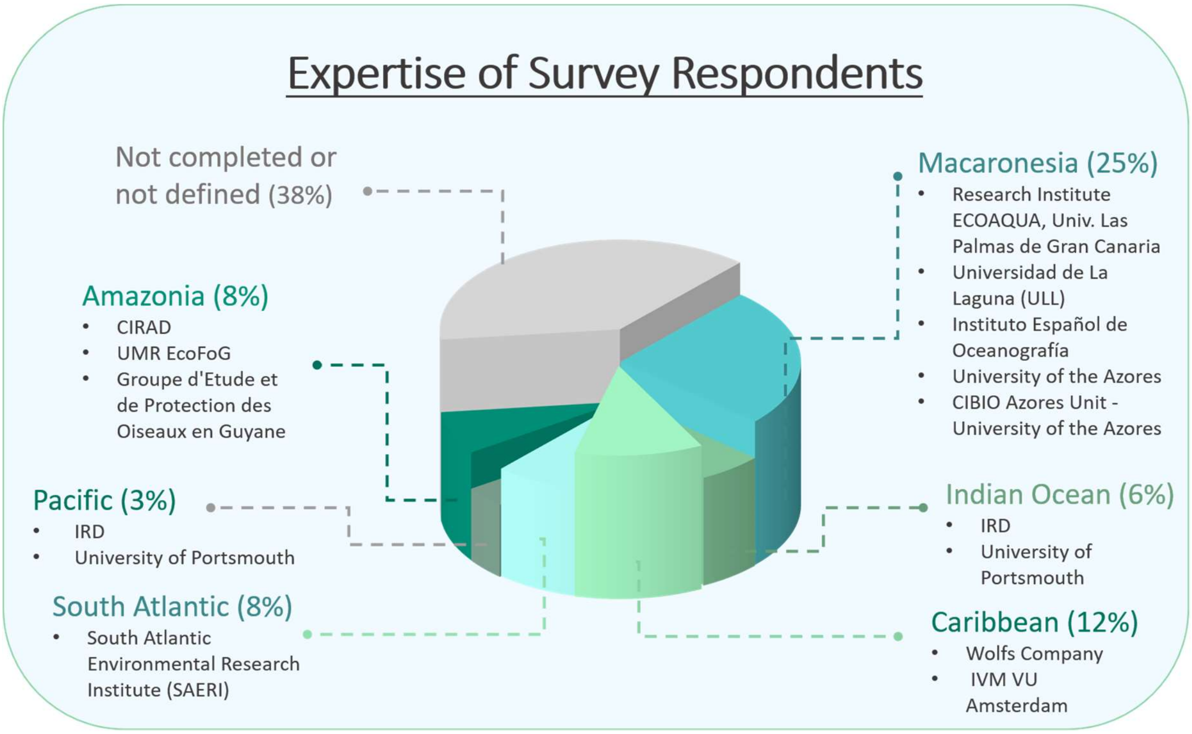


Fig. 6: Expertise and institutional background of the survey respondents.

3. MAPPING AND ASSESSMENT OF ECOSYSTEMS AND THEIR SERVICES IN THE EU OVERSEAS

3.1 General results

The literature review (Sieber et al., 2018) obtained 161 publications from Web of Science, Scopus and Google Scholar, using a predefined search string. The obtained scientific Studies covered the EU territories in the Caribbean (60), the Pacific (39), Macaronesia (28) and Indian Ocean (26), the Polar and Subpolar regions (10) and Amazonia (7). The literature review highlighted that many ORs and OCTs remain blank spots in terms of ecosystem services mapping and assessment, such as Saint-Pierre and Miquelon, the British Antarctic Territories, Scattered Islands, Madeira, Tristan da Cunha, Ascension Island, Anguilla, Saint Martin or Curacao. The study concluded that "despite many biodiversity studies referring to species abundance, little has been published on ecosystem services" (Sieber et al. 2018, p1).

The consortium member survey added another 70 studies. As studies cover multiple ORs and OCTS, summing up the studies and publications, including those that cover multiple ORs and OCTs, results in 271 ES assessments.

During the last decades, the number of studies and publications on ecosystems and their services in the EU Overseas has been increasing. This reflects the rising awareness and application of the ES concept. The number of publications on ES mapping and assessment in EU Overseas areas was scarce prior to 2005 (Fig. 8) but increases after the release of the MEA reports (Millennium Ecosystem Assessment 2005). The number of studies continuously increased during the following years and accelerated in 2010, as the EU started to invest in Overseas programs such as NetBiome[20] and EU BEST, and after the publication of the EU Biodiversity strategy. A peak was reached in 2014, with 43 publications.

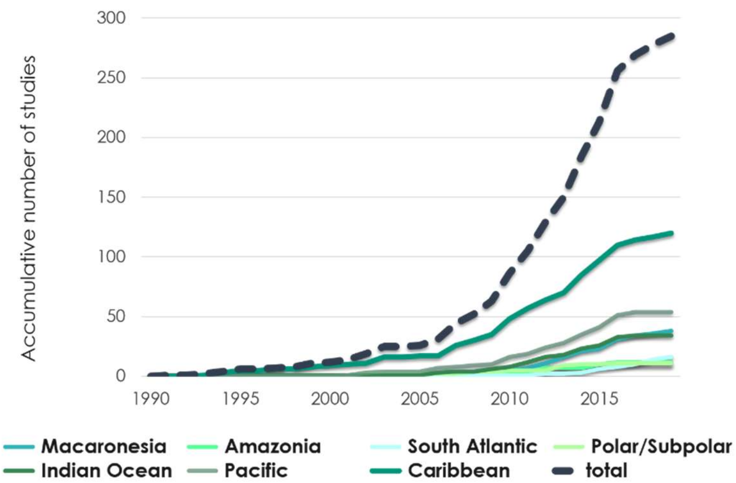


Fig. 7: annual number of publications, showing rising numbers of ES studies for the EU Overseas (n=271).

[20] http://www.netbiome.eu/

A geographical overview shows that the 271 ES mapping and assessment publications cover all 7 regions (Fig. 8). 32 out of the 34 ORs and OCTs were represented in the publications - only Sint Maarten and Saint-Pierre et Miquelon remain without ES studies, even though the Caribbean region showed the highest overall number of studies.

Some publications both mapped and assessed ES in multiple regions Therefore, these publications were counted for each OR and OCT separately. ES in the Caribbean Region are described in 97 publications. The Pacific Ocean EU territories are covered abundantly with 52 studies and reports. The Macaronesian Archipelago has 41 publications, of which 8 are project reports and 2 case studies or stakeholder input. The Indian Ocean Associated territories is covered with 30 studies and reports. Thereafter, the Associated South Atlantic Territories (14), Amazonia (12), and the Polar and Subpolar regions (11) follow.

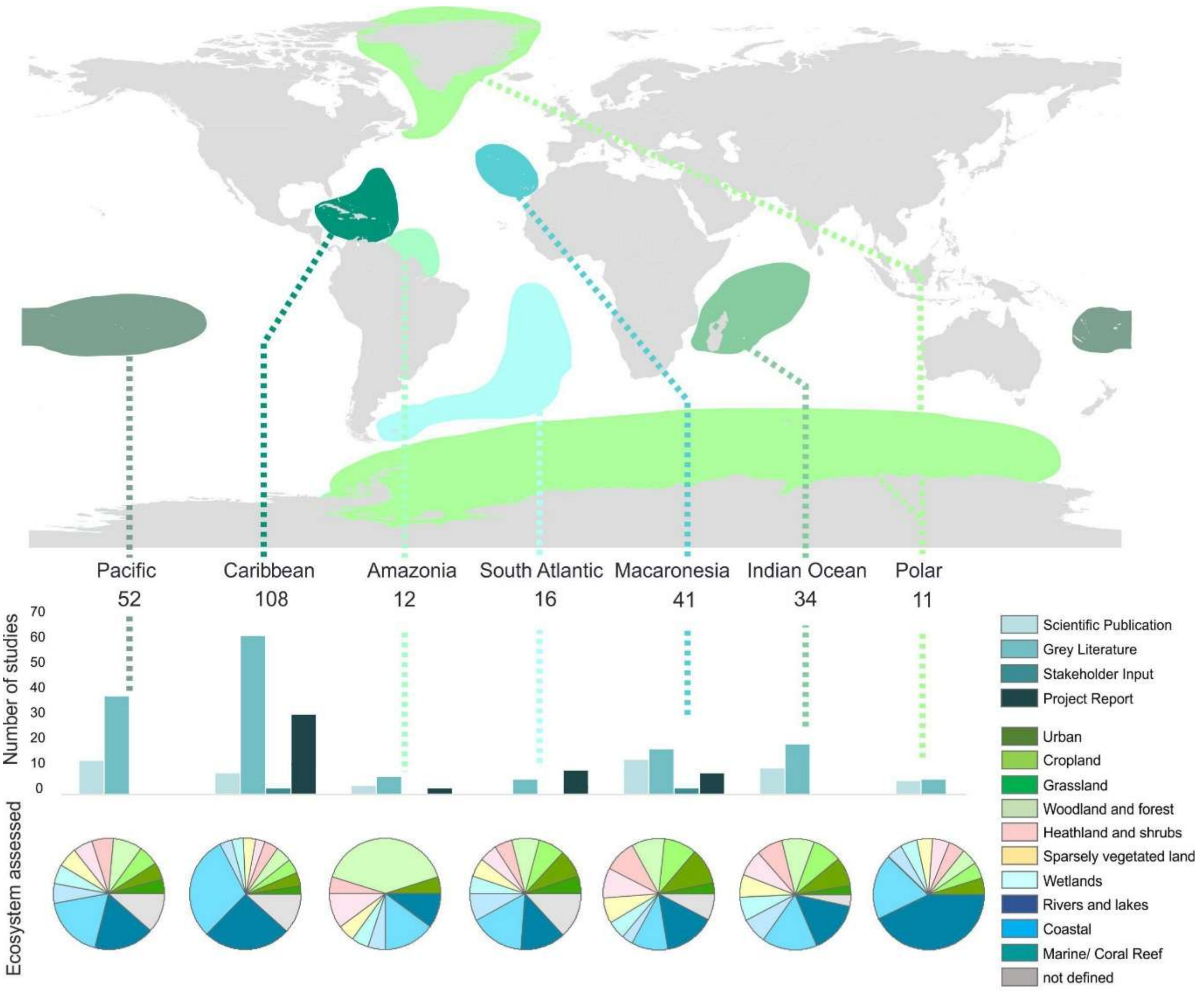


Fig. 8: regional overview of ORs and OCTs, number of studies and publications (publication types in the bar charts) as well as the ecosystem type mapped or assessed (colours in the bottom pie chart refer to ecosystem types assessed).

The majority of the studies and publication assesses coastal and marine ecosystems (115 and 114 respectively) (Fig. 8). Thereafter, forest ecosystems follow (53). 41 publications describe croplands. Urban areas (18 assessments) are the least well assessed in the ORs and OCTs. Many studies do not define the ecosystem type mapped or assessed (48).

In terms of the study type (biophysical, socio-cultural and/or economic assessments), the EU Overseas show a slightly skewed picture. Out of the 271 assessments, 40% apply biophysical methods, 13% entail socio-cultural assessments and 47% of all assessments monetize the value of ES based on economic assessment methods. Only a minority provides ecosystem services maps (<25%). There is no correlation between number of studies and distance to EU mainland, as Fig. 9.

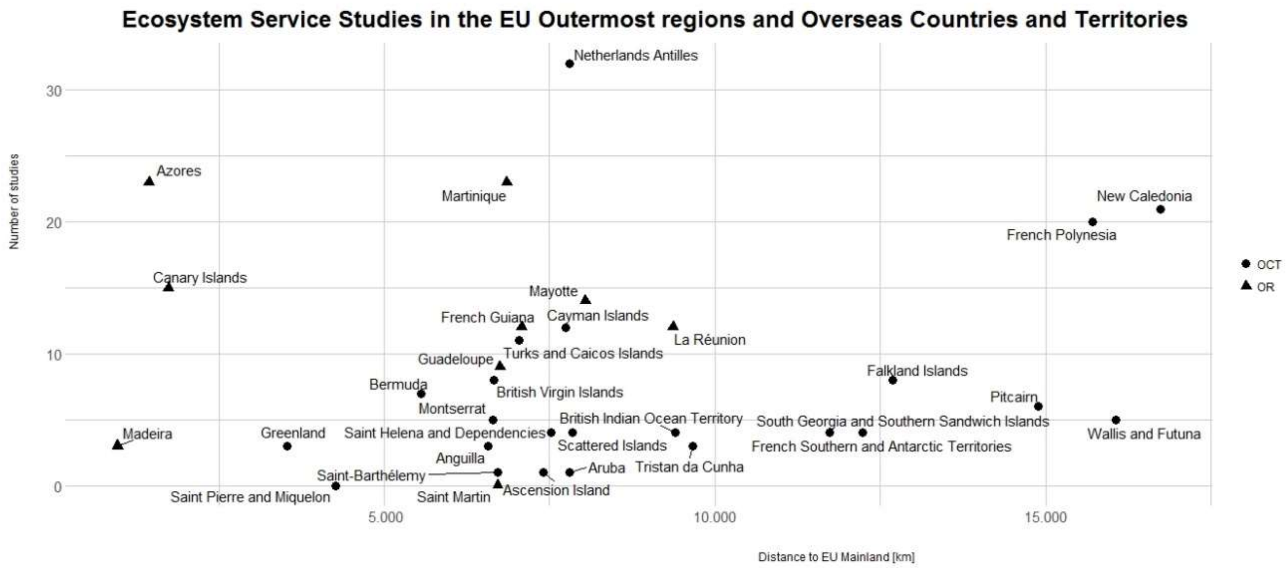
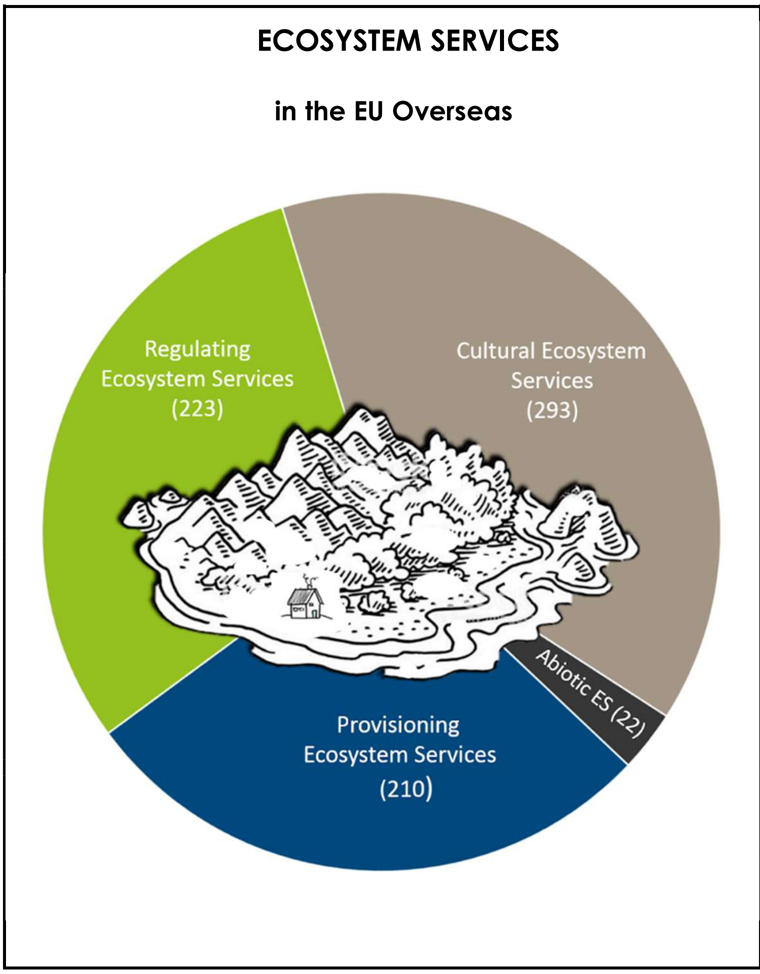


Fig. 9: number of publications on 'EU Overseas' ecosystem s and their services and its relation to distance from EU Mainland (based on the review of 271 studies and publications).



Provisioning
- wild animals and their outputs (60)
- Wild plants and their outputs (25)
- surface water for drinking (18) and non-drinking purposes (17)

Regulating
- Flood and storm protection (61)
- Global and regional climate regulation (31)
- filtration/sequestration/storage /accumulation by ecosystems (28)

Cultural
- physical use of land- and seascapes in different environmental settings (56)
- Entertainment (36)
- Existence (35)

Abiotic
- abiotic materials (minerals, non-minerals) (5)
- energy (renewable and non-renewable energy sources) (5)

Fig. 10: Provisioning, regulating, cultural and abiotic ES mentioned in the reviewed literature (271 publications), categorized after CICES.

For the EU Overseas, the 271 publications describe 748 ecosystem services. Of these, cultural ES are the most frequently mentioned (293). Physical use of land- and seascapes are most often assessed, mostly in the form of (eco-) tourism (Fig. 10). Thereafter, entertainment (fishing for non-commercial purposes) and existence follow. Regulating ES are second most mentioned (223). Flood and storm protection, global and regional climate regulation, often through of carbon storage and filtrating functions of ecosystems are important for the EU Overseas. In terms of provisioning ES (210), wild animals and their outputs (fish stocks), wild plants and their outputs (biomass, algae etc.) and surface water for drinking and non-drinking purposes are mentioned most frequently.

3.2. Results from individual regions

The ORs and OCTs groups represent seven biogeographical regions. In the following, these regions are described, introducing the biogeographic region, characterizing the current state-of-the art on MAES with examples of mapping applications and drawing upon knowledge gaps and regional opportunities for MAES.

3.2.1 Regional Results: Macaronesia

Biogeographic introduction

The Macaronesian biogeographical region is located close to continental Europe and composed of three volcanic archipelagos with multiple islands and islets: the Portuguese ORs of Azores and Madeira, and the Spanish Canary Islands. This region is renowned as one of the 35 biodiversity hotspots of the planet (EU BEST, 2016c). Their ecosystems have largely been undisturbed by glaciations and could thus maintain unique flora and fauna with high levels of endemism. One example is the endemic laurel forest on the Azores of which only 12.5 percent of its original area remains (Férnandez-Palacios et al., 2010).

Results from the literature review

Mapping and assessment of Macaronesian ecosystems and their services has been included in the National Ecosystem Assessments of Spain and Portugal. Many studies have focused on the ecosystems of the Azorean archipelago, the Canary Islands and Madeira (45 publications, Fig. 10). Especially the relation between Natural Parks, Natura 2020 sites and ecosystem services has been in the focus (Cruz et al., 2011; Kettunen et al., 2013; Fonseca et al., 2014; Bragagnolo et al., 2016).

A variety of ES studies were conducted in the nine islands of the Azorean Archipelago, applying different methods and ES classifications, including the CICES method. The 12 Biosphere Reserves and multiple Key Biodiversity Areas (KBA) have been studied. For example, Cruz et al. (2011) present a method to assess socio-economic benefits of Natura 2000 areas, based on a case study approach. Also, Kettunen & Ten Brink, (2013) published an assessment guide to investigate social and economic benefits of protected areas. Bragagnolo et al. (2016) assessed and mapped local conflicts related to protected areas in small islands. Out of the 23 studies, 70% focused on terrestrial ecosystems and their services. For example, Picanço et al., 2017 conducted a mapping and assessment study on pollinator abundance for Terceira Island ((Box 2). Vergílio et al. (2017) published a comprehensive assessment of ecosystem functions and structures and their implications for ecosystem services on Pico Island. A key finding of this work is that most ecosystem functions simultaneously occurred in Natural Parks or protected landscapes. Such an analysis of multi-functionality of islands can lead to better integration of community needs into planning and decision-making. The Autonomous Region of Azores entails more than 60 Marine Protected Areas (MPA's)[21]. The relation between MPAs and ecosystem services has been assessed in terms of hotspots of biodiversity and direct benefits, cultural preferences for conservation of protected areas and also their importance for tourism (Schmiing et al., 2014; Ressurreicao et al., 2012; 2013; Fonseca et al., 2014).

