BASMATI

Baltic Sea Maritime Spatial Planning for Sustainable Ecosystem Services

Proposal for an ecosystem service framework for assessment of impacts of planning alternatives in a MSP perspective

Deliverable 4.1

BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

BONUS BASMATI

Proposal for an ecosystem service framework for assessment of impacts of planning alternatives in a MSP perspective

February 2018

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Contents

BONUS Basmati in brief

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Blue Baltic

Project coordinator:
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Project abstract:
Maritime Spatial Planning (MSP) requires a spatially explicit framework for decision-making, and on that background the overall objective of BONUS BASMATI is to develop integrated and innovative solutions for MSP from the local to the Baltic Sea Region scale. This is to be realised through multi-level governance structures and interactive information technology aiming at developing an ecologically and socio-economically sound network of protected marine areas covering the Baltic Sea. Based on the results of former MSP projects, the BONUS BASMATI project sets out to analyse governance systems and their information needs regarding MSP in the Baltic Sea region in order to develop an operational, transnational model for MSP, while maintaining compliance with existing governance systems. It also develops methods and tools for assessments of different plan-proposals, while including spatially explicit pressures and effects on maritime ecosystem services in order to create the Baltic Explorer, which is a spatial decision support system (SDSS) for the Baltic Sea region to facilitate broad access to information. During the project running until 2020, new data will be produced and tested in assessments corresponding to policy goals. The data will support the combined analysis of the three elements of the concept of ecosystem services: the capacity, flow and benefit of provisioning, regulating and cultural services. A central aim of the project is to facilitate cross-border collaboration, and the project is carried out in close cooperation with relevant stakeholders in the BSR. The impact of the project will be facilitated and assessed in transnational case studies, where integrated solutions are required. The local scale will consist of case study areas in the South-West Baltic, the Latvian territorial and EEZ waters including open part of the Baltic Sea and the Gulf of Riga, and across the region, a pan-Baltic case study will be performed.

Report Summary

Marine ecosystems are increasingly affected by maritime activities, and several EU policies, such as the EU Directive on Maritime Spatial Planning (MSP), aim at striking a balance between blue growth and an environmentally sustainable management of the seas. We shortly review ecosystem-based management and impact assessments frameworks in light of MSP and show that they are not sufficiently comprehensive for addressing both environmental, social and economic impacts of MSP alternatives, and neither integrated enough to assist prioritization among these. We argue that adaptations to the DPSIR framework can accommodate the integration of ecosystem services as an approach to address multiple - both positive and negative - outcomes from introducing new maritime activities in sea regions. The ecosystem service concept clearly relates marine ecosystems, through a flow of services, to the multiple benefits humans can receive from them. Integrating it into the DPSIR framework allows for conceptualization of the way human drivers influence the ecosystems' processes and functions, and the need to find management responses if impact assessments turn out in undesired ways.

A comprehensive review on extant ecosystem service classifications show that there are three main classifications: The Millennium Ecosystem Assessment (MA), the Economics of Ecosystems and Biodiversity (TEEB), and the Common International Classification of Ecosystem Services (CICES). All three have been modified and applied to the marine environment but they differ in the definitions of ecosystem services, the categories used and the level of complexity. For the purpose of BONUS Basmati, we propose to depart in CICES as it is most commonly used in Europe and is flexible enough to allow for modifications. As CICES does not specifically refer to marine ecosystems, we propose modifications to make it marine-specific and MSP relevant. The main modification proposed for the latter is the inclusion of abiotic ecosystem services, such as the provision of raw materials and hydrophysical energy, as these are highly relevant for MSP. As ecosystems are composed of both the living and the non-living environment, the inclusion of abiotic ecosystem processes and outputs into ecosystem service classifications can be justified. Since this is work in progress, the first proposal for a modified ecosystem service framework is presented here and we expect that some additional modifications might occur subsequently.
In order to operationalize ecosystem services, the selection of adequate indicators is necessary. A structuring framework to identify indicators is the ecosystem cascade by Haines-Young and Potschin. A literature review shows that the different steps of the cascade and corresponding indicators are interpreted quite differently among studies. Therefore, we propose clear definitions for the cascade steps and an indicator list that is structured accordingly, which shall serve as an inspiration for case-study specific selections of indicators in BONUS Basmati. Vice versa, it is expected that the case studies will provide input to the development and specification of the indicator list as well as to the ecosystem service framework.