[21] http://mpas-portugal.org/azores/

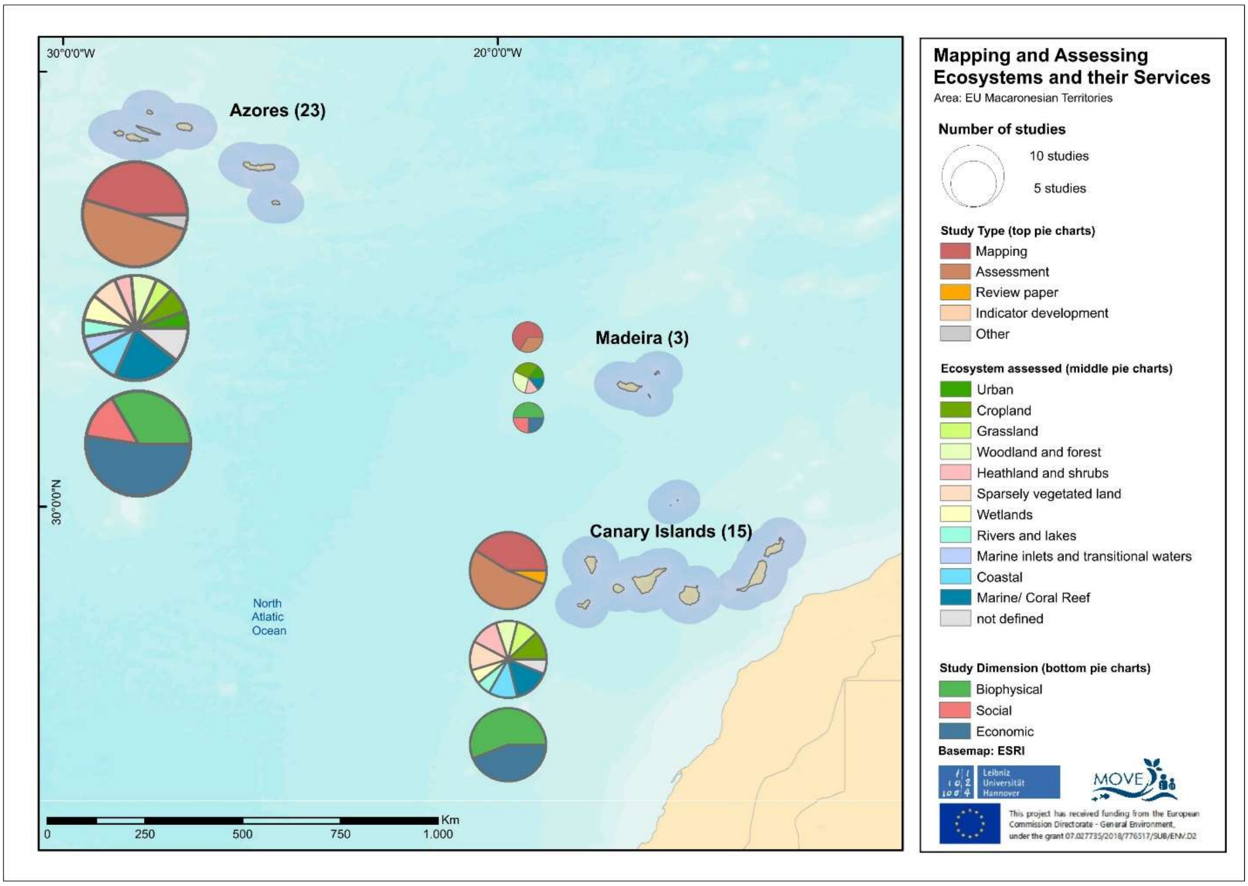


Fig. 11: Overview of publications for the Macaronesian region.

For the Canary Islands, a high number of studies focuses on ecosystem functions rather than on ecosystem services. Forest ecosystems have been assessed regarding forest fire, timber and fuel production on El Hierro Island (Alonso-Benito et al., 2008; 2016). Arévalo et al., 2012 assessed the forage quality of native flora on Lanzarote Island. The Islands were considered in multi-national and Europe-wide assessments, for example a Spanish study on national ES values (Quintas-Soriano et al., 2016), a study on spatial distribution of marine ES capacity in European Seas (Tempera et al., 2016) or a mapping study on global coastal recreation values (Ghermandi & Nunes, 2013). Similarly to the Azores, the Canaries ES have been assessed in the context of protected natural areas. Santos-Martín et al. (2019) provided a mapping study on marine ES in Natura 2000 Areas and Martín-García discussed the identification of conservation gaps and redesign of island marine protected areas (2015).

Madeira has only three ES-related assessments. Cruz et al. (2009) studied the impacts of climate change on terrestrial ecosystems, through modelling future scenarios for the forestry, agricultural hydrological sector as well as its impacts on biodiversity. Also, Madeira appears in a project report on the spatial distribution of marine ecosystem service capacity in the European seas (Tempera et al, 2016). Nunes et al. (2019) conducted an analysis of land use change scenarios impacts on ES in ecosystems under human influence altering land use patterns in Madeira between 1990- 2040.

Box 2: ES mapping example from the Azores

Pollinator abundance mapping for Terceira, Azores

Pollination is defined as the transfer of pollen grains from one to another plant stigma by wind or animals. Insect pollinators provide a vital input. This ecosystem service contributes to the maintenance of plant biological diversity and food production. Next to food production, pollination and the abundance of pollinator species is an essential part of biodiversity. Adequate pollination services can increase the production and quality of fruit and vegetable crops. However, pollinator abundance is currently challenged on many islands by the insect population decline, intensified land uses and expanding built-up areas. A study by Picanço et al. (2017) analysed the potential of Azorean island ecosystems for pollinator abundance - one example of a biophysical mapping method to assess ES (Fig. 12).

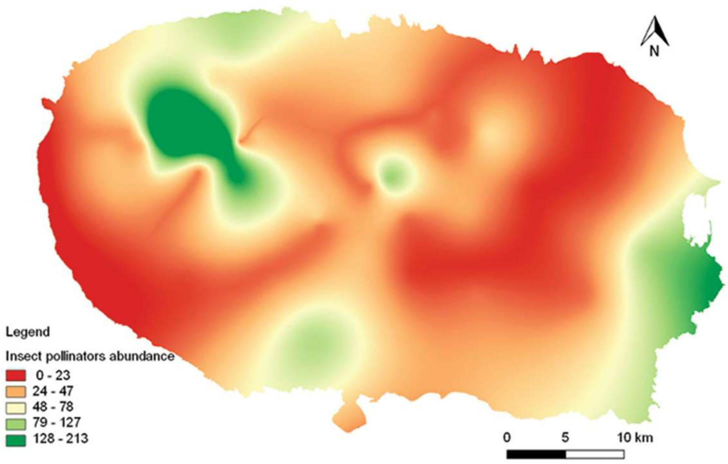


Fig. 12: Insect pollinator abundance on Terceira Island, Azores, modelled by Picanço et al. (2017).

3.2.2 Regional Results: Caribbean

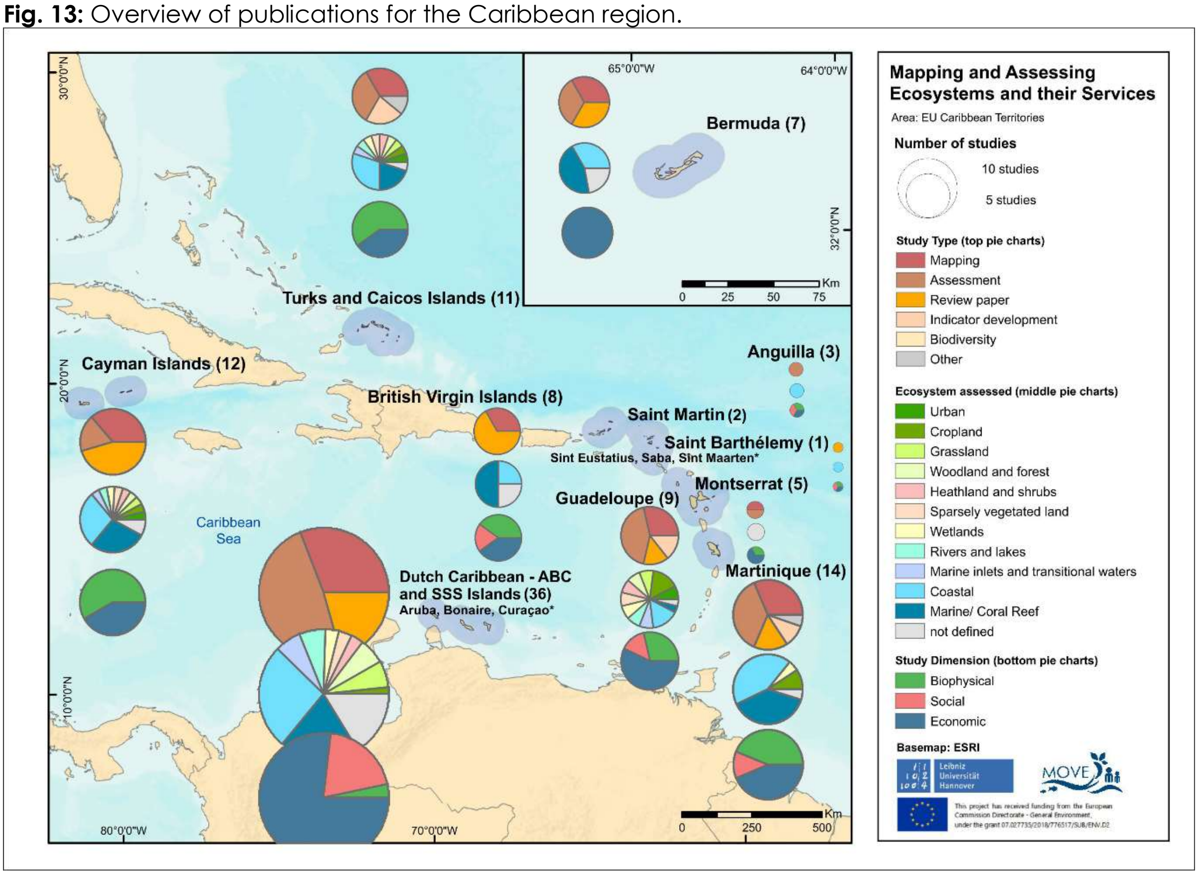
Biogeographic introduction

The Caribbean represents one of the biogeographic hotspot regions, comprising over 7,000 islands, islets, cays and reefs ranging in size from just 5 km² to over 100,000 km²(EU BEST, 2016b). The 16 Caribbean ORs and OCTs are located in the eastern Caribbean. The Turks and Caicos and Cayman Islands are located north of the Greater Antilles. . The French ORs Saint Martin, Guadeloupe and Martinique, the OCTs British Virgin Islands, Anguilla, Saint Barthélemy, Montserrat, and the Dutch Caribbean OCT Sint Maarten and ORs Saba and Sint Eustatius are part of the Lesser Antilles. The Dutch Caribbean OCTs Aruba and Curacao and OR Bonaire are found off the coast of Venezuela. Together, these islands cover 880 km² of land areas and span an Exclusive Economic Zone (EEZ) of 674,840 km² (EU BEST, 2016b). These islands are renowned for their ecosystems and habitats diversity, ranging from marine coral reefs, seagrass beds and mangroves, coastal sandy beaches, rocky shores and desert like shrubland to tropical, mountainous rainforests.

Results from the review

The Caribbean region is frontrunner with its 108 ES studies on ES (Fig. 13) with an average of 6 studies per island. ES research has increased in this region in the last decade, particularly the application of MAES has risen. Also, a broad range of economic valuation studies (Table 1) have been conducted, making economic ES valuation an important tool for support in planning and decision-making.

Fig. 13: Overview of publications for the Caribbean region.



The British Overseas Territories were part of a Natural Capital Assessment[22]. A gap analysis of economic valuation studies completed in the Caribbean UK OCTs has taken place, as well as various economic assessments (JNCC, 2018; eftec & JNCC, 2018; JNCC; 2019). One of their key findings is that "existing studies focus mainly on services provided by coral reefs and beaches. Other coastal ecosystems, such as mangroves and seagrass, have been rarely assessed, and terrestrial ecosystems are in general overlooked" (JNCC, 2016; p31). Therefore, the study called for more research and value mapping. Here, JNCC mentions that the "use of primary and spatially explicit data can increase the robustness of the results" (2016; p31).

For the three French ORs, systematic ES assessments were not found in the literature. For Guadeloupe, 9 studies or reports and for Martinique 14 studies and publications were found (Box 3), whereby most of them assess ES in terms of economic values (Maréchal & Trégarot, 2016a; 2016b; Maréchal, Trégarot & Meesters, 2016). Yet, without referring to the spatial dimension of ES supply and demand.

The Dutch Caribbean (36 studies) was intensively covered, dominated by economic assessment and valuation studies (76%). The majority of these studies has applied the TEEB methodology. Examples of such studies include fisheries values and coastal protection values on Bonaire ((Schep et al., 2012; van Zanten & van Beukering, 2012), the tourism value of nature on Aruba (van Zanten et al., 2018) or mapping studies on the economic value of ecosystems on Sint Eustatius (Tieskens et al., 2014).

Box 3: Exemplary ES study for the Caribbean

Tropical marine and coastal habitats on Martinique

A first ecosystem services assessment for tropical coastal marine habitats has been conducted for Martinique (Maréchal & Trégarot, 2016), qualifying and quantifying ES based on literature and field data. This assessment was conducted under the umbrella of CARIPES (Payments for Marine protected area ecosystem services in the Caribbean) and served as a starting point to assess possible PES funding schemes.

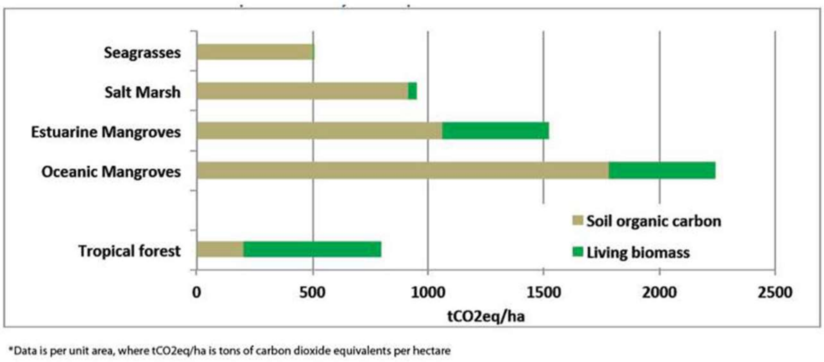


Fig. 14: coastal and marine ecosystem function to fixate atmospheric carbon (Maréchal & Trégarot, 2016, based on Murray et al., 2011).

Caribbean coastal ecosystems

Coastal and marine ecosystems are of utmost importance - > 50% of all reviewed Caribbean studies. Coastal protection service is an important function. Due to island specificities such as small size and location, most Caribbean ORs and OCTS are densely populated. The coastal

[22] Natural Capital in the Caribbean and South Atlantic Overseas Territories: Valuation, Vulnerability and Monitoring Change (http://jncc.defra.gov.uk/page-7443)

zones reach population densities up to 1196 inhabitants per km² [23]. For these coastal zones, tropical storms and hurricanes are major threats (Pérez-Maqueo et al., 2007). Ecosystems have proven to contribute to coastal protection through the moderation of extreme events. Healthy coral reefs, seagrass meadows and mangroves significantly dissipate wave forces, stabilize soils and enhance sedimentation processes. Hence, they reduce the effects of hurricanes and their storm surges on coastlines. With deteriorating state, continuing coastal squeeze and increased frequency of extreme events, healthy ecosystems are more important than ever before (Schleupner et al., 2008). For this reason, the ES concept is applied to assess flood and storm protection functions of Caribbean ecosystems (Teeb, 2009).

Different studies assess the contribution of Caribbean seagrass ecosystems to food security (Harborne et al., 2008; Baker et al., 2015). They provide important habitats for fish nurseries, contributing to the fisheries sector both for local subsistence and for commercial fisheries to support the growing tourism industry on the islands. The example of Turks and Caicos shows that these ecosystems are especially endangered through clearance of seagrass meadows near shorelines to meet the idyllic image of the Caribbean with its endless, clear white beaches (Baker et al., 2015.)

Mangrove ecosystems similarly contribute ES such as nurseries and coastal protection. Whilst the image of mangroves has historically been negatively connoted, a study in Martinique and Guadeloupe shows that sustainable tourism and awareness on the importance of mangroves and their services can contribute to the maintenance of healthy mangrove ecosystems (Avau et al., 2011).

Coral reef ecosystems and their services have received special attention. An overview of economic value of these services has been published as part of a TEEB study (Box 4). Specifically for the Caribbean, flood and storm protection functions have been studied (Table 2). For example, the capacity of coral reefs to dissipate wave power, based on their health status, has been estimated to reach 75-85% in the Virgin Islands (Thornton and Guza (1982) in Pascal et al., 2016). For Bonaire, wave dissipation was estimated to have an annual economic value of $33 000 - $70 000 US Dollar (USD) (Van Zanten & Beukering, 2012). With rising population numbers, coastal protection services were estimated up to $265.9 million USD Yr^{-1} in Bermuda (Sarkis et al., 2010) (Table 2). In the Caribbean, healthy coral reefs are a precondition for tourism, including the scuba diving industry. Studies found that 80% of their interviewees would not return to the island of Bonaire, if the coral reefs were to deteriorate or erosion would affect beaches (Uyarra et al., 2005).

Box 4: Benefits from ecosystem services in coral reef ecosystems.

Table 1: Benefits from ecosystem services in coral reef ecosystems (TEEB 2009). Estimates are based on an ongoing analysis for The Economics of Ecosystems and Biodiversity (TEEB) project. Table for illustrative purposes only (in Gravestock and Sheppard (2015).

Ecosystem service	Value (US$ ha^{-1} yr^{-1}, 2007 values) Average	Maximum	No. of studies
Provisioning services			
Food	470	3818	22
Raw materials	400	1990	5
Ornamental resources	264	347	3
Regulating services			
Climate regulation	648	648	3
Moderation of extreme events	25 200	34 408	9
Waste treatment/water purification	42	81	2
Biological control	4	7	2
Cultural services			
Aesthetic information/amenity	7425	27 484	4
Opportunities for recreation and tourism	79 099	1 063 946	29
Information for cognitive development	2154	6461	4
Supporting services			
Maintenance of genetic diversity	13 541	57 133	7
Total	**129 245**	**1 196 323**	**90**

[23] https://www.cia.gov/library/publications/the-world-factbook/geos/bd.html

Table 2: Examples of ES provided by coastal ecosystems for the Caribbean ORs and OCTs, as classified by CICES.

Ecosystem type	Ecosystem service	Variable	Unit/value	Method	OR&OCT	Source
Coastal	Wild animals and their outputs	Fisheries	$4.8 million USD Yr^{-1}	TEV	Bermuda	Sarkis et al., (2010)
	Flood protection/ storm protection	Ecosystem value	0.95	Ecosystem Service Product (ESP)	Bermuda, Cayman Islands	Pérez-Maqueo et al., (2007)
	Flood protection/ storm protection	Coastal protection of coral reefs	$265.9 million USD Yr^{-1}	TEV	Bermuda	Sarkis et al., (2010)
	Flood protection/ storm protection	Ecosystem value	0.87	ESP	Martinique, Guadeloupe	Pérez-Maqueo et al., (2007)
	Flood protection/ storm protection	wave dissipation	75-85%	field measure-ment	British Virgin Islands	Thornton and Guza (1982) in Pascal et al (2016)
	Flood protection/ storm protection	wave dissipation	$33,000 - $70,000 USD Yr^{-1}	model	Bonaire	Van Zanten & Beukering (2012)
	Physical/ experiential use of nature/Cultural	Recreation and Cultural	$36.5 million USD Yr^{-1}	TEV	Bermuda	Sarkis et al., (2010)
	Physical/ experiential use of nature	Tourism	$405.9 million USD	TEV	Bermuda	Sarkis et al. (2010), Van Beukering et al (2015)
	Existence/ Bequest	Amenity	$6.8 million USD Yr^{-1}	TEV	Bermuda	Sarkis et al., (2010)

3.2.3 Regional Results: Amazonia

Biogeographic introduction

The Amazonian Overseas Territory French Guiana is situated on the Guiana Shelf on the South American continent, bordering Suriname and Brazil. This territory covers 83 500 km², of which roughly 83% is protected Amazon Rainforest. A majority of this dense forest is still in primary condition (Petit and Prudent, 2008, EU BEST 2016a). Savannas, wetlands and mangrove ecosystems are present in the littoral belt. This area is highly inhabited and marked by anthropogenic influences: urban settlements, intensive and traditional agriculture as well as animal husbandry. Human activities pose a major threat to the pristine ecosystems: the forest is cut on a large scale for artisanal and industrial gold mining activities (and illegal mining), causing river and water pollution through the outwash of heavy metals, e.g. mercury (Régine et al., 2006).

Results from the review

The MAES process is still under development in this region. Though the country has a broad knowledge of its forests, it only shows a small, but a rising number of studies applying the ES concept (Fig. 14). Because of French Guiana's large tropical forest cover (>90%), the focus is on terrestrial ES. Studies range from provisioning services of timber production, Above Ground Biomass (AGB) estimations to complex carbon models (Jaziri, 2007; Rossi et al., 2015; Guitet et al., 2015). The most intensively assessed ES is carbon sequestration of ecosystems and global and local climate regulation through carbon storage (see Box 5).

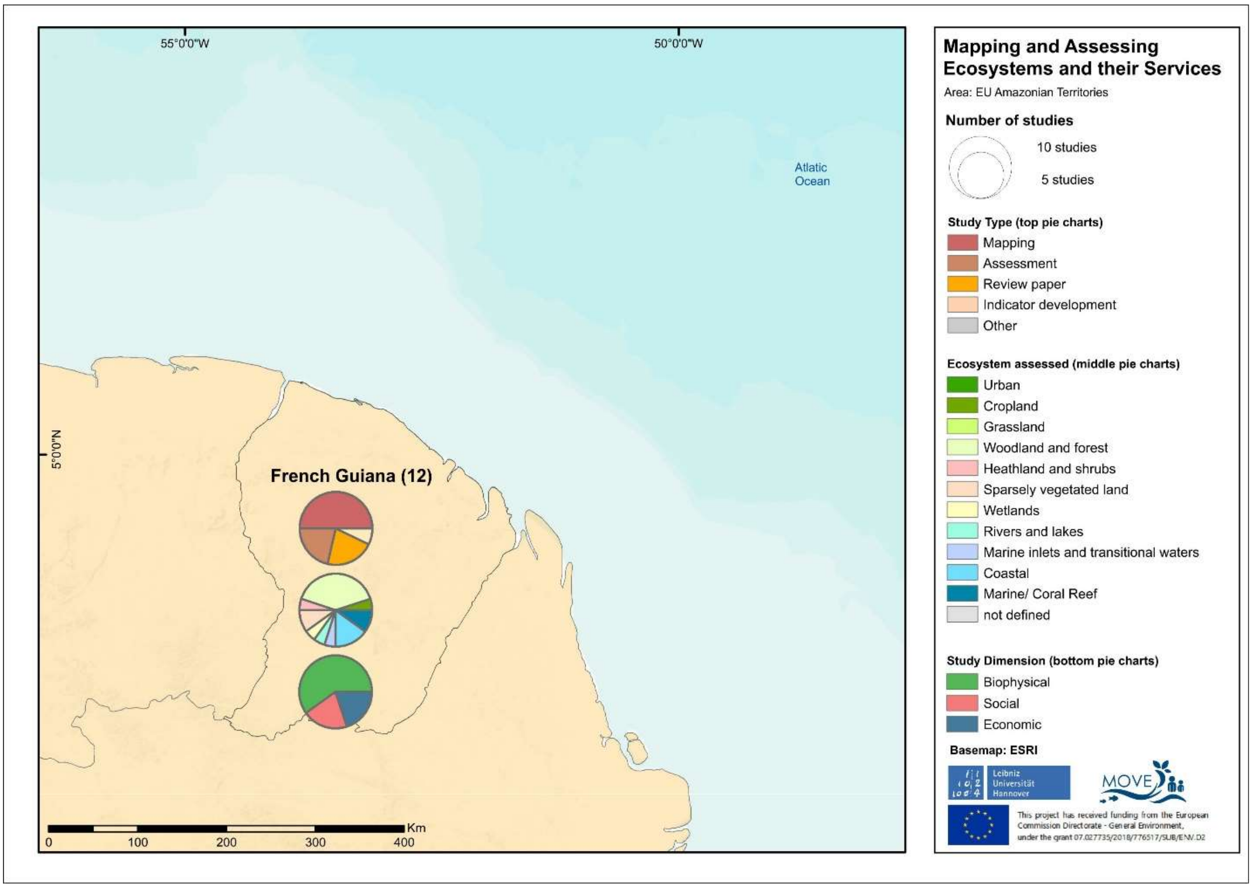


Fig. 15: Overview of publications for the Amazonian region.

Only three studies touched upon cultural aspects of ES, e.g. forest ES in the territory (Scott et al., 1999). Besides forest ecosystems, mangroves and coastal ecosystems are the second most studied. Specifically, mangrove cover, beaches and their habitat functions for sea turtles and the ES provided by turtles have been assessed (Teelucksingh et al., 2010),.mangrove cover, beaches and their habitat functions for sea turtles and the ES provided by turtles have been assessed (Teelucksingh et al., 2010).

Box 5: Exemplary ES mapping study in the Guianas.

Carbon storage of tropical French Guiana rainforests

With over 90% forest cover, French Guiana has the largest forest area of all EU Overseas Territories. Mapping forest aboveground biomass (AGB) has gained importance, particularly for reporting carbon stocks and changes. Fayad et al. (2016) present one of the few mapping studies for the OR (Fig. 14). They developed a model to estimate AGB and ES of forests to store carbon and mitigate global climate change. Their study is based on remote sensing and field data and estimates the total carbon stocks in French Guiana to be 1 323 010 kt C according to the modelled AGB map.

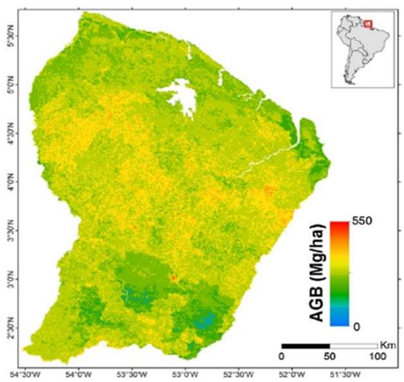


Fig 16: AGB for French Guiana – Fayad et al. (2016)

3.2.4 Regional Results: South Atlantic

Biogeographical Introduction

The UK Overseas Territories of the Falkland Islands, the Islands of Saint Helena, Tristan da Cunha and Ascension Island are located in the Southern Atlantic region, situated approximately 600 km off the south-eastern coast of South America. Though most of the South Atlantic islands are sparsely inhabited, their ecosystems are of global importance. They span a wide range of climatic systems and include different ecosystem types[24], with a high level of endemism. These ecosystems are characterized by sub-tropical to cool oceanic climates with strong winds and comprise rugged, basalt coastlines, green plateaus and mountainous forest, unique, undisturbed nesting sites for turtles and seabirds and marine areas with nursery grounds for many fish species of commercial importance (EU BEST, 2016d).

Results from the literature review

ES studies and Natural Capital assessments are increasing in this region (Fig. 17). With only 16 studies, however, it is one of the least studied EU Overseas region in terms of ES.

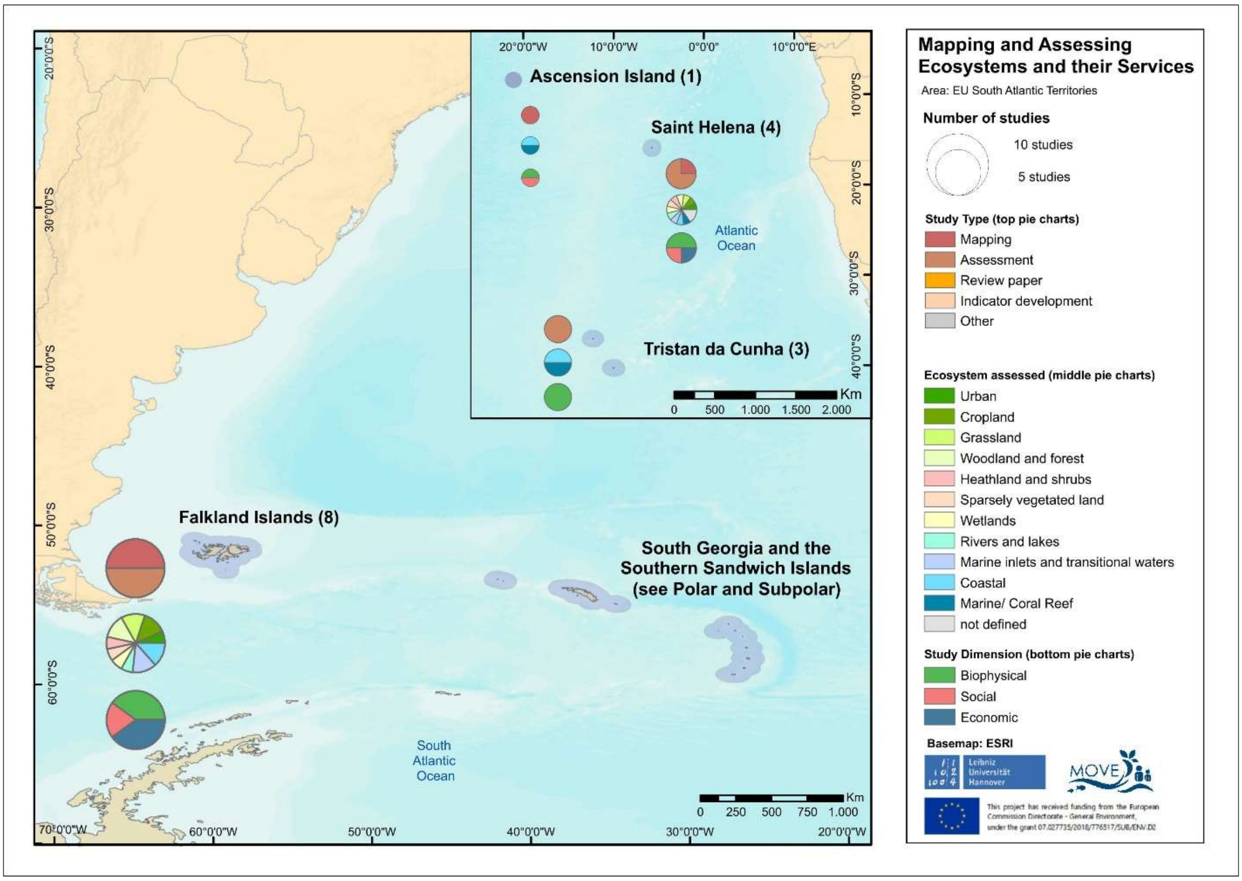


Fig. 17: Overview of publications for the South Atlantic region.

Eight studies have been conducted in in the Falkland Islands. Upson et al. (2016) studied the ecosystems of the Falkland Islands and their services under changing climate effects. Blake et

[24] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/best-ecosystem_profile_south_atlantic_2016.pdf

al., 2017 used participatory mapping to elicit cultural coastal values for Marine Spatial Planning, the only mapping study for the region (Box 6). Natural Capital Assessments for the Falklands cover the value of land-based tourism (SAERI, 2018).

Eight studies cover ES in the UK Overseas Territories of Saint Helena, Ascension and Tristan da Cunha. A first ecosystem services identification has been conducted for St. Helena. In their report, Rees et al. highlight 18 marine ES/benefits, their 'significance' to local stakeholders and the level of 'sensitivity' of the identified ES to future changes (2016), based on a stakeholder workshop. In addition, a Natural Capital Assessment has been conducted for the island (SAERI, 2018).

For Ascension Island, a national Natural Capital Accounting was carried out, identifying the link between ES and coastal and deep-sea ecosystems. This work was based on an extensive literature review as well as a first ES matrix application (Box 7), connecting ES and the EUNIS Deep-sea bed habitat classification[25] (La Bianca et al., 2018).

3 ES studies were obtained for Tristan da Cunha in the review. This most remote island provides unique and pristine, untouched marine ecosystems. A first Ecosystem Assessment has been conducted (Caselle et al., 2017), focusing on marine and coastal ecosystems and the provision on wild animals and their outputs. Fish biomass is estimated to be 1.5 - 2.5 tons ha^{-1} and fish density calculated to be 130 - 200 no. m^2. Next to this, Natural Capital Assessments cover tourism and waste management on the island (Acorn Tourism et al., 2019; Smith, 2019).

Box 6: Exemplary ES mapping study in the South Atlantic region.

Cultural coastal values for marine spatial planning through participatory approaches

Marine Spatial Planning (MSP) is gaining importance world-wide as a holistic approach to marine management. A precondition for effective MSP is the inclusion of socio-economic factors in this process. A case study on the Falkland Islands (Blake et al., 2017) has mapped different values for the Falklands' coastlines (Fig. 18). This study applied in-person interviews and Public Participation GIS (PPGIS) techniques to assess ES of natural beauty, sense of place, recreational value and cultural historical values, based on a stakeholder approach.

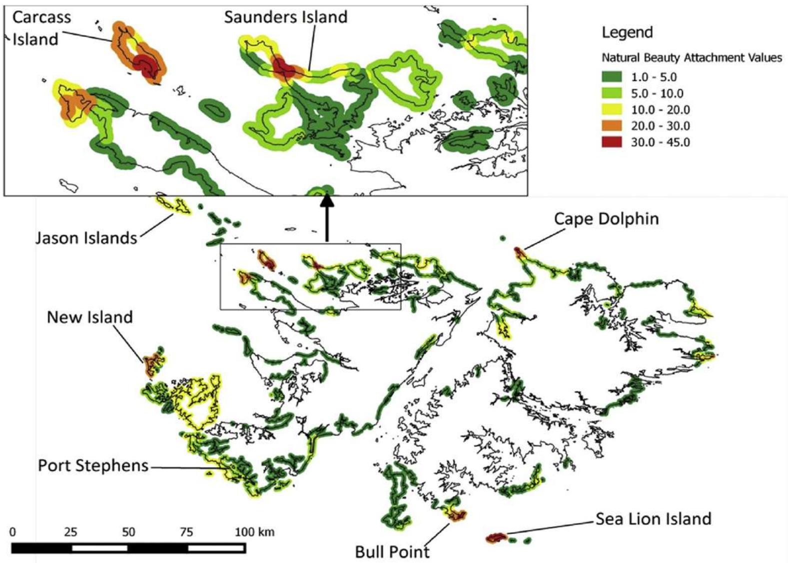


Fig. 18: Participatory mapping of natural beauty values (in British Pound) for the north-Western Falkland Islands (Blake et al., 2017).

[25] https://eunis.eea.europa.eu/habitats/421

Box 7: Exemplary ES assessment study in the South Atlantic region.

South Atlantic Deep-Sea Habitat Assessment

Ascension Island's marine and deep-sea habitats have been assessed under the Natural Capital Assessment. The presence and extent of deep-sea habitats and key species has been identified by La Bianca et al. (2008), linking EUNIS habitat classes[26] and the services they provide (Fig. 19). They conclude that all present habitats support the formation of species habitats, contributing to supporting (intermediate) ecosystem services. Final ecosystem services of deep-sea habitats were estimated to contribute marginally, e.g. to the water cycling service, algae and seaweed or ornamental materials. Cultural services are associated with deep-sea habitats through the potential to support research and education and public engagement activities. The biggest influences on these deep-sea habitats were estimated to be fishing activities through human activities and climate change, altering sea temperatures, which in turn affects ES provision of these ecosystems.

	Intermediate Services											Final Ecosystem Services										
	Supporting services							Regulating				Provisioning					Regulating			Cultural		
EUNIS code 2007	Primary production	Larval/Gamete supply	Nutrient cycling	Water cycling	Formation of species habitats	Formation of physical barriers	Formation of seascape	Biological control	Natural hazard regulation	Regulation of water & sediment quality	Carbon sequestration	Fish and shellfish	Algae and seaweed	Ornamental materials	Genetic resources	Water supply	Climate regulation	Natural hazard protection	Clean water and sediments	Tourism/Nature watching	Aesthetic benefits	Education
A6.11 Deep-sea bedrock	3	2	3		3	3	1			1	1				1				1	1	1	1
A6.14 Boulders on the deep-sea bed	3	2	3		3	3	1			1	2				1				1	1	1	1
A6.2 Deep-sea mixed substrata	3	2	3		3	3	1			1	2				1				1	1	1	1
A6.22 Deep-sea biogenic gravels (shells, coral debris)	3	2	3		3	3	1			1	1				1				1	1	1	1
A6.3 Deep-sea sand	3	3	3		3	3	1			1	1	3			1				1	1	1	1
A6.4 Deep-sea muddy sand	3	3	3		3	3	1			1	1	3			1				1	1	1	1
A6.5 Deep-sea mud	3	3	3		3	3	1			1	1	3			1				1	1	1	1
A6.52 Communities of abyssal muds	3	3	3		3	3	1			1	1	3			1				1	1	1	1
A6.6 Deep-sea bioherms	3	3	3		3	3	1			2	1	2					3		2	1	1	1
A6.61 Communities …	3	3	3		3	3	[illegible]			2	1	2					3		2	[illegible]	[illegible]	[illegible]

Fig. 19: Example of a Matrix application, linking deep sea ecosystems and the services they provide (La Bianca et al., 2018).

[26] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification

3.2.5 Regional Results: Indian Ocean

Biogeographic Introduction

The Indian Ocean entails four Overseas Territories: the two French ORs Mayotte and La Réunion and the French Scattered Islands with its five islands and multiple islets, without permanent populations. The British Indian Ocean Territory with its seven atolls and over 1000 islets is located halfway between Tanzania and Indonesia, geographically known as Chagos archipelago (EU BEST, 2017a). A military base is the only human influence impacting the natural environment in this region. The ecosystems range from volcanic mountains of 3000 m elevation (La Réunion), semi-dry and humid forests, and rocky shores. Over 4800 km^2 of coral reefs spread over multiple atolls and islets, seamounts and deep-sea habitats. Flora and fauna are diverse: high numbers of endemic and many endangered species live in this region. Ecosystems are prone to anthropogenic impacts such as urbanization, agriculture, overfishing, poaching and pollution, but are also susceptible to consequences of global climate change (rising sea levels and increasing sea temperatures, acidification, extreme weather events)[27].

Results from the literature review

The MAES methodology has not yet been applied in the BIOT region. Though there are studies on ecosystem services, most of them describe ecosystem functions and processes. However, various valuation studies have been conducted, applying the Total Economic Value (TEV) framework (Fig. 19). Ecosystem service maps are still scarce in this region.

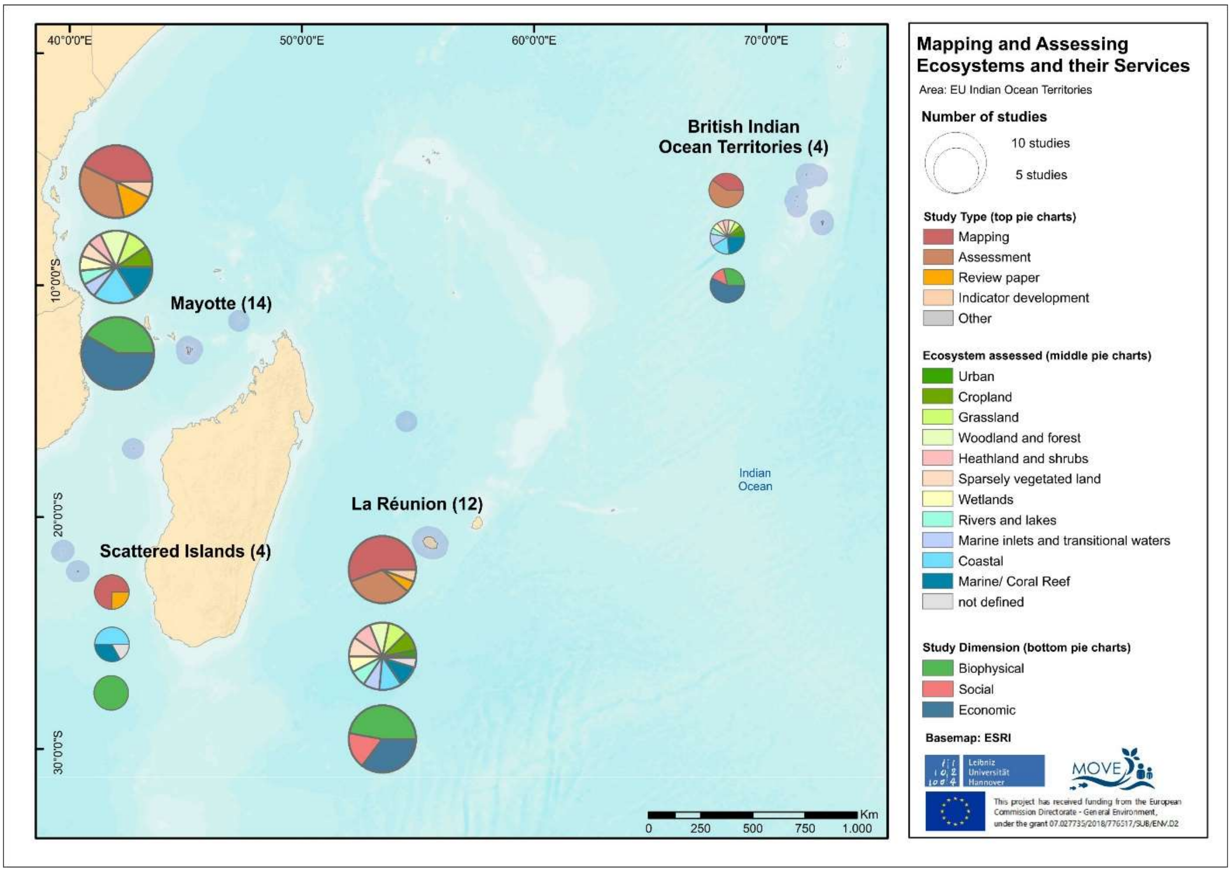


Fig. 20: Overview of ES publications for the Indian Ocean region.

[27] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/best-profil_d-ecosysteme_ocean_indien_2016.pdf

The OR Mayotte provides detailed studies following the TEV method, assessing ES provided by coral reefs, seagrass and mangroves. The coastal protection value for Mayotte and the whole Western Indian Ocean was estimated to be $3370 USD Ha^{-1} Yr^{-1} (Hicks, 2011). Trégarot et al. (2017) provide an economic estimation of coastal protection, carbon sequestration and water purification, including ecosystem condition in the assessment (Trégarot et al., 2017; Box 8). Trégarot et al. specify the values for coral reefs and their associated ecosystems (mangroves €4.2 million Yr^{-1}; seagrass € 2.7 million Yr^{-1}) (2017).

For the Scattered Islands, remote sensing and spatial modelling studies exist for coastal and coral ecosystem structures (Andréfouët, 2014; Collin et al., 2014). Also, marine plankton communities of the region and their relation to ES have been studied (Bouvy et al., 2016; Dupuy et al., 2016).

The OR La Réunion shows a variety of both terrestrial and coastal/marine ES assessments. Due to its size and population density, numerous studies also covered terrestrial ES, including cultural ES assessments. Participatory stakeholder modelling was applied to promote integrating conservation with land-use planning (Box 9) (Lagabrielle et al., 2010). On species level, an assessment of mosquito distribution has been conducted, touching upon the ecosystem disservice as a disease vector (Beilhe et al., 2013). In the coastal zone, regular coral reef monitoring is done, using remote sensing technologies (Scopélitis et al., 2009; Mustapha et al., 2014).

Box 8: Exemplary ES mapping study for the Indian Ocean region.