1 Introduction

Recent years have seen several policy initiatives on European level responding to two interlinked challenges in the management of the marine space. The first challenge identified was the increased human pressure on the marine environment and resources. As in many other sea regions, the EU expects and supports a huge development of economic activities at sea. This is clearly expressed in the EU Blue Growth Strategy that aims to expand economic activities in the European Seas for creating growth and jobs in a sustainable manner – thereby forming the maritime pillar of the EU 2020 strategy (COM(2012) 494 final). Several actions realize this strategy, including those for information sharing, education, research and innovation, as well as for ensuring sustainability, supported by e.g. the Marine Strategic Framework Directive (2008/56/EC).

A critical element in any strategy for Blue Growth is that maritime activities require space. Some activities may be compatible, others contradictory, and ultimately, marine space may become scarce, as already acknowledged e.g. in the Blue Growth Strategy: *'Lack of available maritime space for aquaculture activities…are amongst the challenges to growth'* (COM(2012) 494 final, p 8). It is argued that different policy areas such as environment, fisheries, maritime transport, and offshore energy, amongst others, are managed in a way that is not sufficiently coordinated across maritime sub-regions – thereby running the risk of undermining each other.

The need for integrated and holistic approaches to the management of the maritime sectorial interests and activities while ensuring an environmentally sustainable marine development was acknowledged by the EU Thematic Strategy on the Protection and Conservation of the Marine Environment (COM(2005)504 final). The adoption of an Integrated Maritime Policy for the European Union (COM(2007) 574 final) followed, aiming to reconcile different sectorial interests in coordinated governance approaches at all levels and to support cost effective shared data. In 2008 the EU adopted the Marine Strategy Framework Directive (MSFD, 2008/56/EC), defining the environmental pillar of the EUs marine policy. Together, these policies aimed to ensure a sustainable development by halting the deterioration of the marine environment, the associated erosion of its ecological capital, and to highlight the disastrous impacts that further deterioration could have on economic activities and employment. They promote the Thematic Strategy's overall objective to ensure present and future generations' enjoyment and benefit from 'biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive'.

The next challenge was to address the multiple uses of the marine space, and to find ways in which it is possible to transparently prioritize between conflicting uses and seek synergies where possible. This challenge is addressed by the EU in the Directive on Maritime Spatial Planning (DMSP), aiming to advance the increase in the human utilization of the marine space and the socio-economic potentials to be further developed for economic growth and human well-being (2014/89/EU). The directive's aims are to

- Reduce conflicts between sectors and create synergies between different activities.
- Encourage investment – by creating predictability, transparency and clearer rules.
- Increase cross-border cooperation – between EU countries to develop energy grids, shipping lanes, pipelines, submarine cables and other activities, but also to develop coherent networks of protected areas.
- Protect the environment – through early identification of impact and opportunities for multiple use of space.

Planning is a holistic discipline, and spatial plans are suitable methods to ensure coherence and prevent conflicts between sectoral interests and policies, as already realized by the EU in the approach to a balanced territorial development (European Spatial Development Perspective (EC, 1999)). Moving from terrestrial to marine contexts however, presents new challenges – in terms of both the complexity and the gaps in knowledge of the marine ecosystems, and in terms of management approaches. While the use of terrestrial space is often described through land use, the use of marine space can both address the sea surface, the water column, or the seabed. In addition, a lack of spatial overlap between human activity and sensitive ecosystems is not necessarily a guarantee for lack of impact (e.g. excess of nutrients may be transported to other more fragile ecosystems). It has been argued that the ecological and regulatory concerns may have prevented the planning disciplines to take a forefront in the discussion of the analytical approach to MSP, representing an 'underdevelopment of planning rationales shaping the marine environment as space from a spatial and sense-of-place perspective' (Gazzola et al., 2015). In addition, the featureless surface combined with remoteness to settlements, may have resulted in a certain reluctance to map the oceans (Guerry et al., 2012). However, recent approaches to planning using an ecosystem

service approach, seems to some extent to address these aspects more explicitly, by also including cultural issues related to sense-of-place (Lillebø et al., 2016; Ivarsson et al., 2017).
MSP practices usually depart in approaches that – in line with most planning processes – involve several consecutive actions. Ehler and Douvere (2009) describe the Maritime Spatial Planning process as a number of steps, which take place in the pre-planning process, as well as in the phases where the existing conditions are analyzed, where future conditions are defined and analyzed, and where the plan is approved and implemented. We can identify three main phases in which an assessment framework and corresponding indicators are useful. These cover the analysis of existing conditions, and the exploration of implications of future scenarios designed to fulfill policy and development objectives. Also monitoring the later implementation of the adopted plan usually builds on indicators, which are, however, not necessarily the same as for assessment of impacts. The phases are illustrated with the red circles in figure 1, in which the main steps of MSP are described as a circular process, to indicate an adaptive management approach, where monitoring and evaluation provide the bases for subsequent learning and adaptation in a new planning phase.