Scenario mapping on La Réunion

The OR La Réunion has applied first mapping studies to integrate biodiversity conservation into land use planning and to facilitate the incorporation of ecological knowledge into public decision making for spatial planning (Lagabrielle et al., 2016). Together with stakeholders and researchers, participatory modelling sessions were held to assess the influence of rapid land use changes and intensification on biodiversity (Fig. 20). In all explored scenarios, urbanization led to shifting agricultural patterns to marginal areas, displacing pristine upland ecosystems.
The study concludes that promoting the participatory development of land-use simulation models can help to explore alternative scenarios for biodiversity conservation with stakeholders, especially in situations with conflicting land-use.

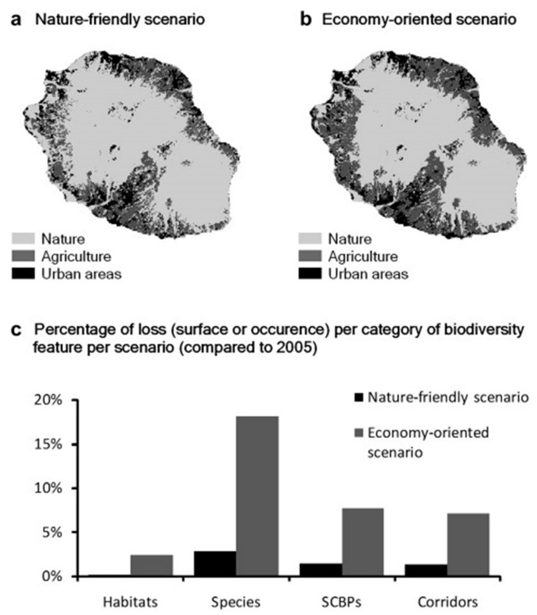


Fig. 21: Scenario Mapping for planning (Lagabrielle et al., 2016).

For the BIOTs without permanent inhabitants, coastal and marine ES dominated: a local ecosystem valuation of the archipelago (Gravestock et al., 2015), one modelling study on reef fish biomass (McClanahan et al., 2016) and a study on effects on sea cucumber abundance and illegal harvesting (Price et al., 2010) were found.

Box 9: Exemplary ES assessment study for the Indian Ocean region.

Monetary valuation of coral reef and associated ecosystems in Mayotte

Based on spatially explicit data, Trégarot et al. (2017) assessed the economic values of reefs, mangroves and seagrass meadows for the Island of Mayotte. Based on monetary valuation techniques (indirect use values), provisioning and regulating coastal and marine ES were assessed: coastal protection values, water treatment, carbon sequestration and fish biomass production are valued based on maximum unit values (Fig. 22). According to their estimations, the annual monetary value for these ES amounts 124 million EUR. The study remarks that quantity and quality of these services have been decreasing steadily for years, a continuing negative trend if no action is taken to counteract anthropogenic pressures. The article concludes that the protection of coastal ecosystems is important also from an economic perspective.

Fig. 22: Geographical distribution of coral reefs and associated ecosystems of Mayotte and their services – Trégarot et al. (2017)[28].

Table 3: Monetary values of coral reef associated ecosystems (CRAE) for Mayotte (Trégarot et al, 2017).

Ecosystem services	Length (km)	Area (km^2)	Max Unit value	Monetary value (€/year)
Coastal Protection				
Outer barrier reef	210	266	222,518 €/km	45,089,035
Optional values				
Inner barrier	18	30	222,518 €/km	3,816,249
Fringing reefs	195	47	222,518 €/km	40,861,390
Mangroves	-	8.46	695,200 €/km^2	4,154,515
Seagrass	42	7.6	89,007 €/km	2,684,095
Water treatment				
Coral reefs		342	7752 €/km^2/year	> 2,651,184
Mangroves		8.46	271,008 €/km^2/year	1,619,544
Seagrass		7.6	1,732,255 €/km^2/year	9,452,569
Carbon sequestration[a]				
Coral reefs		342	-	-
Mangroves		8.46	22,442 €/km^2/year	134,113
Seagrass		7.6	2662 €/km^2/year	14,527

Whilst assessments of the individual EU Indian Ocean Territories were little, many economic studies covered the entire region. These studies identified the contribution of the Indian Ocean to fisheries to be between £1.2 million Yr^{-1} and \$2.3 USD Ha^{-1} Yr^{-1} (Gravestock and Sheppard, 2015; Hicks, 2011). The supporting function of ecosystems to fisheries was estimated to have an additional value of £750 million Yr^{-1} (Hicks, 2011).

[28] Modified from Gigou et al. (2009) Copyright 2017 by Agence des Aires Marines Protégées.

3.2.6 Regional Results: Pacific

Biogeographic introduction to the region

Four French and British Associated Territories are located in the Pacific Ocean. The French OCTs Wallis and Futuna, French Polynesia and New Caledonia as well as The British OCT Pitcairn, declared UNESCO World Heritage[29], are located here. Pitcairn has a total population of 50 inhabitants, making it the world's smallest political entity in terms of population number[30]. The five French Polynesian island groups stand out due to their remoteness from any continent. In turn, the islands host pristine and well-studied coral reefs (Gabrié and Bossanyi-Johnson, 1998). Together, the Pacific OCTs entail various ecosystems: from coral reefs, mangroves and tropical dry and humid forests (>57% endemism (Murienne et al, 2009)), seagrass beds, ultramafic ecosystems, mountainous forest and a total of about 4500 endemic species[31]. Many of the islands' ecosystems are under threat - reasons for this are plentiful: extensive land use, mining (e.g. Nickel mining on New Caledonia), fishing, tourism and the introduction of alien invasive species as well as climatic changes, leading to sea level rise and increasing ocean temperatures.

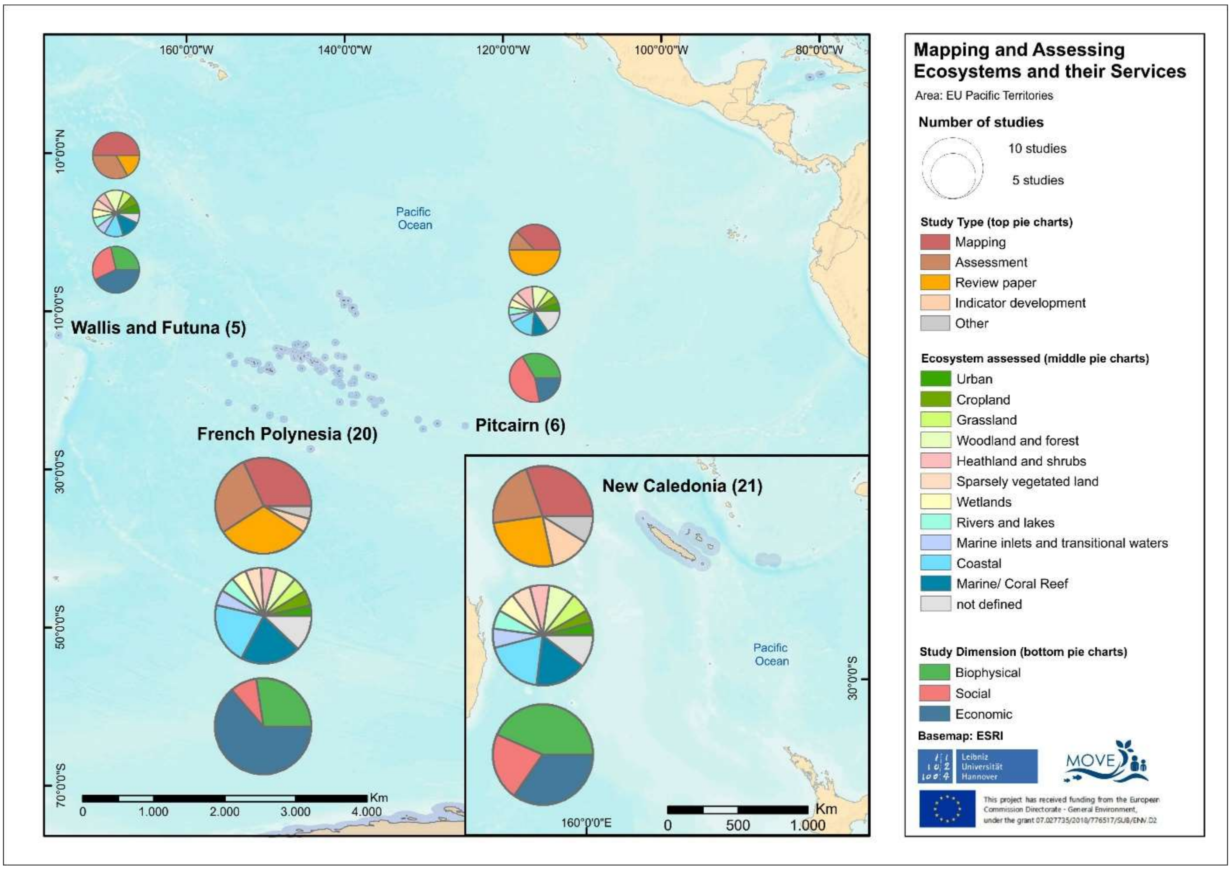


Fig. 23: Overview of publications for the Pacific region.

[29] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/best-ecosystem_profile_pitcairn_2016.pdf
[30] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/hubfactsheet-pacific.pdf
[31] http://ec.europa.eu/environment/nature/biodiversity/best/pdf/hubfactsheet-pacific.pdf

Results from the literature review

The Pacific region provides good examples of ES studies and their application into decision making. A large proportion of the studies are reviews, thus taking their information from existing literature (40%) (Fig. 22). 40% of the studies can be classified as mapping study, with even less publications containing maps for planners and decision-makers. Considering the small size of the islands and islets in this region, there is a balanced focus on terrestrial and coastal or marine ES (~50%).

20 ES related studies were conducted in French Polynesia, of which 60% applied economic valuation methods. One of the best examples for the application of socio-cultural mapping methods is a PGIS method for Moorea Island, mapping fisheries efforts (Box 10). Socio-Economic Benefits of the EU Marine Protected Areas, including ecosystem services, have been assessed (Russi et al, 2016). Leenhard et al. (2015) referred to the existence of iconic species within MPA's and their contribution to increased recreation/tourism value of tropical and temperate reefs, referring to the study on sickle fin lemon sharks (Clua, 2011).

The number of local studies and detailed ES maps for Wallis and Futuna is low (5 studies). Only ES assessments on global or multinational scale were obtained in our review. Thackway (2015) mentioned the islands of Wallis and Futuna in his report on protective functions and ecosystem services of global forests. Also, the territory was mentioned in a first outlook for future of ecosystem services in Asia and the Pacific (Kubiszewski et al., 2016).

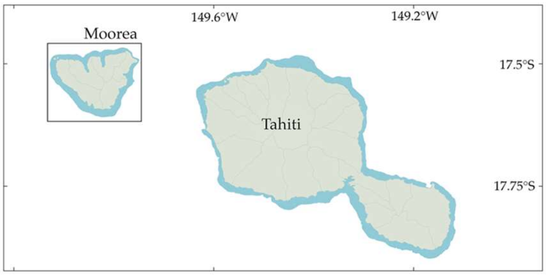
Though the ecosystems of New Caledonia have been studied intensively, only 23 publications describe ecosystems and their services. The OCTs show a high number of terrestrial ES assessments: for example, Fernando et al. (2008) describe the terrestrial ecosystem capacity to remediate manganese pollution. Also, terrestrial invasive species seem to be a problem on the islands: e.g. for New Caledonia, Thibault et al. (2017) describe the threats of invasive rodents for biodiversity.

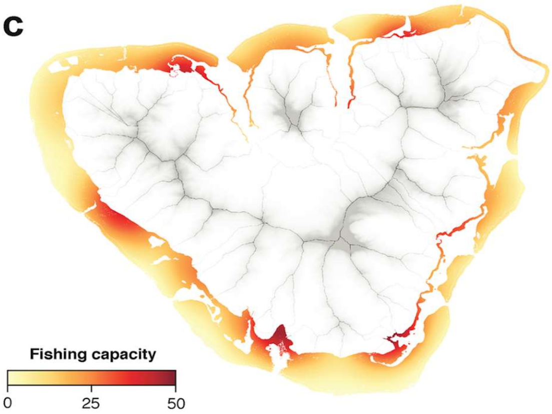
Many studies cover coastal and marine ecosystems. Graham & Nash (2013) described the structural complexity of coral reefs, referring to habitats and maintaining nursery functions. Economic valuation of coral ecosystems can be found (Laurans et al. 2013; Marre, 2015). The contributions of coral reefs to coastal protection is valued at roughly \$ 42 million yr^{-1} (Pascal 2010). Ferrario et al. (2014) describe the effectiveness of coral reefs, thus flood and storm protection services, for coastal hazard risk reduction. Also, the non-market use and non-use values for coral reefs have been assessed (Marre, 2015). Special attention was paid to the ES concept application to inform decision making in fisheries. The base for this builds on the work of Pascal (2010), valuing the ES fisheries, tourism, science and education, nutrient cycling, carbon storage and plants for medical use. However, the spatial and temporal dimension of ES provision is not discussed. Building on this work, habitat scenarios were developed, based on which sustainable fish stock exploitation was proposed (5 ton km^2 Yr^{-1}) (Deas et al., 2014).
Socio-cultural aspects of ES have been analyzed: for example, governance of coral reefs has been studied. As the coral reefs around New Caledonia are fragile ecosystems, protection strategies between neighboring Australia and the French Overseas Territories were compared (Caillaud et al., 2011). Littaye et al. (2016) applied social mapping methods, presenting the added value of stakeholder collective ES assessments for the Pacific region.

Box 10: Exemplary ES mapping study for the Pacific region.

Participatory mapping fisheries efforts in Moorea, French Polynesia

A study by Thiault et al (2017) presents an approach to map the spatial allocation of fish stocks and fishing efforts for Moorea Island, French Polynesia. Their study highlights that predicting fishing efforts is not a straightforward process: fishing efforts were not simply located in front of, or close to, main fishing villages with high dependence on marine resources, but rather complex. Thiault et al. (2017) argue that spatial knowledge is needed on fishing efforts.





Combining participatory mapping approaches (fishers' spatial preference for fishing grounds, or fishing suitability) with socioeconomic approaches (spatial extrapolation of social surrogates, or fishing capacity) can generate a comprehensive map of predicted fishing effort. For effective fisheries management, key stakeholders need to be included in the decision making process. This can bear difficulties in the implementation, as small-scale fisheries sectors are often complex, diffuse, informal and multifaceted by nature.

Fig. 24: Location of Moorea Island; Fig. 25: Fishing capacity, calculated using the cumulated distance to households weighted by their level of dependence on marine resources (Thiault et al., 2017).

3.2.7 Regional Results: Polar and Subpolar regions

Biogeographic introduction

The polar and subpolar regions host five OCTs. The Danish autonomous country Greenland and the French collectivity Saint Pierre and Miquelon are located in the Arctic and North Atlantic Ocean. The French Southern and Antarctic Lands (TAAF – French: Terres australes et antarctiques françaises) are located in the Southern Ocean, the British Antarctic Territory (BAT) in Antarctica and the British South Georgia and the Sandwich Islands in the Southern Atlantic Ocean. Together, they present the largest EU Overseas region. They are located in Polar climatic zones and are sparsely or not inhabited. They host pristine ecosystems of global importance, as breeding and foraging grounds for a diverse marine wildlife, contributing to species richness of the world's oceans. They are of major importance for global fisheries (EU BEST 2017b).

Results from the literature review

The polar and subpolar marine ecosystems have only recently started to apply the ES concept. Only 11 assessments described its implementation in these regions (Fig. 26).

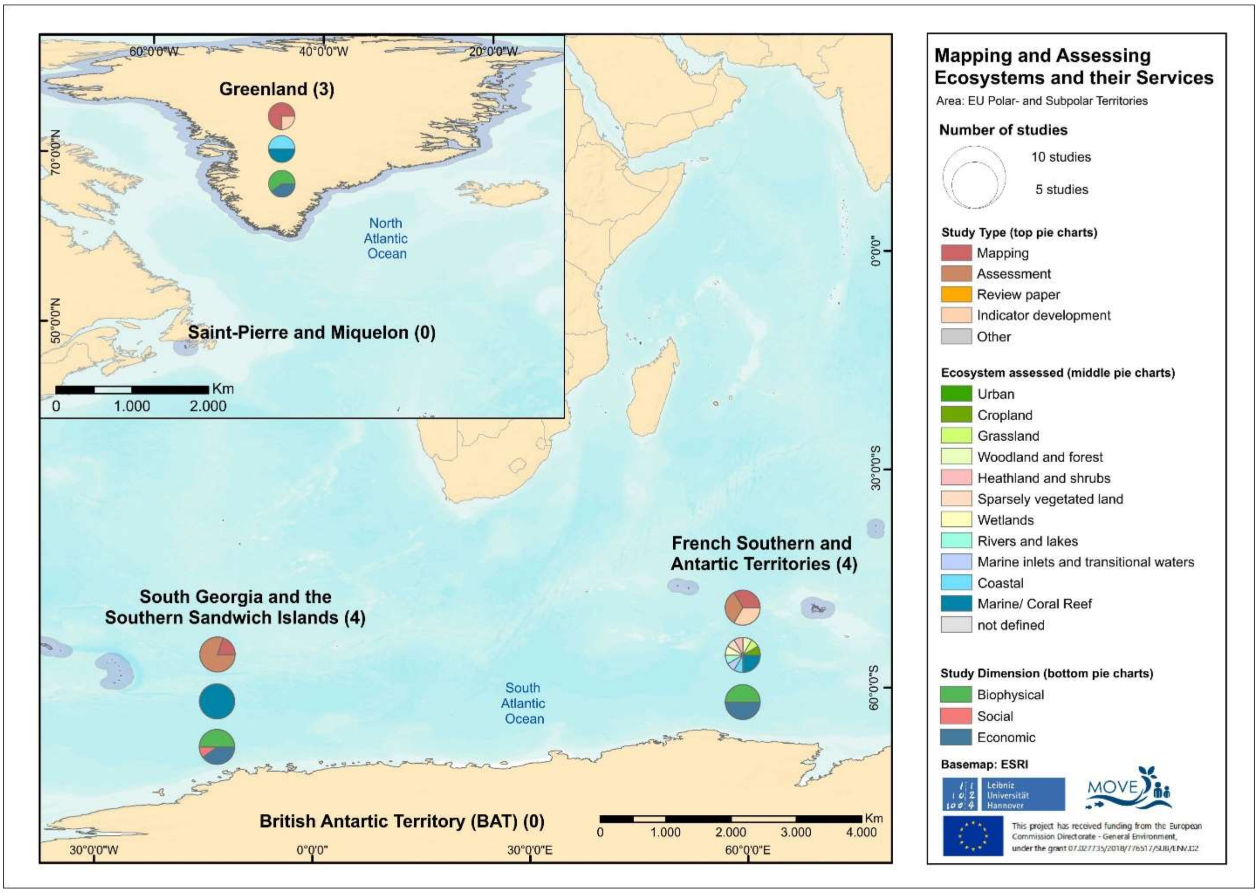


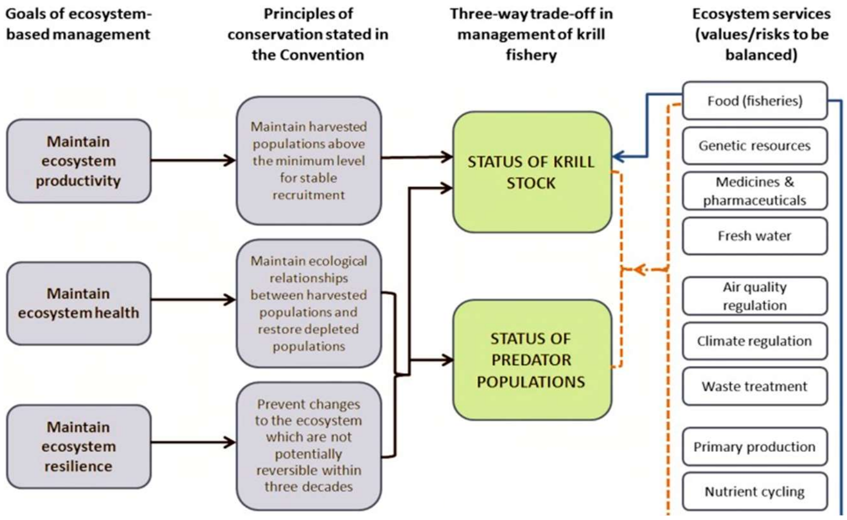
Fig. 26: Overview of publications for the Polar and Subpolar regions.

A complete ecosystem service identification for the Southern Ocean has been conducted by Grant et al. (2013)[32]. They focused on coastal and marine ecosystem services such as fishery products, nutrient cycling, climate regulation and the maintenance of biodiversity, and cultural services. However, no mapping and assessments were realized. Provisioning ecosystem services, especially wild animals and their outputs, were studied most extensively. For example, Grant et al. (2013) estimated the contribution of coastal and marine ecosystems to economics in terms of krill production and catch at $ 8.224×10^9 USD Yr^{-1} (Box 11). Pikitch et al. (2012) studied the application of Ecopath models and estimated the importance of Antarctic forage fish for fisheries to $149 USD km^2 Yr^{-1} in South Georgia up to $1000 USD km^2 Yr^{-1} in the Kerguelen fishing grounds.

Box 11: Exemplary ES assessment study for the Polar and Subpolar region.

A first multi-national ecosystem assessment for the Southern Oceans
Grant et al. (2013) conducted a first assessment of the Southern Oceans, including South Georgia and the Southern Sandwich Islands. They present an overview of ES provided by from marine and coastal ecosystems on multi-national scale, mainly based on literature and statistical data following the TEV framework. Key ES in this assessment are products from wild animals and their outputs (krill, krill meal and krill oil) and their economic values.

Fig 27: schematic representation of management goals and ecosystem services related to krill populations - including the three-way trade-off used in krill fishery management and its relationship with conservation principles and ecosystem services (adjusted from Grant et al., 2013).



32 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3808095/

3.3. SWOT analysis and suggestion for further work

A SWOT analysis is a method used to evaluate **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats of certain actions. Here we applied it to evaluate the MAES implementation and applications in the EU Overseas based on our review. By distilling favorable and unfavorable internal and external issues for MAES implementation in the four quadrants of a SWOT analysis grid, the challenges for each Overseas region can be highlighted. This helps to better understand how strengths can be leveraged to realize new opportunities as well as how weaknesses can slow progress or magnify organizational threats (Helms and Nixon, 2010).

Almost every island conducts ecosystem monitoring, both in terrestrial and marine ecosystems. However, to date, there has been limited work on ES and ecosystem condition. The SWOT analysis helps to highlight such knowledge gaps and research needs for MAES in the study regions based on information from literature. Further, it outlines the needs for the development of specific case studies in the different regions.

Macaronesia

The Macaronesian region shows progress in its MAES implementation – especially the Azores (23 studies) and the Canaries (15) are well anchored in national ES assessments of their mainlands Portugal and Spain. These Archipelagos shows increasing numbers of ES-related publications, studies and project reports. These regions are strongly bound to the EU, certainly also due to their close location. Both terrestrial and marine ecosystems are well covered. This bears the potential to integrate the relation of ecosystem services across the land-sea interface closer. For this region, spatial data of high quality is available (Copernicus CORINE and locally available data). Future work should test and compare the quality of ES mapping and assessment methods for islands based on different land use land cover data. Apart from this, there is still a lack of knowledge on ES provision related to MPAs. This bears potential for long term monitoring of ES provision in (marine) protected areas, including first indications of effects of ecosystem service provision in such protected areas.

Caribbean

The different territories in the Caribbean biogeographic region share many ecosystem characteristics. Healthy ecosystems have long been recognized as fundamental for human well-being (Agard et al., 2007). For many of the small islands, tourism and recreation, food provision through fisheries, flood and storm protection are important ES. Their monetary values have been estimated in multiple economic valuation studies. However, the qualification and quantification of ES in biophysical dimensions, including the condition of ecosystems and the capacity to provide ES, remain underdeveloped. Therefore, a more balanced application of biophysical, cultural and economic mapping and assessment methods is desirable, closing this gap. Another knowledge gap concerns ecosystem multifunctionality – only few studies include this aspect. Even though a positive trend for ES research is visible in this region in terms of ES valuation studies, mapping the spatial dimension of service provision should be strengthened, as maps can be of utmost importance to communicate the value of nature with planners and decision-makers (Maes et al., 2012).

Amazonia

A vast amount of data on forests and habitats is available in the Amazonia region. This data could be harnessed to fill the knowledge gap on the interrelation between biodiversity, ecosystem functions and ecosystem service supply. With 12 publications on ecosystem services, French Guiana can be placed in the middle range of MAES implementing Overseas Territories. In the context of environmental degradation and deforestation in French Guiana, the ES concept can be a valuable tool to inform policy and decision-makers on the importance of healthy and functioning ecosystems and their related capacity to supply ES. So far, ES assessments focus on few services. Here, the concept of ecosystem functionality and especially non-monetary ES assessments could help to address this missing link between ecosystems and the services they provide. The implementation of case studies could highlight and the potential of such assessments.

South Atlantic

There have been efforts in the South Atlantic OCTs to map and assess ES, especially marine and coastal ES. Under the umbrella of Natural Capital Assessments, a stable foundation for the assessment of condition of ecosystems and their services has been prepared. With only 16 studies on the topic of ES, however, there is still potential for more applications of the MAES concept. With little ES mapping studies available today, MAES could provide valuable insights in the spatial dimension of ES in these territories. Whilst marine and coastal ES are well covered, terrestrial ecosystem assessments fall behind for Ascension and Tristan da Cunha. Also, ES maps are scarce in this region. Addressing these gaps could help achieve a more balances coverage of the South Atlantic British OCTs. With upcoming Brexit, however, the future of MAES and achieving the targets of the EU Biodiversity Strategy in these OCTs remains uncertain.

Indian Ocean

For the Indian Ocean, our review obtained 34 studies and publications related to ecosystem services. Terestrial and coastal/marine ecosystems have been studied well. Translating the broad body of available data into ecosystem services remains the next step. Whilst biophysical and economic methods have been applied plentyful (>60% in this region), socio-cultural assessment studies remain little. As human impact on marine and coastal ecosystems increases fast in the Indian Ocean (Halpern et al, 2019), the ES concept has a strong potential to study changes and effects for the inhabitants. Especially socio-cultral, and participatory approaches bear potential for this region, as few studies of this type currently exist in the Indian Ocen Ors and OCTs. Visualizing the results and creating ES (Szenario) maps (Lagabrielle et al., 2016) can consequentially help communicate the benefits of nature to decision makers (Maes et al., 2012). Therefore, MAES still has a strong potential for the Indian Ocean territories, bridging the gap between science and policy making.

Pacific

For the Pacific region, extensive monitoring of ecosystems and their processes has been conducted. Especially coastal and marine ecosystems are well studied. Still, the review showed that ES mapping and assessment studies on the local and regional scale are still low (<25%). Such local and regional studies, however, give spatial insights needed for local decision making and safeguarding of long-term ES provision. In turn, such studies are of importance to communicate ES flows and benefits to the local population. Therefore, there is a need in this region for detailed ES mapping and assessment studies to understand the link between ES and human well-being.

Polar and Subpolar

For both, the polar and subpolar OCTs, local ES mapping studies are scarce: 90% of the 11 analysed studies are ES mapping and assessments on the global or multinational scale, including the polar and subpolar regions. There might be a link with telecoupling issues, as only a fragment of the ES provided within the territorial bounds directly benefits the local population. Rather, the benefits are collected far distant from where they are supplied - for example nurseries and feeding grounds for wild animals and their outputs - an ecosystem service crucial for global fisheries. This might explain the limited number of ES studies. At the same time, this opens up opportunities for ES research to take place directly within the regions.

		Caribbean	Pacific	Macaronesia	Indian Ocean	South Atlantic	Amazonia	Polar/Sub-polar Regions
		102 studies 4 ORs and 12 OCTs	52 studies 4 OCTs	41 studies 3 ORs	34 studies 2 ORs and 2 OCTs	16 studies 2 OCTs	12 studies 1 OR	11 studies 3 OCTs
Internal	S	• Strong focus on marine and coastal ecosystems • Mix of ES applications for long-term (MPA's) and short-term goals (management)	• Increasing engagement with ES concept • Range and flexibility of ES methods and applications	• Detailed knowledge on ecosystem types, red list of species, KBA's • high amount of studies on local scale	• Experience with monetary estimation of value of ES • participatory ES assessments	• Highly undisturbed marine and coastal ecosystems used as reference ecosystems • Diversity of concepts : ES, NatCap, TEEB	• First experience with the concept: high percentage of local ES assessments	• High potential for ES concept
	W	• Disparities in degree and complexity of ES assessments between ORs and OCTs	• Majority of ES studies on global or multinational scale • limited knowledge on ES at local/regional level	• unbalanced coverage of the different islands	• focus mostly on ecosystem functions and processes • lack of mapping studies	• majority of ES studies on global or multinational scale • limited knowledge on ES at local/regional level	• studies highly specialized in ecosystem structures, processes such as species richness, biodiversity	• majority of ES studies on global or multinational scale • limited knowledge on ES at local/regional level
External	O	• high number of ES related studies as base to put MAES on the local policy agenda • Reconnecting people to nature in densely populated areas	• Social valuation of ES bears great potential • Local studies to showcase the potential of ES concept	• demand for ecosystem management, wilderness • mix of local, regional and national research highlights interest in ES concept on Azores	• Social valuation of ecosystems bears great potential	• remote location allows to study • Potential for spatial dimension of ES provision and telecoupling issues	• OR with 95% tropical forest ideal to study terrestrial ecosystems • ES as tool to highlight the importance of threatened ecosystems	• ES of global importance for e.g. marine wildlife, nurseries, fisheries • opportunities to investigate telecoupling issues
	T	• ecosystem multifunctionality often reduced to single monetary values • need for balance between biophysical, social and economic assessment methods	• Difficulty to connect individual work to a broader scope • Lack of systematic/interdisci-plinary assessments	• lack of integrated ES studies across land-sea interface	• Difficulty to connect individual work to a broader scope • no long term monitoring of ecosystems, their condition and changes in MPA's	• uncertain future of ES research under EU BD 2020 under Brexit • competing approaches	Lack of focus on equitable access to and benefit from ecosystems Monetary approaches incompatible with indigenous lifestyles	• dominance of coastal and marine ES studies may underestimate the importance of terrestrial ecosystems

Table 4: SWOT Analysis for MAES implementation in the EU Overseas Regions based on the literature review and survey.

4. COMPARISON OF STUDIES AND METHODS BETWEEN THE EUROPEAN MAINLAND AND THE EU OVERSEAS

Identifying and comparing the main difference between Europe Overseas and mainland for ecosystem services mapping and assessment studies is an important component of this report. The results of this section will help to identify the main gaps (e.g. methods used, ecosystem type, ecosystem service categories) for Overseas Territories and to provide guidance on how to overcome them. To achieve these results, we used an updated version of the ESMERALDA database (Santos-Martín et al., 2018). This database forms the basis for an online ecosystem service 'methods finder'[33] in the EU. This database has been updated with the results of our literature review on EU Overseas. These new entries to the 'methods finder' are now available online.

The comparison provides an overview of the EU Mainland with a total of 881 entries (until April 2018) and the consultation within the MOVE consortium that shaped its development with 171 additional new entries (until June 2019) for the Overseas Territories. Such a comparison of studies between overseas and mainland provides an overview of the spatial distribution of MAES related studies - it helps identify the main gaps and opportunities for alignment and development of commonalities in analytical approach amongst the MAES process in EU mainland and overseas. The results illustrate the different conditions, dimensions and geographical contexts between EU, which can be used as background information to inform the development of MAES in the Overseas Territories. Therefore, this work highlights some challenges for future activities on mapping and assessment of ecosystem services in the EU Overseas Territories.

[33] http://database.esmeralda-project.eu/home

4.1 Number of studies in the EU mainland and Overseas

For the European mainland, 28 countries were selected (as part of the ESMERALDA database, this included 2 Baltic and 2 western Balkan countries, linked via regional hubs). Under the umbrella of ESMERALDA EU Project, However, the analysis done for EU mainland indicated that ES mapping and assessments have been conducted in 26 countries (Fig. 28). 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 already been performed (e.g. UK NEA, Spanish NEA, NEA-D). The studies included in the database cover all ecosystem types as identified 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.

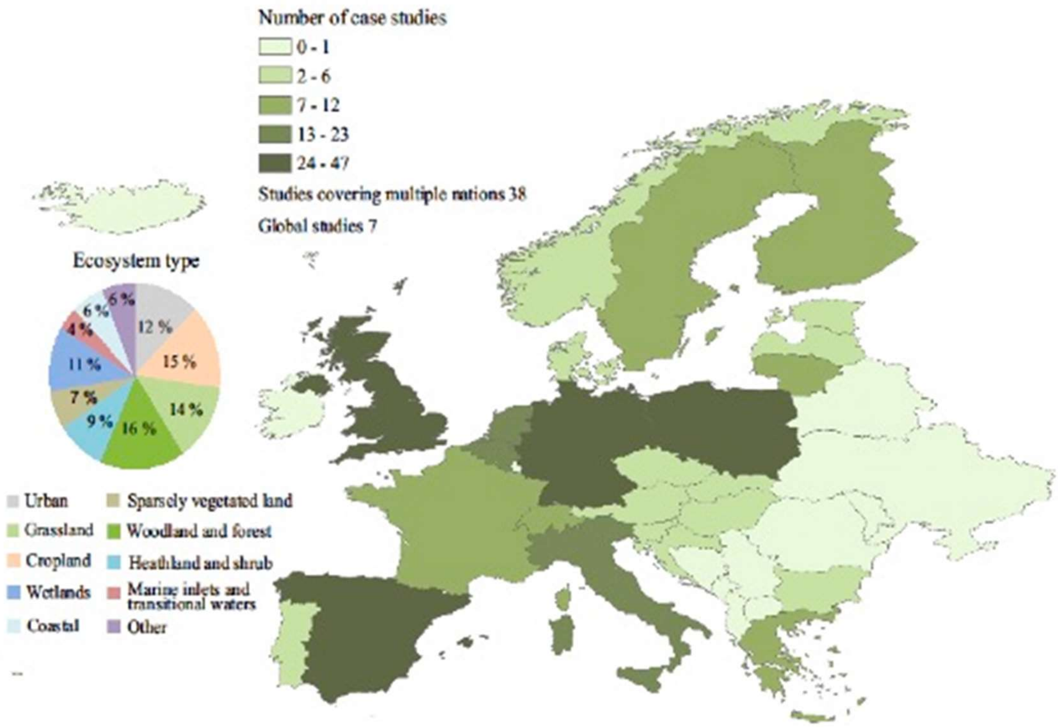


Fig. 28: Spatial distribution of EU mainland case study locations by country and type of ecosystem, in which the mapping and assessment methods were applied (Santos-Martín et al., 2018).

If we compare the number of ES studies and publications in the EU mainland and overseas (Fig. 29), we observe that both curves show an increase during the last decades (Fig. 28). Although the implementation and application of MAES methods has increased exponentially in the EU mainland, this trend cannot be observed in the EU Overseas. In the EU mainland, the first increase was found in 2005, when the MEA (Millennium Ecosystem Assessment 2005) was published, but the main increase started after 2010, when the EU Biodiversity Strategy was published and the MAES working group was created. Additionally, the ESMERALDA project presents another landmark in 2015, accelerating the

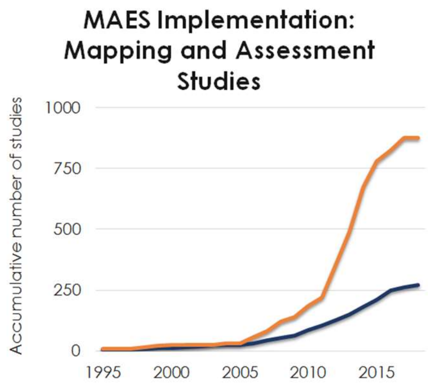


Fig. 29: Temporal trend on the number of publications for mapping and assessment of ES in EU Overseas and Mainland.

application of MAES in all EU member states, including also non-EU countries Norway, Switzerland and Israel. In the Overseas, however, the number of studies is not yet following the exponentially growing trend in Europe.
However, this type of increase could take place in the upcoming years (2020 and onwards), with the help of the MOVE and the follow-up MOVE-ON projects. These results reflect that, although there is a rising awareness and application of the ES concept at global level, there is a need to develop regional research programs for the implementation and development of the ES concept.

4.2 Type of studies

Despite the large number of ES studies in EU mainland and overseas, less than half (38% for Overseas and 42% for Mainland) actually provides ecosystem services maps. Instead, the majority of studies touches upon aspects of ES using an assessment type of study (Fig. 30). '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. With assessment studies prevailing, this gap on mapping, and thus spatial explicit information, needs to be addressed for future research efforts in both EU Overseas and Mainland.

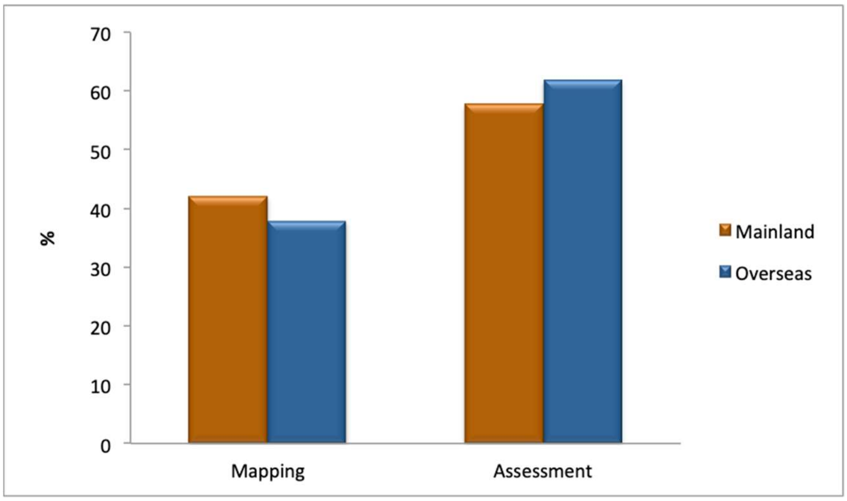


Fig. 30: Type of mapping and assessment ES studies implemented in EU Mainland and Overseas territories based on the reviewed studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

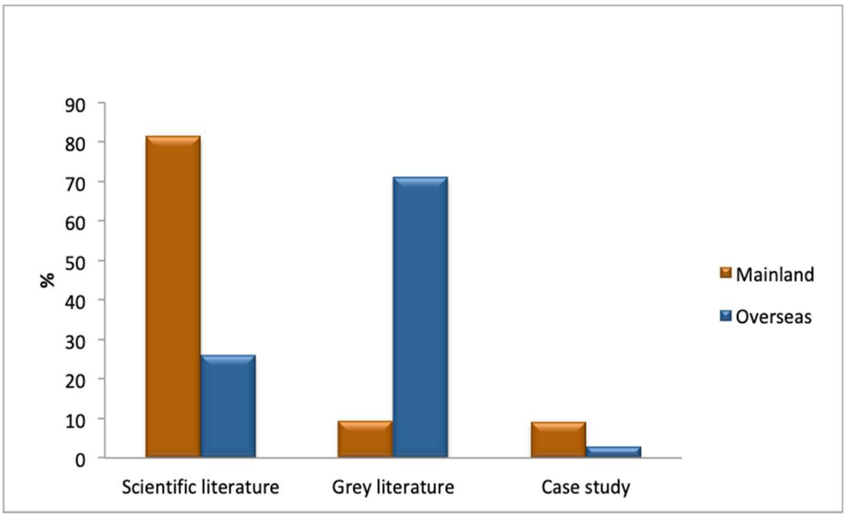


Fig. 31: Source of information used in mapping and assessment studies implemented in EU Mainland and Overseas Territories (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

In terms of the source of information (scientific literature, grey literature or case studies), the comparison between EU overseas and mainland shows very different results (Fig. 31). For the overseas, only 26% of the studies are based on scientific literature whilst 71% rely on grey literature. For EU mainland our database showed the opposite results, 81% scientific literature and 9% are based on grey literature. One possible solution to balance this difference will be to strengthen the collaboration between scientific networks in the Overseas Territories together with research teams from the EU mainland. 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 therefore, avoided double counting.

4.3 Ecosystem types

Comparing ecosystem types, the majority of the studies or publications for the EU Overseas focused on coastal and marine ecosystems (22 and 23 % respectively) (Fig. 32). In EU mainland, forest or cropland ecosystems were most intensively studied (14 and 13 % respectively), with a clear gap in marine and coastal types. The interaction between these two communities could be mutually beneficial to enrich the expertise on MAES.

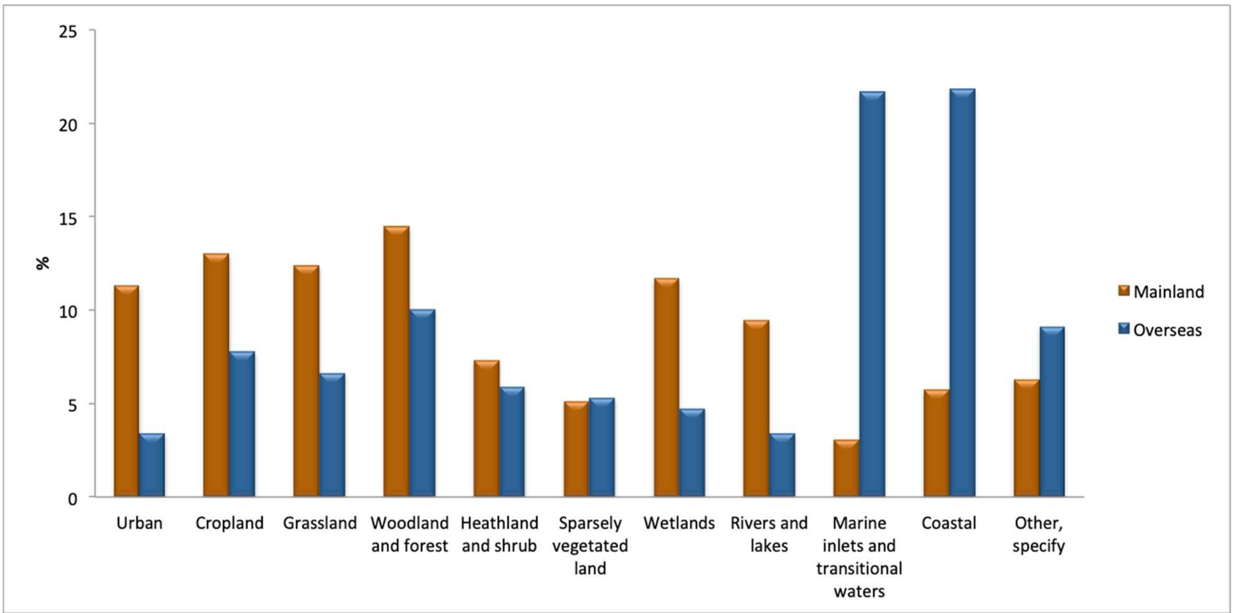


Fig. 32: Type of ecosystems mapped and assessed in ES studies in EU Mainland and Overseas based on the reviewed studies (n = (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

4.4 Ecosystem services

In terms of the different ecosystem services (provisioning, regulating and cultural), the comparison between EU Overseas and Mainland showed small differences (Fig. 33, Fig. 34, Fig. 35). For the provisioning ES in the EU Overseas, wild animals and their outputs (fish stocks), wild plants algae and their outputs (biomass) and surface water for drinking and non-drinking purposes are used most frequently in the studies. For the EU mainland, the major interest in provisioning ES are cultivated crops (food), material from plants (timber) and animals and their products (livestock). However, there is a balance distribution in almost all the rest of provisioning ES suggesting that there is an overlap interest in both regions.