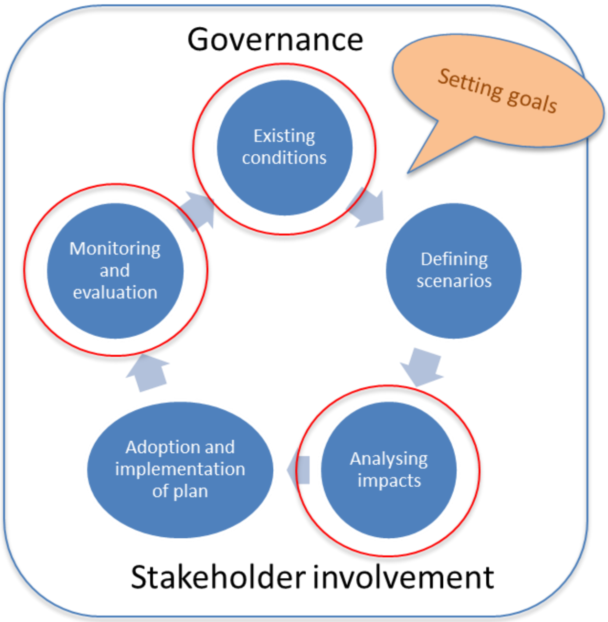

Figure 1
The planning cycle

The depth and detail of the assessment of alternative scenarios on maritime sustainable development, however, varies widely between different practices and guidelines.

The HELCOM-VASAB guideline on implementing the ecosystem-based approach in the context of maritime spatial planning (MSP) in the Baltic Sea recommends a number of analyses to be considered in the planning process. These include *Alternative development: Reasonable alternatives shall be developed to find solutions to avoid or reduce negative environmental and other impacts as well as impacts on the ecosystem goods and services*[1]*.* The guideline is specific and detailed in terms of environmental assessments and the incorporation of Strategic Environmental Assessments (SEA) in the planning process, and it suggests that impact assessments might demand more investigations during the planning procedures to be able to make sustainable decisions. In the planning step *'Setting goals'*, a subsection is *'Identification of issues, investigations and impact assessment'*. This involves ensuring the identification and valuation of ecosystem services (ibid, p. 14). However, the way this identification and valuation is to be used in later steps of the planning process, including in trade-off analyses is not clear, and it seems that there is a need for further work on these issues.

Due to the often transboundary nature of the maritime activities, policies on marine management suggest that harmonized approaches should be developed for the prevention of pick-and-choose approaches, and for facilitating cross-border co-operation[2]. This provides an argument for a unified

[1] Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area. Adopted by the 72nd meeting of VASAB CSPD/BSR on 8 June 2016 and approved by HELCOM HOD 50-2016 on 15-16 June 2016.

[2] Commission staff working document Impact Assessment (SWD(2013) 65 final), accompanying the MSP Directive proposal.

framework of criteria and indicators to be used in assessment of alternative planning scenarios. As plans will be highly varied due to different preconditions for economic and social development as well as different development goals in national and local contexts, such a framework might be generic for the regional sea(s), so each planning exercise could choose those criteria and indicators that are relevant for the planning and actual sea area.

The aim of the present report is to contribute to such a development. We will first describe our departure in what is now well known as ecosystem-based management, followed by an argument of why we aim for a framework for impact assessment that builds on the ecosystem service (ESS) concept, and why we see this as embedded in the environmental assessment framework called DPSIR. Next, we review existing recent literature on ecosystem service frameworks and propose a framework and criteria for the BONUS Basmati project. We populate this framework with existing indicators from scientific articles, terrestrial ESS frameworks and HELCOM indicators. Based on a short summary of user objectives expressed in policy and planning objectives related to the Baltic Sea, we ask experts close to the MSP processes to provide feedback on criteria and indicators.

The resulting framework and indicators will be tested and evaluated in the BONUS Basmati case studies for further complementation and adjustment.