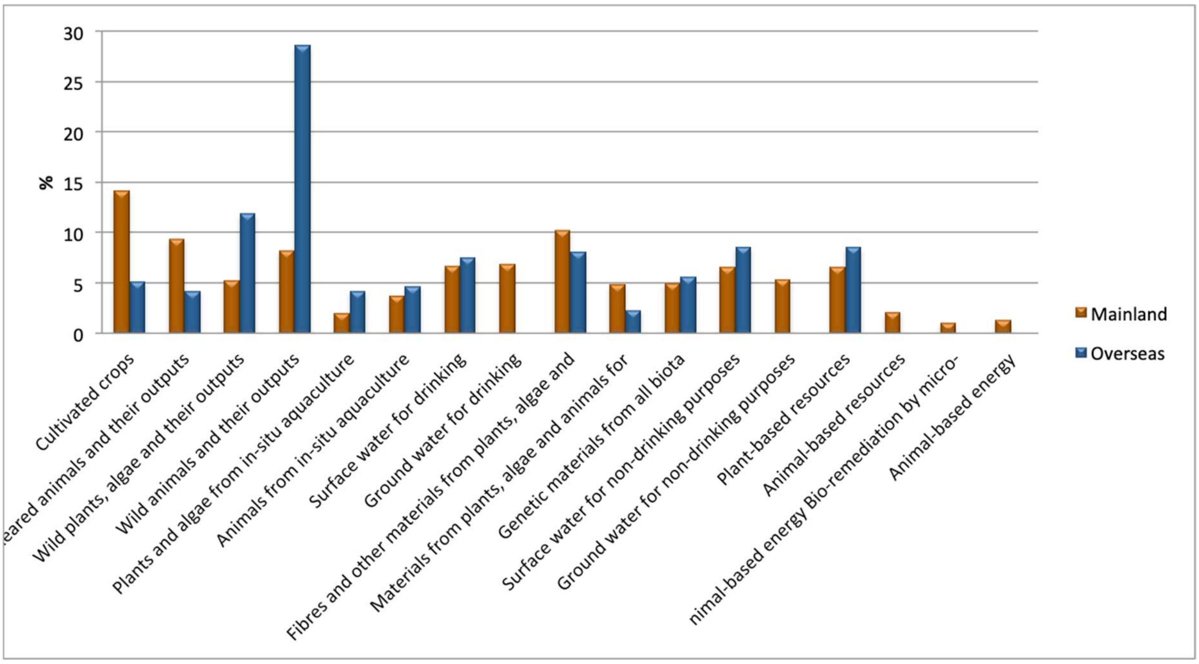


Fig. 33: Type of provisioning ecosystem services mapped and assessed in EU mainland and overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

For regulating ES, in the EU Overseas there is a clear bias on flood and storm protection, suggesting that this is a critical problem that receives much more attention than in the EU mainland - not surprisingly, as the majority of the ORs and OCTs are islands. In a second level of interest, global and regional climate regulation, often through of carbon storage and filtrating functions of ecosystems are addressed in the EU Overseas. In contrast, in EU mainland, the main interest in regulating ES seems to be on pollination and seed dispersal and control of soil erosion among others.

For cultural ES in the EU Overseas and mainland, similar trends could be observed. In both regions, physical use of land- and seascapes are most often assessed, mostly in the form of (eco-) tourism.

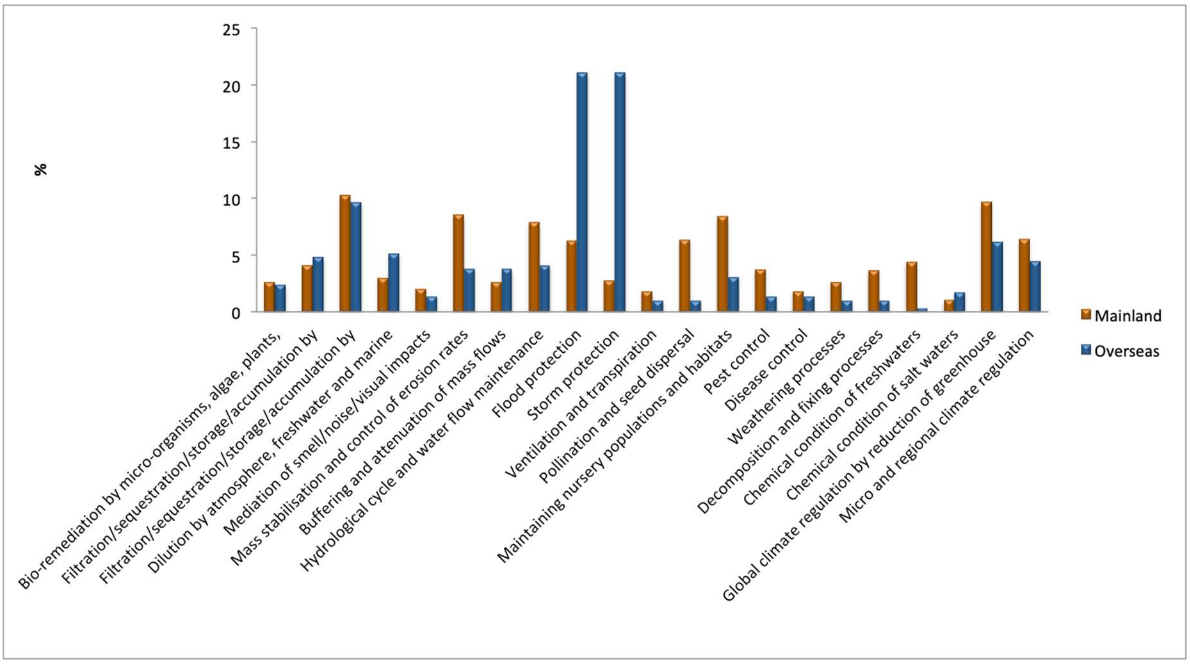


Fig. 34: Type of regulating ecosystem services mapped and assessed in EU mainland and overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

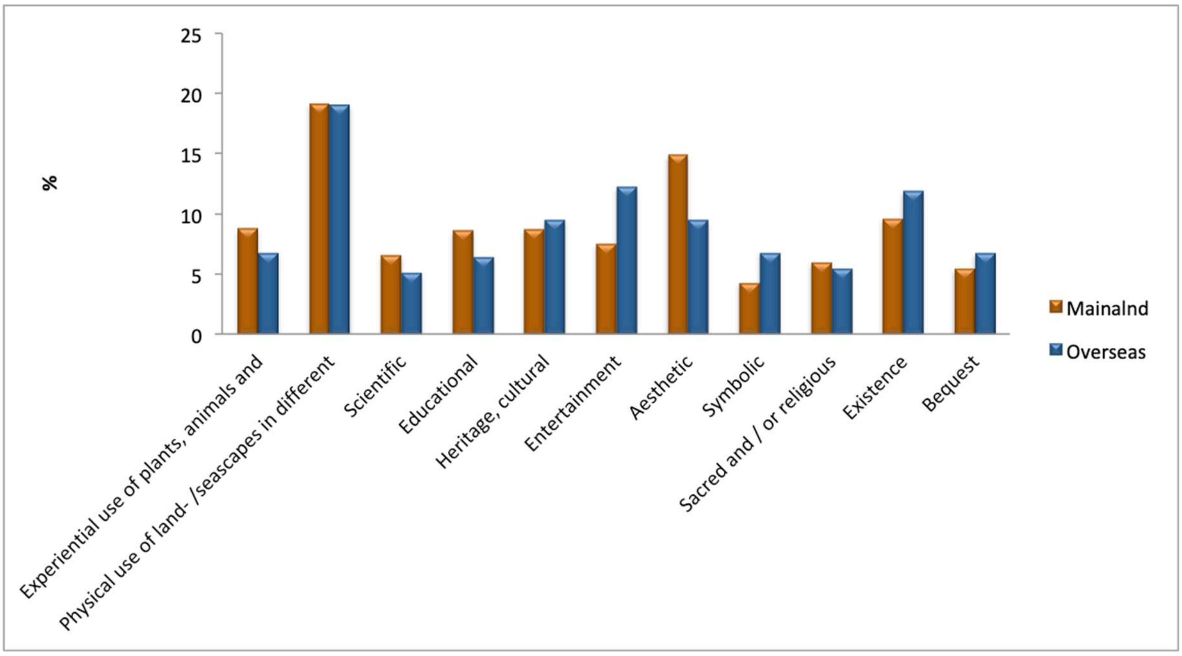


Fig. 35: Type of cultural ecosystem services mapped and assessed in EU mainland and overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

4.5 Methods used

An analysis of the type of methods used (biophysical, socio-cultural and economic) shows a skewed picture for the comparison between EU overseas and mainland (Fig. 36). For the Overseas more than half of the studies have focused on an economic perspective (59% economic, 28% biophysical, 12% socio-cultural assessments). Especially in the Caribbean region, economic assessments can be found. This can be related to the involvement of partnerships between science and private companies in which most of these studies involve economical valuation. However, this bears a risk of neglecting socio-cultural and biophysical ES mapping methods. To avoid this, such socio-cultural and biophysical mapping methods need to be put into focus for future research efforts in the EU Overseas. For the mainland, out of all 1538 entries, the distribution is more balanced, with biophysical studies dominating (44% biophysical, 26% socio-cultural and 30% economic assessments).

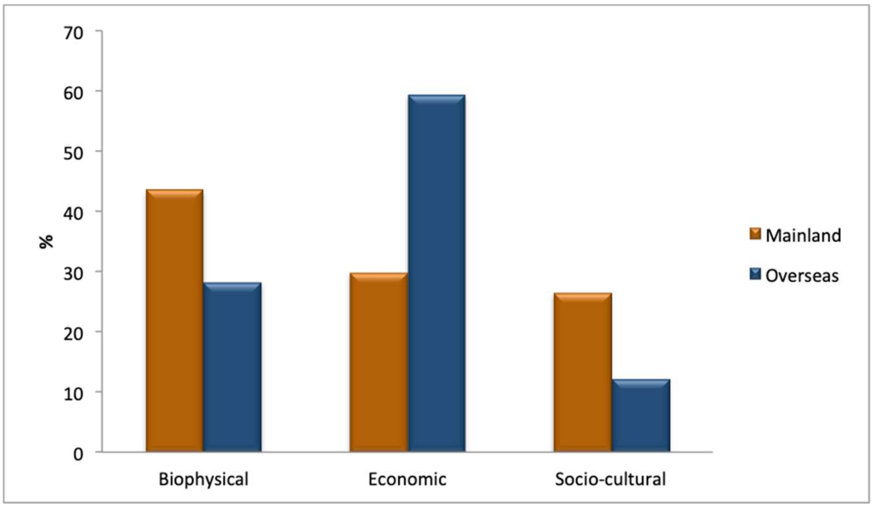


Fig. 36: Type of the methods (Biophysical, Economic or Socio-cultural) at which mapping and assessment studies could be applied in relation to EU mainland and overseas territories (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

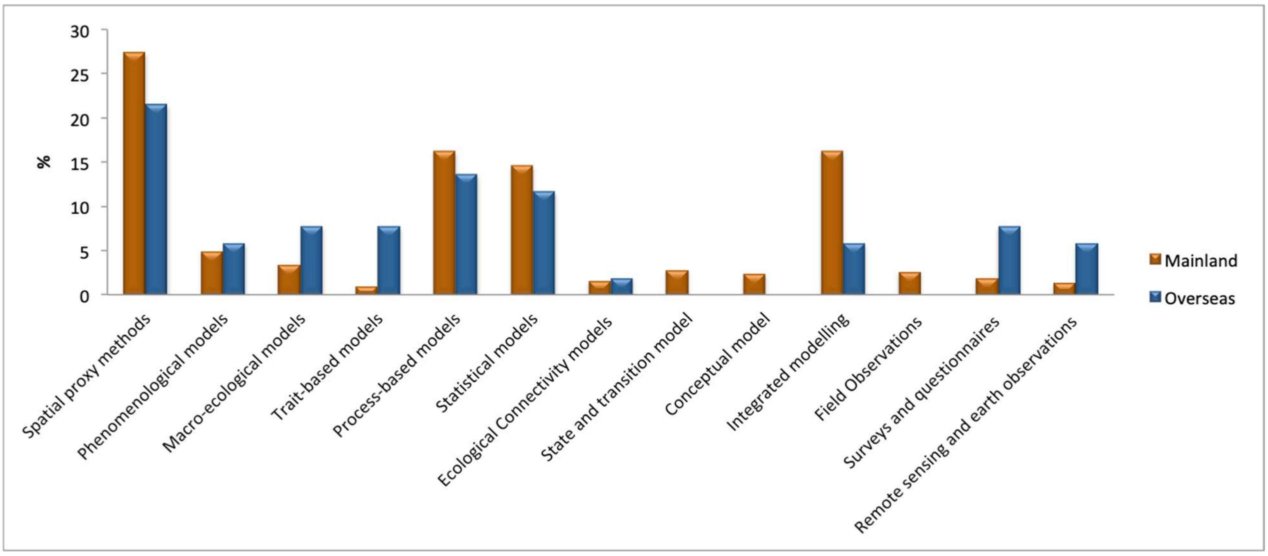


Fig. 37: Type of biophysical mapping and assessment methods used in the EU mainland and overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

In terms of the specific methods used, slight differences were found between EU Overseas and Mainland (Fig. 36 - 39). For instance, amongst economic mapping and assessment methods, value transfer has been a very common method to quantify ES in monetary terms for EU mainland while it has barely been applied in the EU Overseas. On the other hand, for sociocultural methods, participatory methods have most frequently been applied: both GIS mapping, participatory scenario planning and preference assessment are most used approaches to assess ES in the Overseas while they find less applications in EU mainland. For biophysical methods, no significant differences were found among EU overseas and mainland Even though multi-tiered approaches bear great potential for mapping and assessing ES (Grêt-Regamey et al, 2015), they still find little application in the EU Overseas.

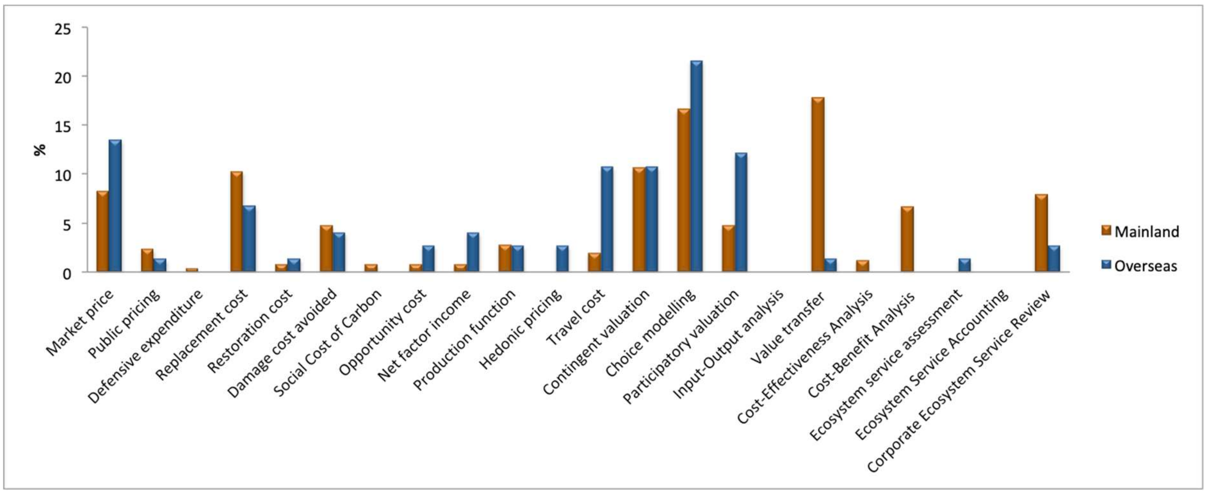


Fig. 38: Type of economic mapping and assessment methods used in the EU mainland and overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

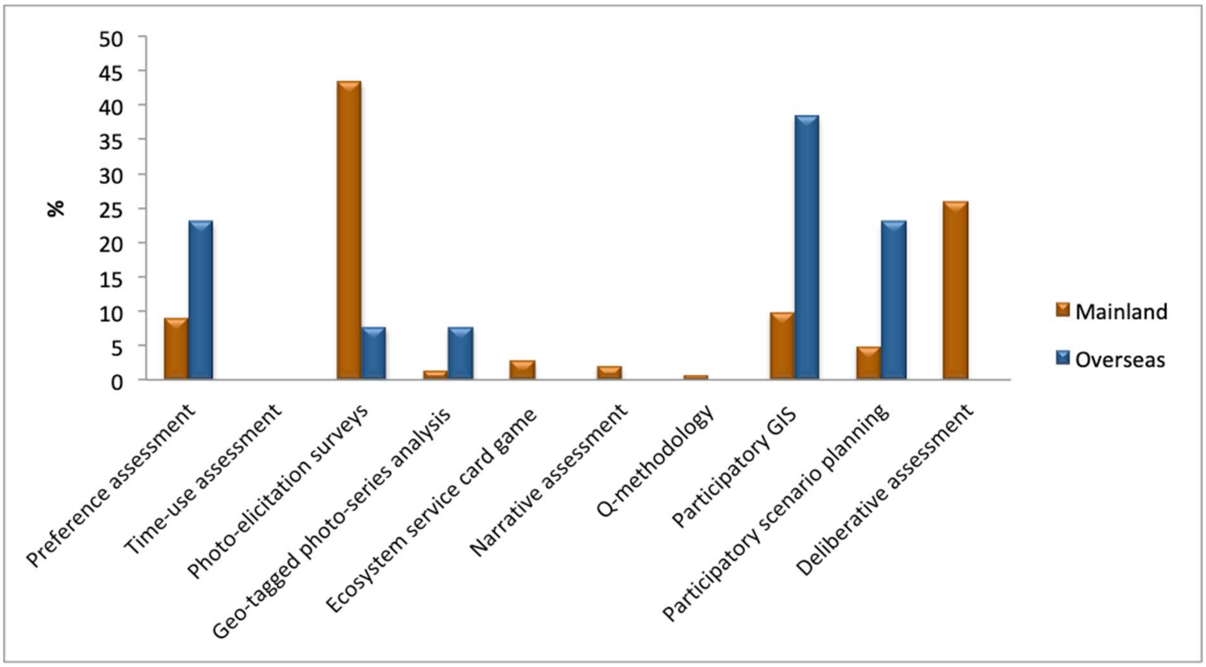


Fig. 39: Type of sociocultural mapping and assessment methods used in the EU mainland and Overseas territories studies (n = 881 for the EU mainland, and n = 171 for the EU Overseas).

5. CONCLUSIONS

This study described in this report aims to enable MAES-related stakeholders from science, policy, practice and society to become familiar with existing studies, projects, literature and other information related to MAES in the OCTs and ORs. Respective studies have been presented for each region. A comparison of mapping and assessment methods between EU (Santos-Martín et al, 2019) and EU Overseas allowed to identify knowledge gaps and regional trends as well as examples of mapping studies.
The literature reviewed for this report has been included in the 'ESMERALDA MAES Explorer' and 'ESMERALDA MAES Methods Explorer and is available online[34]. This allows for comparison with the EU mainland's collection of existing studies, but most importantly, it enables stakeholders to find suitable methods for mapping and assessing ecosystems and their services in a particular region at a specific scale (Reichelt and Klug, 2018).

As the review and the survey revealed, the MAES process has been started in many parts of the EU Overseas. In some regions, this process might be more advanced than in others. For example, in the Macaronesian and the Caribbean region, the ORs and OCTs have been included in National Ecosystem Assessments, based on which a higher number of MAES-related studies was obtained. This highlights the importance of the connection between the EU Member States and their associated Territories. Such a connection can be the foundation for mutual learning, and a contribution for better understanding and decision making related to ecosystems throughout the entire EU. However, in other regions such as the Polar/Subpolar regions and Amazonia, the ES concept has hardly found application yet.

This report identified gaps as well as potentials of MAES implementation in the EU Overseas. Even though there are multiple studies and efforts on MAES for most of the ORs and OCTs, a holistic approach oriented toward integrative social-ecological system analysis is still lacking for many Overseas regions. As main drawbacks for MAES implementation, insularity, the fragmented efforts in the different territories were identified. A lack of knowledge or capacities to carry out MAES, including financial resources should be mentioned. Also, limited availability of data for many regions slows the MAES process. This also presents a methodological drawback - most of the studies are based on literature or field data, surveys and interviews. The use of geo-referenced data and data-intensive methods, e.g. integrative models or tiered ES mapping and assessment approaches is limited, but growing. Especially in relation to marine parks, long-term monitoring studies on ES provision are still lacking.

Building upon the seven steps of MAES implementation identified by ESMERALDA, we recommend the following (see also Fig. 41).

1) Addressing **questions** of stakeholders is of utmost importance to create meaningful ES mapping and assessment strategies. Most frequently asked questions in the analysed literature were, for example, how future land use changes affect people and society, especially under growing tourism and climatic changes or how to sustainably exploit natural resources without losing their ecosystem integrity. Other questions addressed the economic value of ecosystems, their services and related activities, e.g. (eco-)tourism or fishing.

[34] http://database.esmeralda-project.eu/database

This indicates the importance of ecosystems for the tourism sector for many ORs and OCTs. More details on stakeholder questions can be found in MOVE Deliverable 2.1 - "*list of institutional and individual stakeholders of MAES*", specifically focusing on questions that stakeholders, institutions and policy makers in the different regions have.

2) Identifying stakeholders on multiple scales is the second step for effective MAES implementation. Based on our research, the identification of stakeholders in the analysed regions was mainly limited to scientific and institutional bodies. However, a full delineation of relevant stakeholders can be found in MOVE Deliverable 2.1 - "*list of institutional and individual stakeholders of MAES*" in the EU Overseas.

3) Setting up a network of scientists, practitioners and civil society is important to anchor MAES efforts, as European experience shows (Burkhard et al, 2018). Therefore, for instance the MOVE project and it *online forum* can help to bring stakeholders together virtually[35]. Nonetheless, workshops and face-to-face meetings with stakeholders proved to be a key to build a strong network. Including multiple stakeholders on multiple levels is also relevant for the EU Overseas, as the review shows: Especially participatory ES mapping and assessment methods (e.g. PGIS, collective scenario planning) can help to include local knowledge and perceptions of stakeholders (point 1). Therefore, it can increase the acceptance and understanding of ecosystems and their services (point 6), and provide knowledge and tools needed for informed decision-making (point 1).

4) Mapping and assessment methods need to be tested and adjusted for regional differences. Whereas numerous applications of terrestrial ES mapping studies can be found at the EU mainland, the focus of the Overseas has – until now - been largely on marine and coastal ES. This bears enormous potential for further research on marine and coastal realms and their integration into holistic assessment studies at the terrestrial-marine interfaces. Such assessments (including marine and terrestrial ES) are needed to integrate these two domains for effective land use /coastal zone planning, not only within the EU Overseas, but also comparable islands or small island developing states.

Most often, the literature mentions cultural ecosystem services (40%, Fig. 41), followed by regulating (30%) and provisioning services (28%). Especially economic mapping and assessment methods dominate for the EU Overseas (59%; 28% biophysical, 12% socio-cultural assessment methods).

[35] https://moveproject.eu/community/

Thus, the majority of studies applied monetary assessment methods, rather than understanding where and which ecosystem services, and hence benefits, are particularly provided and what the natural base (including biodiversity and ecosystem functioning) of this provision is. Ecosystem condition has rarely been addressed in any of the studies, a topic of utmost relevance, considering also current and expected climatic and anthropogenic pressures (Maes et al, 2018). To balance this, specifically biophysical and cultural assessment methods (e.g. ES matrix assessments, integrative models, participatory ES mapping) need to be tested and adapted. Based on this, a selection of most suitable methods for ORs and OCTs can be created, including best practices.

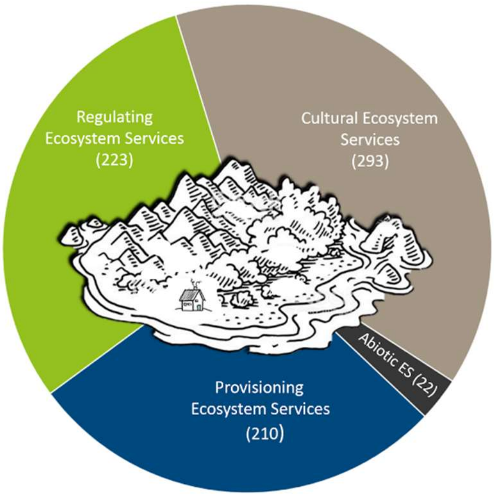


Fig. 40: ES assessed in EU Overseas. In the total literature of 271 studies on EU Overseas, 293 cultural ES were mentioned, 223 studies referred to regulating ES and 210 provisioning ES.

5) Addressing MAES through **case study examples** is important. Based on Step 4, it is recommended to address multiple ecosystem services, in terms of mapping and assessment, applying biophysical, socio-cultural and economic methods on various spatial scales. Assessments that are combining marine and terrestrial ecosystems under a flexible methodology are needed to apply the ES concept throughout the EU's different biogeographic regions, whilst being specific enough for the individual ORs and OCTs (point 4). The EU MOVE project will select and implement case studies in all participating regions to test methods to achieve this. This work will be continued by the MOVE-ON EU Project[36], implementing so called anchor regions as accelerators to effective MAES implementation, including monitoring of the implementation progress between ORs, OCTs and the biogeographical regions.

6) Dissemination and communication of MAES outcomes, especially between involved stakeholders, institutions, the public, but specifically between scientists and policy makers, is crucial for effective decision making. Therefore, an **online forum** could help to bring together stakeholders, practitioners and decision makers[37]. In addition, we recommend producing Overseas factsheets to present national efforts, but also case study booklets to present specific ES mapping and assessment methods. Here, the ESMERALDA project has presented good examples of an effective communication and dissemination strategy. For the EU mainland, this has already led to increased acceptance and understanding of ecosystems and their services.

[36] MOVE-ON (Pilot Project – Mapping and assessing the state of ecosystems and their services in the Outermost Regions and Overseas Countries and Territories: Establishing links and pooling resources), Grant Agreement Nº: 07.027735/2019/SI2.808239/SUB/ENV.D2

[37] https://moveproject.eu/community/

7) Implementation: Based on this literature review and the survey, a first overview of MAES-related efforts is presented - with gaps and opportunities presented for each biogeographic region. This can act as a starting point to push the MAES process forward. The identified knowledge gaps will be addressed in the different case studies carried out by the MOVE project, starting beginning of 2020, and can guide the creation of the anchor regions implemented under the MOVE-ON EU Project.

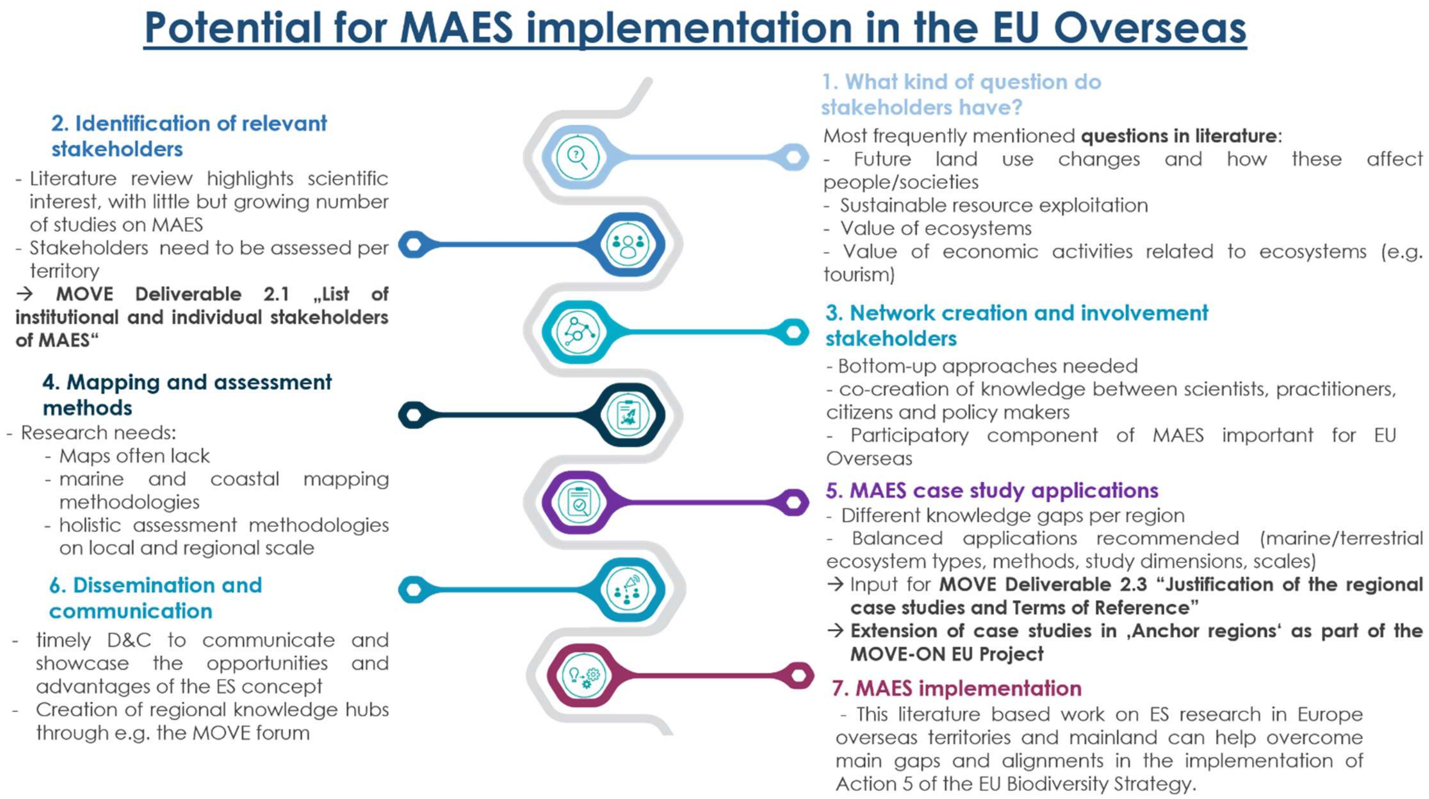


Fig. 41: Potential for the implementation of MAES in the EU Overseas based on the review of scientific literature.

There is a large potential for comprehensive ecosystem assessments in the EU ORs and OCTs, building on the work of existing initiatives such as NetBiome or BEST. For integrated mapping and assessment of ORs' and OCTs' ecosystems and their services, the necessary steps for MAES implementation (see above) should be applied in all areas. There is a need for flexible, guidance-based ES mapping and assessment approaches in the EU Overseas, based on examples from specific case studies (with focus on marine, terrestrial and their combination, socio-cultural and biophysical methods, multi-tiered and modelling methods, different spatial scales). For this, stakeholders from multiple disciplines and sectors need to be included to provide a comprehensive overview of the current status of biodiversity, the ecosystems and the services they provide. Such an overview will help to safeguard biodiversity, healthy ecosystems, a continuous supply of ecosystem services, to improve human well-being and to ensure an effective and timely implementation of Action 5 of Target 2 of the EU Biodiversity Strategy.

6. REFERENCES

Acorn Tourism, Repetto, D. & Smith, N. (2019). South Atlantic Natural Capital Assessment: Tristan da Cunha tourism assessment.

Alonso-Benito, A., Hernandez-Leal, P.A., Arbelo, M., Moreno-Ruiz, J.A. & Garcia-Lazaro, J.R. (2016). Satellite image based methods for fuels maps updating. Proceedings of SPIE.

Agard, J., Cropper, A.N., Aquing, P., Attzs, M., Arias, F., Beltran, J., Bennett, E., Carnegie, R., Clauzel, S., Corredor, J. & Creary, M. (2007). Caribbean Sea ecosystem assessment (CARSEA). Caribbean Mar Stud. 8. 1-85.

Andréfouët, S. (2014). Remote Sensing of Coral Reefs and Their Environments in the Red Sea and Western Indian Ocean: Research and Management. Remote Sensing of the African Seas, 8(2), 118. DOI: https://doi.org/10.3390/rs8020118

Arévalo, J. R., Mora, J. L., & Chinea, E. (2012). Forage quality of native pastures on Lanzarote Island (Canary Islands). Journal of Food, Agriculture & Environment, 10 1 part 2, 696-701.

Avau, J., Cunha-Lignon, M., De Myttenaere, B., Godart, M. F., & Dahdouh-Guebas, F. (2011). The commercial images promoting Caribbean mangroves to tourists: Case studies in Jamaica, Guadeloupe and Martinique. *Journal of coastal research*, 1277-1281.

Baker, S., Paddock, J., Smith, A. M., Unsworth, R. K., Cullen-Unsworth, L. C., & Hertler, H. (2015). An ecosystems perspective for food security in the Caribbean: Seagrass meadows in the Turks and Caicos Islands. *Ecosystem services*, *11*, 12-21.

Beilhe, B.L., Delatte, H., Juliano, S.A., Fontenille, D., Quilici, S. (2013). Ecological interactions in Aedes species on Reunion Island. *In Medical and veterinary entomology* 27 (4), pp. 387–397. DOI: 0.1111/j.1365-2915.2012.01062.x

Blake, D., Augé, A. A., & Sherren, K. (2017). Participatory mapping to elicit cultural coastal values for Marine Spatial Planning in a remote archipelago. *Ocean & coastal management*, 148, 195-203. Doi: 10.1016/j.ocecoaman.2017.08.010

Bragagnolo, C., Pereira, M., Ng, K. & Calado, H. (2016). Understanding and mapping local conflicts related to protected areas in small islands: a case study of the Azores archipelago. Island Studies Journal.

Borges, P.A., Azevedo, E.B., Borba, A., Dinis, F.O., Gabriel, R., Silva, E. (2009) Ilhas Oceânicas. In: Pereira HM, Domingos T, Vicente L, Proença V (Eds) Ecossistemas e bem-estar humano em Portugal: Avaliação para Portugal do Millennium Ecosystem Assessment. Escolar Editora, Lisboa, 463-510pp. [In Portuguese]. URL: http://hdl.handle.net/10400.3/2011

Bouvy, M., Got, P., Domaizon, I., Pagano, M., Leboulanger, C., Bouvier, C., Carré, C., Roques, C., Dupuy, C. (2016). Plankton communities in the five Iles Eparses (Western Indian Ocean) considered to be pristine ecosystems. *Acta Oecologica*, 72, 9-20. DOI: 10.1016/j.actao.2015.10.013

Burkhard, B., Maes, J. (Eds) (2017). Mapping Ecosystem Services. Pensoft. ISBN: 9789546428295

Burkhard, B., Maes, J., Potschin-Young, M.B., Santos-Martín, F., Geneletti, D., Stoev, P., Kopperoinen, L., Adamescu, C.M., Adem Esmail, B., Arany, I., Arnell, A., Balzan, M., Barton, D.N., van Beukering, P., Bicking, S., Borges, P.A.V., Borisova, B., Braat, L.M., Brander, L.M., Bratanova-Doncheva, S., Broekx, S., Brown, C., Cazacu, C., Crossman, N., Czúcz, B., Daněk, J., Groot, R., Depellegrin, D., Dimopoulos, P., Elvinger, N., Erhard, M., Fagerholm, N., Frélichová, J., Grêt-Regamey, A., Grudova, M., Haines-Young, R., Inghe, O., Kallay, T.K., Kirin, T., Klug, H., Kokkoris, I.P., Konovska, I., Kruse, M., Kuzmova, I., Lange, M., Liekens, I., Lotan, A., Lowicki, D., Luque, S., Marta-Pedroso, C., Mizgajski, A., Mononen, L., Mulder, S., Müller, F., Nedkov, S., Nikolova, M., Östergård, H., Penev, L., Pereira, P., Pitkänen, K., Plieninger, T., Rabe, S., Reichel, S., Roche, P.K., Rusch, G., Ruskule, A., Sapundzhieva, A., Sepp, K., Sieber, I.M., Šmid Hribar, M., Stašová, S., Steinhoff-Knopp, B., Stępniewska, M., Teller, A., Vackar, D., van Weelden, M., Veidemane, K., Vejre, H., Vihervaara, P., Viinikka, A., Villoslada, M., Weibel, B., Zulian, G. (2018) Mapping and assessing ecosystem services in the

EU - Lessons learned from the ESMERALDA approach of integration. One Ecosystem 3: e29153. DOI: 10.3897/oneeco.3.e29153

Caselle, J.E., Hamilton, S.L., Davis, K., Bester, M., Wege, M., Thompson, C., Turchik, A., Jenkinson, R., Simpson, D., Mayorga, J., Rose, P., Fay, M., Myers, D., Glass, J., Glass, T., Green, R., Repetto, J., Swain, G., Herian, K., Lavarello, I., Hall, J., Schofield, A., Dews, S., McAloney, D., and Sala, E. (2017). Ecosystem Assessment of the Tristan Da Cunha Islands. National Geographic Pristine Seas, Royal Society for Protection of Birds and Tristan da Cunha Government. Expedition Report. July 2017.

Caillaud, A., Damiens, F., Salvat, B., & Wilkinson, C. (2011). Preventing coral grief: a comparison of Australian and French coral reef protection strategies in a changing climate. *Sustainability Development Law & Policy*. 12.

Clua, E., Buray, N., Legendre, P., Mourier, J., & Planes, S. (2011). Business partner or simple catch? The economic value of the sicklefin lemon shark in French Polynesia. Marine and Freshwater Research, 62, 764-770.

Coll M., Libralato S., Tudela S., Palomera I., Pranovi F. (2008). Ecosystem Overfishing in the Ocean. *PLoS ONE* 3(12): e3881. Doi: 10.1371/journal.pone.0003881

Collin, A., Archambault, P. & Planes, S. (2014). Revealing the regime of shallow coral reefs at patch scale by continuous spatial modeling. Frontiers in marine science. DOI: 10.3389/fmars.2014.00065

Cruz, A., Benedicto, J. & Gil, A. (2011). Socio-economic benefits of natura 2000 in Azores Islands - A case study approach on ecosystem services provided by a special protected area. *Journal of Coastal Research.*

Deas, M., Andréfouët, S., Léopold, M., Guillemot, N. (2014). Modulation of habitat-based conservation plans by fishery opportunity costs: a New Caledonia case study using fine-scale catch data. In *PloS one* 9 (5), e97409. DOI: 10.1371/journal.pone.0097409.

Dupuy, C., Pagano, M., Got, P., Domaizon, I., Chappuis, A., Marchessaux, G. & Bouvy, M. (2016). Trophic relationships between metazooplankton communities and their plankton food sources in the Iles Eparses (Western Indian Ocean). Marine Environmental Research. 116. DOI: 10.1016/j.marenvres.2016.02.011.

EU BEST (2016a). Profil d'écosystèmede la Guyane Française – Région Amazonie Européenne. 2016. Union européennes Régions Ultra-pèriphériques et Pays et Territoires d'Outre-mer. Marion Roger, Anna Cohen-Nabeiro, Ruben Lopez & Laurent Kelle. BEST, contract de service 07.0307.2013/666363/SER/B2, Commission Européenne, 2016, 167 p + 11 annexes

EU BEST (2016b). Regional ecosystem profile –Caribbean Region. EU Outermost Regions and Overseas Countries and Territories, Amandine Vaslet & Romain Renoux. BEST, Service contract 07.0307.2013/666363/SER/B2, European Commission, 261pp+ 5 Appendices.

EU BEST (2016c). Regional ecosystem profile – Macaronesian Region. 2016. EU Outermost Regions and Overseas Countries and Territories, Luisa Madruga, Francisco Wallenstein, José Manuel N. Azevedo. BEST, Service contract 07.0307.2013/666363/SER/B2, European Commission, 233 p + 10 Appendices.

EU BEST (2016d). Regional ecosystem profile – South Atlantic Region. EU Outermost Regions and Overseas Countries and Territories, Maria Taylor, Tara Pelembe & Paul Brickle. BEST, Service contract 07.0307.2013/666363/SER/B2, European Commission, 209p+ 3 Appendices.

EU BEST (2017a). Profil d'écosystème –Région Océan Indien. 2017. Union européennes Régions Ultra-pèriphériques et Pays et Territoires d'Outre-mer. Tanguy Nicolas, Léa Trifault & Yohann Legraverant. BEST, contract de service 07.0307.2013/666363/SER/B2, Commission Européenne, 2017, 366p + 3 annexes.

EU BEST (2017b). Regional ecosystem profile – Polar and Sub-polar Region. EU Outermost Regions and Overseas Countries and Territories, Claire-Sophie Azam, Cédric Marteau, Vincent Piton, Cynthia Borot, Paul Tixier. Terres australes et antarctiques françaises (TAAF). BEST, Service contract 07.0307.2013/666363/SER/B2, European Commission, 225p + 31 Annexes.

European Commission (unknown). The EU and international ocean governance. Experience and commitment towards sustainable and multilateral management. Available on https://www.eesc.europa.eu/sites/default/files/resources/docs/eu-and-international-ocean-governance_en.pdf. Accessed on June 2019.

European Commission (2008) Message from Reunion Island. The European Union and its Overseas Entities: Strategies to counter Climate Change and Biodiversity Loss, Reunion Island, 07.-11.06.2008. European Commission, 20 pp.