2 Ecosystem-based management and impact assessments

2.1 EBM underpinning impact assessments in MSP

The concept of Ecosystem Based Management (EBM) emerged from an increasing consideration of the management insufficiency of sector-based policy and regulation and silo-structured approaches. Integration became a key-word already in the 1960'ies and 70'ies, as demonstrated, for instance, in the concepts of integrated coastal zone management, ICZM (Douvere, 2008). EBM captures the essence of this integration by including humans as part of the system to be managed (Crowder and Norse, 2008). While there is broad consensus on the intrinsic values of ocean ecosystems and on integrating aspects of improved management approaches, there is, however, no well-defined consensus on the principles and criteria on which EBM should rest (Long et al., 2016). The principles and definition of an Ecosystem Approach used by HELCOM and the OSPAR Commission derive from the work with the Convention on Biological Diversity, and is closely related but not identical to the Convention's definition[3]. It reads as follows:

The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity. The application of the precautionary principle is equally a central part of the ecosystem approach.[4]

Some of the principles concerning integration between sectors and actors are well-known in today's environmental policy approaches, as exemplified in the Water Framework Directive or the Marine Strategy Framework Directive. It has however, been argued that progress in transferring the principles into real-world applications has been slow (Arkema et al., 2006, Douvere, 2008). An example of this is that the definition above focuses on integrating sector pressures that affect ecosystem health, but it does not describe the impacts that new activities may have for other economic and social ecosystem services, which are linked to marine or coastal ecosystems. We argue that a framework for impact assessment may help to establish and integrate ecological, social and economic impacts that are caused by changes in human activities and pressures.

[3] Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area. Adopted by the 72nd meeting of VASAB CSPD/BSR on 8 June 2016 and approved by HELCOM HOD 50-2016 on 15-16 June 2016
[4] 2003 Joint HELCOM and OSPAR Ministerial Statement on the Ecosystem Approach to the Management of Human Activities

2.2 Frameworks for impact assessments

Environmental impact assessments have been a requirement in the EU since 1985, where the Environmental Impact Assessment Directive was adopted. The scope of this directive was to prevent environmental impacts from larger projects by assessing these before the projects were finally designed and decided. This was later followed by a directive on Strategic Environmental Assessment, which was adopted in 2001, and aimed at assessing the environmental impact of plans and policies, requiring elaboration of alternative options to be assessed. Finally, the EU adopted a procedure for policies at the EU level as part of its Better Regulation Agenda, aiming at improving policy proposals. (Tscherning et al., 2008). The procedure was initiated with a communication from the Commission (2002), and implied ex-ante impact assessment of alternative policy options – the latter to address both economic, social and environmental implications of policy options.

Following this, it is clear that the SEA procedure is mandatory for maritime plans according to EU law, and this is addressed in the HELCOM-VASAB guideline (2016). While the SEA is mandatory, no common policy requires socio-economic assessments. This has led some countries to adopt national procedures for assessing social and economic dimensions (Zaucha, 2014, Schmidtbauer-Crona, 2012). The UK requires Sustainability Appraisal (SA) of all maritime plans (program level), while in Germany socio-economic assessments (project level) are implemented under a Territorial Impact Assessment procedure. Zaucha (2014) discusses if a SA procedure should be introduced as a minimum for MSP in the Baltic Sea. With the EBM principles in mind, it seems obvious that social and economic impacts of future 'blue growth' scenarios should be identified and described in order to highlight management priorities. How to strike the balance of detail and extent between project oriented assessments and assessments of plans remains a question that needs to be solved, but a framework for impact assessment needs to take into account all sustainability dimensions. In the following, we discuss frameworks that could support this aim.

Well-known environmental impact assessment frameworks are PSR, DSR and DPSIR (driver, pressure, state, impact and response), used by OECD and EEA – see figure 3 for a conceptual model of the DPSIR framework that is exemplified for the oceans.