Failler, P., Montocchio, C., Binet, T., Borot, A., de Battisti and Maréchal, J.P. (2019). Monetary evaluation of marine reserve ecosystem services in the Caribbean. National Accounting Review, 2019, 1(1): 3-15. doi: 10.3934/NAR.2019.1.3

P. Failler, C. Montocchio, A. Borot de Battisti , T. Binet, J.-P. Maréchal, M. Thirot (2019). Sustainable financing of marine protected areas: the case of the Martinique regional marine reserve of “Le Prêcheur”. Green Finance, 2019, 1(2): 110-129. doi: 10.3934/GF.2019.2.110

Failler P., Pètre É., Binet T. and Maréchal J.-P. (2015). Valuation of marine and coastal ecosystem services as a tool for conservation: The case of Martinique in the Caribbean. Ecosystem Services. 11: 67-75. SNIP: 1.521

Binet T., Borot de Battisti a., Failler P. & Maréchal J.-P. (2014). Valeur économique totale des écosystèmes marins et côtiers de la future aire marine protégée régionale du Prêcheur (Martinique). URL : http://etudescaribeennes.revues.org/6620 ; DOI : 10.4000/etudescaribeennes.6620

Failler P., Pètre E. et Maréchal J.-P. (2010). « Valeur économique totale des récifs coralliens, mangroves et herbiers de la Martinique », Études caribéennes [En ligne]. URL : http://etudescaribeennes.revues.org/4410 ; DOI : 10.4000/etudescaribeennes.4410

Fayad, I., Baghdadi, N., Guitet, S., Bailly, J. S., Hérault, B., Gond, V., El Hajj, M., & Minh, D. H. T. (2016). Aboveground biomass mapping in French Guiana by combining remote sensing, forest inventories and environmental data. *International journal of applied earth observation and geoinformation*, *52*, 502-514. DOI: 10.1016/j.jag.2016.07.015

Ferrario, F., Beck, M.W., Storlazzi, C.D., Micheli, F., Shepard, C.C., & Airoldi, L. (2014). The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nature communications 13, 5:3794. DOI: 10.1038/ncomms4794.

Fonseca, C., da Silva, C. P., Calado, H., Moniz, F., Bragagnolo, C., Gil, A., Phillips, L., Pereira, M. & Moreira, M. (2014). Coastal and marine protected areas as key elements for tourism in small islands. *Journal of Coastal Research*, *70*(sp1), 461-467.

Gabrié, C. and Bossanyi-Johnson I. (1998). State of Coral Reefs in French Overseas Départements and Territories : New Caledonia, Wallis and Futuna, French Polynesia, Clipperton, Guadeloupe, Martinique, Mayotte, La Réunion, Scattered French Indian Ocean Islands”. Documentation Ifrecor. http://ifrecor-doc.fr/items/show/1503.

Ghermandi, A., & Nunes, P. A. (2013). A global map of coastal recreation values: Results from a spatially explicit meta-analysis. Ecological Economics 86. DOI: 10.1016/j.ecolecon.2012.11.006

Gigou, A., Dinhut, V., Arnaud, J-P. (2009). Richesses de Mayotte - Parc naturel marin de Mayotte - Un patrimoine naturel d’exception - Mission d’études pour la création d’un parc naturel marin à Mayotte [Resources of Mayotte - Natural Marine Park Mayotte - An exceptional natural heritage - Mission of studies for the creation of a marine park in Mayotte. Mayotte: Agence des Aires Marines Protégées.

Graham, N.A.J., & Nash, K.L. (2013). The importance of structural complexity in coral reef ecosystems. *Coral Reefs*, Volume 32, Issue 2, pp 315-326. DOI: 10.1007/s00338-012-0984-y

Grant, S. M., Hill, S. L., Trathan, P. N., & Murphy, E. J. (2013). Ecosystem services of the Southern Ocean: trade-offs in decision-making. *Antarctic Science*, *25*(5), 603-617. DOI: 10.1017/S0954102013000308.

Gravestock, P. & Sheppard, C. (2015). Valuing the ecosystem services of the Chagos: A review of challenges and estimates. Marine Ecology Progress Series. 530. DOI: 10.3354/meps11235

Grêt-Regamey, A., Weibel, B., Kienast, F., Rabe, S.E., Zulian, G. (2015): A tiered approach for mapping ecosystem services. Ecosystem Services 13, pp. 16–27. DOI: 10.1016/j.ecoser.2014.10.008.

Guitet, S., Herault, B., Couteron, P. & Sabatier, D. (2015). Ecosystem Services in French Guiana old-growth rainforests.

Halpern, B. S., Frazier, M., Afflerbach, J., Lowndes, J. S., Micheli, F., O'Hara, C., Scarborough, C. & Selkoe, K. A. (2019). Recent pace of change in human impact on the world's ocean. Scientific reports, 9(1), 1-8.

Haines-Young, R., Potschin-Young, M. (2018). Revision of the Common International Classification for Ecosystem Services (CICES V5.1): A Policy Brief. One Ecosystem 3: e27108. DOI: 10.3897/oneeco.3.e27108

Harborne, A.R., Mumby, P.J., Kappel, C.V., Dahlgren, C.P., Micheli, F., Holmes, K.E., & Brumbaugh, D.R. (2008). Tropical coastal habitats as surrogates of fish community structure, grazing, and fisheries value. *Ecological Applications*, *18*(7), 1689-1701.

Helms, M. and Nixon, J. (2010). Exploring SWOT analysis – where are we now? A review of academic research from the last decade. Journal of Strategy and Management, Vol. 3 No. 3, pp. 215-251. https://doi.org/10.1108/17554251011064837

Hicks, C.C. (2011). How Do We Value Our Reefs? Risks and Tradeoffs Across Scales in "Biomass-Based" Economies. In Coastal Management 39 (4), pp. 358–376. DOI: 10.1080/08920753.2011.589219.

Jaziri, W. (2007). Finding optimal directions for forest trees harvesting using GIS-based techniques. Environmental Science and Engineering. DOI: 10.1007/978-3-540-71335-7_46.

Kettunen, M., & Ten Brink, P. (2013). Social and economic benefits of protected areas: an assessment guide: Routledge. International Journal of the Commons. DOI: 10.18352/ijc.496

Kochenov, D. (2012). 'The Application of EU Law in the EU's Overseas Regions, Countries, and Territories after the Entry into Force of the Treaty of Lisbon', 20(2) Michigan State Journal of International Law, pp. 669–743

Kubiszewski, I., Anderson, S. J., Costanza, R., & Sutton, P. C. (2016). The Future of Ecosystem Services in Asia and the Pacific. Asia & the Pacific Policy Studies. DOI:10.1002/app5.147

Kushner, B., Waite, R., Jungwiwattanaporn, M. and Burke, L. (2012). Influence of Coastal Economic Valuations in the Caribbean: Enabling Conditions and Lessons Learned. Working Paper. Washington, DC: World Resources Institute. Available online at http://www.wri.org/coastal-capital.

La Bianca G., Tillin H., Hodgson B., Erni-Cassoll G., Howell K., & Rees S. (2018). Ascension Island-Natural Capital Assessment.

Lagabrielle, E., Botta, A., Daré, W., Aubert, S. & Fabricius, C. (2010). Modelling with stakeholders to integrate biodiversity into land-use planning - Lessons learned in Réunion Island (Western Indian Ocean). Environmental Modelling and Software 25, 1413–1427.

Laurans, Y., Pascal, N., & Binet, T. (2013). Economic valuation of ecosystem services from coral reefs in the South Pacific: Taking stock of recent experience. Journal of Environmental Management 116C:135-144. DOI: 10.1016/j.jenvman.2012.11.031

Leenhardt, P., Low, N., Pascal, N., Micheli, F., & Claudet, J. (2015). The role of marine protected areas in providing ecosystem services. Aquatic functional biodiversity: an ecological and evolutionary perspective. London: Elsevier Inc. DOI: 10.1016/B978-0-12-417015-5.00009-8

Littaye, A., Lardon, S. & Allonce, N. (2016). Stakeholders' collective drawing reveals significant differences in the vision of marine spatial planning of the western tropical Pacific. Oceans and Coastal Management 130:260-276. DOI: 10.1016/j.ocecoaman.2016.06.017

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J. P., Grizetti, B., Drakou, E.G., La Nozzr, A., Zulian, G., Bouraoui, F., Paracchini, M.L., Braat, L., & Bidoglio, G. (2012). Mapping ecosystem services for policy support and decision making in the European Union. Ecosystem services, 1(1), 31-39.

Maes, J., Teller, A., Erhard, M., Grizzetti, B., Barredo, J.I., Paracchini, M.L., Condé, S., Somma, F., Orgiazzi, A., Jones, A., Zulian, A., Vallecilo, S., Petersen, J.E., Marquardt, D., Kovacevic, V., Abdul Malak, D., Marin, A.I., Czúcz, B., Mauri, A., Loffler, P., Bastrup-Birk, A., Biala, K., Christiansen, T., Werner, B. (2018). Mapping and Assessment of Ecosystems and their Services: An analytical framework for ecosystem condition. Publications office of the European Union, Luxembourg.

Maréchal J.-P. & Trégarot E (2016a). Tropical Marine Ecosystem Services. Report 2.1. Payments for Marine protected area ecosystem services in the Caribbean (CARIPES). Preparatory Action 'BEST' (Voluntary scheme for Biodiversity and Ecosystem Services in Territories of the EU Outermost Regions and Overseas Countries and Territories). 37p.

Maréchal J.-P. & Trégarot E. (2016b). Quantification of Ecosystem Services and Users. Report 2.3. Payments for Marine protected area ecosystem services in the Caribbean (CARIPES). Preparatory Action 'BEST' (Voluntary scheme for Biodiversity and Ecosystem Services in Territories of the EU Outermost Regions and Overseas Countries and Territories). 30p.

Maréchal J.-P., Trégarot E. & Meesters E.(2016). Ecological assessment and health status indicators. Report 2.2. Payments for Marine protected area ecosystem services in the Caribbean (CARIPES). Preparatory Action 'BEST' (Voluntary scheme for Biodiversity and Ecosystem Services in Territories of the EU Outermost Regions and Overseas Countries and Territories). 88p.

Marre, J., Brander, L. & Thebaud, O. (2015). Non-market use and non-use values for preserving ecosystem services over time: A choice experiment application to coral reef ecosystems in New Caledonia. *Oceans and Coastal Management*, Volume 105, pp 1-14. DOI: 10.1016/j.ocecoaman.2014.12.010

Martín-García, L., Sangil, C., Brito, A., & Barquín-Diez, J. (2015). Identification of conservation gaps and redesign of island marine protected areas. Biodiversity and conservation, 24(3), 511-529.

McClanahan, T.R., Maina, J.M., Graham, N.A., & Jones, K.R. (2016). Modeling reef fish biomass, recovery potential, and management priorities in the western Indian Ocean. *PloS one* 11(6): e0156920. DOI: 10.1371/journal.pone.0156920

Miura, S., Amacher, M., Hofer, T., San-Miguel-Ayanz, J., Ernawati, Thackway, R. (2015). Protective functions and ecosystem services of global forests in the past quarter-century. In Forest Ecology and Management 352, pp. 35–46. DOI: 10.1016/j.foreco.2015.03.039.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Steward, L.A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P). Systematic Reviews4 (1), p.1. DOI: 10.1186/2046-4053-4-1.

Murienne, J. (2009). New Caledonia: Biology. Encyclopedia of islands, 643-645.

Murray B.C., Jenkins W. A., Sifleet S., Pendleton L., and Baldera A., 2011a. Payments for Blue Carbon: Potential for Protecting Threatened Coastal Habitats. Policy brief: Nicholas Institute for Environmental Policy Solutions, Duke University.

Mustapha, M. A., Lihan, T., & Khalid, L. I. (2014). Coral reef and associated habitat mapping using ALOS satellite imagery. *Sains Malaysiana*. 43. 1363-1371.

Nunes, P.A., Ghermandi, A., Onofri, L. (2014) Guidance manual on valuation and accounting of ecosystem services for small island developing states. UNEP, Ecosystem Services Economics Unit, Division of Environmental Policy Implementation, 128pp. [ISBN 978-92-807-3407-2].

Pascal, N. (2010). Ecosystèmes coralliens de Nouvelle-Calédonie Valeur économique des services écosystémiques Partie I: Valeur financière. In IFRECOR Nouvelle-Calédonie, Nouméa 155.

Pascal, N., Allenbach, M., Brathwaite, A., Burke, L., Le Port, G., Clua, E. (2016). Economic valuation of coral reef ecosystem service of coastal protection: A pragmatic approach. Ecosystem Services 21, pp. 72–80. DOI: 10.1016/j.ecoser.2016.07.005.

Petit, J., & Prudent, G. (2008). Climate change and biodiversity in the European Union Overseas entities. UICN, Brussels. 178 pp.

Pérez-Maqueo, O., Intralawan, A., & Martínez, M. L. (2007). Coastal disasters from the perspective of ecological economics. Ecological Economics, 63(2-3), 273-284.

Picanço, A., Gil, A.J.F., Rigal, F., & Borges, P.A. (2017). Pollination services mapping and economic valuation from insect communities: a case study in the Azores (Terceira Island). *Nature Conservation*, *18*, 1-25. DOI:10.3897/natureconservation.18.11523

Price, A.R.G., Harris, A., McGowan, A., Venkatachalam, A.J. & Sheppard, C.R.C. (2010). Chagos feels the pinch: Assessment of holothurian (sea cucumber) abundance, illegal harvesting and conservation prospects in British Indian Ocean Territory. Aquatic Conservation: Marine and Freshwater Ecosystems 20(1). DOI: 10.1002/aqc.1054

Quintas-Soriano, C., Martín-López, B., Santos-Martín, F., Loureiro, M., Montes, C., Benayas, J., & García-Llorente, M. (2016). Ecosystem services values in Spain: A meta-analysis. Environmental Science and Policy, 55:186–195. DOI: 10.1016/j.envsci.2015.10.001

Rees S., Fletcher S., Clingham E. (2016). Marine Ecosystem Services Assessment of St Helena. A report for the Environment and Natural Resources Directorate, St Helena Government by the Centre for Marine and Coastal Policy Research, Plymouth University.

Régine, M. B., Gilles, D., Yannick, D., & Alain, B. (2006). Mercury distribution in fish organs and food regimes: Significant relationships from twelve species collected in French Guiana (Amazonian basin). Science of the Total Environment, 368(1), 262-270.

Reichel, S., Klug, H. (2018). An online method database for mapping and assessing ecosystem services. One Ecosystem 3: e25542. DOI: 10.3897/oneeco.3.e25542

Ressurreição, A., Gibbons, J., Kaiser, M., Dentinho, T. P., Zarzycki, T., Bentley, C., Austen, M., Burdon, D., Atkins, J., Santo, R.S. & Edwards-Jones, G. (2012). Different cultures, different values: The role of cultural variation in public's WTP for marine species conservation. Biological Conservation, 145(1), 148-159. DOI: 10.1016/j.biocon.2011.10.026

Ressurreicao, A & Giacomello, E. (2013). Quantifying the direct use value of Condor seamount. *Deep-Sea Research Part II: Tropical Studies in Ocean*ography. DOI: 10.1016/j.dsr2.2013.08.005

Rossi, V., Dolley, T., Cornu, G., Guitet, S. & Hérault, B. (2015). GuyaSim, a decision-support tool for forest planning: Application in French Guiana | [GuyaSim: Un outil d'aide à la décision pour l'aménagement d'un territoire forestier, la Guyane]. Bois et Foret des Tropiques, N° 326 (4). DOI: 10.19182/bft2015.326.a31285

Russi D., Pantzar M., Kettunen M., Gitti G., Mutafoglu K., Kotulak M. & ten Brink P. (2016). Socio-Economic Benefits of the EU Marine Protected Areas. Report prepared by the Institute for European Environmental Policy (IEEP) for DG Environment

SAERI. (2018). Falkland Islands Natural Capital Assessment: Understanding the Value of land-based tourism.

Santos-Martín F, Viinikka A, Mononen L, Brander L, Vihervaara P, Liekens I, Potschin-Young M (2018) Creating an operational database for Ecosystems Services Mapping and Assessment Methods. One Ecosystem 3: e26719. https://doi.org/10.3897/

Santos-Martín F, Geneletti D, Burkhard B (2019) Mapping and assessing ecosystem services: Methods and practical applications. One Ecosystem 4: e35904. DOI: 10.3897/oneeco.4.e35904

Santos-Martín, F., Gonzalez, A., Garcia, S. & Alcorlo, P. (2015). La aproximación de los servicios de los ecosistemas aplicada a la gestión pesquera. Fondo Europeo de Pesca, Fundación Biodiversidad del Ministerio de Medio Agricultura, Alimentación y Medio Ambiente. Madrid.

Sarkis, S., van Beukering, P. J., McKenzie, E., Hess, S., Brander, L., Roelfsema, M., & Bervoets, T. (2010). Total Economic Value of Bermuda's Coral Reefs Valuation of Ecosystem Services. Report for the Department of Conservation Services of the Government of Bermuda.

Schep, S., Johnson, A., van Beukering, P., & Wolfs, E. (2012). The fishery value of coral reefs in Bonaire. IVM Institute for Enironmental Studies, Amsterdam, The Netherlands.

Schleupner, C. (2008). Evaluation of coastal squeeze and its consequences for the Caribbean island Martinique. Ocean and Coastal Management, 51(5):383-390. DOI: 10.1016/j.ocecoaman.2008.01.008

Schmiing, M., Diogo, H., Santos, R. S., & Afonso, P. (2014). Assessing hotspots within hotspots to conserve biodiversity and support fisheries management. Marine Ecology Progress Series, 513, 187-199.DOI: 10.3354/meps10924

Scopélitis, J., Andréfouët, S., Phinn, S., Tourrand, C. & Done, T. (2009). Changes of coral communities over 35 years: Integrating in situ and remote-sensing data on Saint-Leu Reef (la Réunion, Indian Ocean). Estuarine, coastal and shelf Science, Volume 84, Issue 3, p. 342-352. DOI: 10.1016/j.ecss.2009.04.030

Scott, A., Mori, C.A., Gracie & Mitchell, J.D. (1999). Le Centre de la Guyane française: Une expérience unique et rude. *Journal d'Agriculture Traditionnelle et de Botanique Appliquée*.

Sieber, I., Borges, P., Burkhard, B. (2018). Hotspots of biodiversity and ecosystem services: the Outermost Regions and Overseas Countries and Territories of the European Union. One Ecosystem 3: e24719. DOI: 10.3897/oneeco.3.e24719

Smith, N. (2019). Tristan da Cunha Natural Capital Assessment Waste Management

Teelucksingh, S., Eckert, S., & ALD Nunes, P. (2010). Marine turtles, ecosystem services and human welfare in the marine ecosystems of the Caribbean Sea: a discussion of key methodologies. *Études caribéennes*. DOI: 10.4000/etudescaribeennes.10990

Tempera F., Liquete, C. & Cardoso, A.C. (2016). Spatial distribution of marine ecosystem service capacity in the European seas. EUR 27843. Luxembourg (Luxembourg): Publications Office of the European Union. DOI: 10.2788/753996

Thiault L, Collin A, Chlous F, Gelcich S, Claudet J (2017) Combining participatory and socioeconomic approaches to map fishing effort in small-scale fisheries. PLoS ONE 12(5): e0176862. DOI: 10.1371/journal.pone.0176862

Tieskens, K. F., Schep, S. W., Van Beukering, P. J. H., Van Beek, I. J. M., & Wolfs, E. M. (2014). Mapping the economic value of ecosystems on St Eustatius. IVM Institute for Environmental Studies, Amsterdam, Wolfs Company, Bonaire.

Trégarot, E., Failler, P., Maréchal, JP. (2017). Evaluation of coastal and marine ecosystem services of Mayotte: Indirect use values of coral reefs and associated ecosystems. In International Journal of Biodiversity Science, Ecosystem Services & Management 13 (3), pp. 19–34. DOI: 10.1080/21513732.2017.1407361.

Upson, R., McAdam, J., & Clubbe, C. (2016). Climate Change Risk Assessment for Plants and Soils of the Falkland Islands and the Services they provide.

Uyarra, M.C., Cote, I.M., Gill, J.A., Tinch, R.R., Viner, D., & Watkinson, A.R. (2005). Island-specific preferences of tourists for environmental features: implications of climate change for tourism-dependent states. *Environmental conservation*, *32*(1), 11-19.

van Beukering, P., Botzen, W. & Wolfs, E. (2012). The non-use value of nature in the Netherlands and the Caribbean Netherlands - Applying and comparing contingent valuation and choice modelling approaches. *IVM Institute for Environmental Studies*, Amsterdam, Wolfs Company, Bonaire.

van Beukering, P., Brander, L., Tompkins, E., & Mackenzie, E. (2007). Valuing the environment in small islands: An environmental economics toolkit. ISBN 978 1 86107 5949

van Beukering, P., Sarkis, S., van der Putten, L., Papyrakis, E. (2015). Bermuda's balancing act: The economic dependence of cruise and air tourism on healthy coral reefs. In Ecosystem Services 11, pp. 76–86. DOI: 10.1016/j.ecoser.2014.06.009.

van Zanten, B., & van Beukering, P. (2012). Coastal Protection services of coral reefs in Bonaire. IVM Institute for Environmental Studies, Amsterdam, The Netherlands.

Van Zanten, B., Laclé, F., van Duren, S., Soberon, V. & van Beukering, P. (2018). The Value Natural Capital for the Tourism Industry of Aruba. Wolfs Company and IVM Institute for Environmental Studies, Amsterdam, The Netherlands, Yabi Consultancy, Aruba.

Vilhjálmsson H. (2002). Capelin (Mallotus villosus) in the Iceland–East Greenland–Jan Mayen ecosystem. – ICES Journal of Marine Science, 59: 870–883.

Wong, P.P. (1993). Tourism vs Environment. The case for coastal areas. Springer Science & Business Media [ISBN 978-94-011-2068-5]

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J., Watson, R. (2006) Impacts of Biodiversity Loss on Ocean Ecosystem Services. Science 314 (5800): 787 -790. DOI: 10.1126/science.1132294