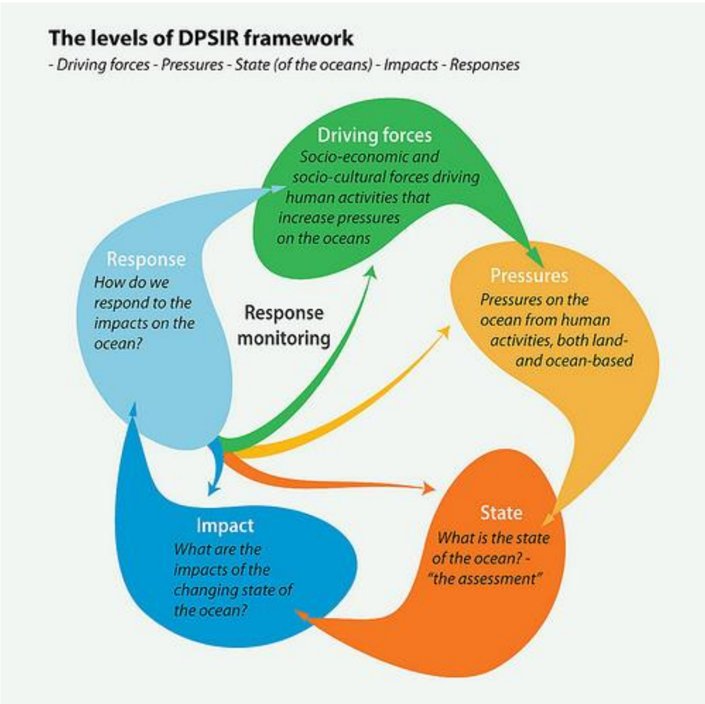

Figure 2

The DPSIR environmental assessment framework (Grid-Arendal, https://www.grida.no/resources/8124)

The DPSIR framework has been widely adopted, especially for organizing State of the Environment reports and for producing environmental assessments (EEA, 2014). It has been discussed, if the DPSIR conceptual model sufficiently takes into account the situations where one activity gives rise to different types of pressures, or where different activities (such as dredging, benthic trawling or anchoring) give rise to the same pressure (such as abrasion) (Smith et al., 2016). Moreover, it has been argued that the impact component of the framework is mainly addressing negative impacts on the environment, and with this focus usually does not cater for management responses that aim at win–win situations for socio-economic and environmental goals (Kelbe et al., 2013).

Sustainability assessments on the other hand take into account a broader range of impacts, as social, economic and environmental aspects need to be integrated. Hacking and Guthrie (2008) defined three aspects to be critical for Sustainable development assessments (SDA):

- SD 'themes' are covered ('comprehensiveness').
- The assessment techniques that are used and/or the themes that are covered are aligned/connected/compared/combined ('integratedness').
- The focus/perspective is broad and forward-looking ('strategicness').

Frameworks for assessing the sustainability of future scenarios for the use of the marine space are structuring tools, which can support the planning of which activities can be allowed, enhanced, or forbidden in the sea space, in order to cater for policies on Blue Growth - or other strategies - while ensuring that sustainability aspects are identified in decision-making processes. While the future scenarios and plans are directed towards the desired outcomes, sustainability assessments address the broader impacts, i.e. which other uses and benefits does the ecosystems contribute to, and how are these affected by the scenarios or plans. From a technical point of view, such assessments are often carried out by the means of indicators (Waas et al., 2014).

A challenge for BONUS Basmati is thus to develop a framework that addresses these broader aspects and impact themes involved. It can be argued that for MSP, the 'strategicness' perspective is already provided, as the planning process is forward looking, and the alternative scenarios are meant to inform planners and policy makers about possible future development. In order to be comprehensive, it is important, as stated above, that analyses of impacts take into account both the (present and future) beneficiaries, and the changes in the sustainability dimensions when scenarios for intensifying human activities at sea are evaluated. In the following, we will argue to use the ecosystem service concept for ensuring the comprehensiveness and 'integratedness'.

2.2.1 Ecosystem services

Moving from a single sector approach to a planning and management practice that takes into account several sectors exerting multiple pressures on ecosystems, which on their side each may provide several services, requires methods and tools to support this practice. In the MSP perspective, concepts and methods are needed that can address the impact that new activities or measures will have on marine ecosystems and their use and value for humans, while remembering the services already provided by the same ecosystems. The Ecosystem Services concept has been suggested as an approach that can ensure that ecosystem health and human well-being dimensions are both integrated into the impact assessment procedures (Hasler et al., 2016; Ivarsson et al., 2017).

So how do ecosystem services appear in indicator frameworks? Müller and Burkhard (2012) places ecosystem services in the DPSIR framework, so it appears as a new box between state and impact, see figure 2. Impact I signifies that changes in the state of the ecosystems will affect the ecosystem services, which will again result in impacts (II) on human wellbeing. This perspective is the same as taken by Kelbe et al. (2013), who argues that a EBM-DPSER framework can be used, where the DPSIR category 'impact' is substituted by a category for ecosystem services. Müller and Burkhard (2012) divides the impact category into an ecosystem service category and a benefit/wellbeing category – thereby allowing for an important division for flow of ecosystem services and their contribution to human well-being (through benefits and their valuation).

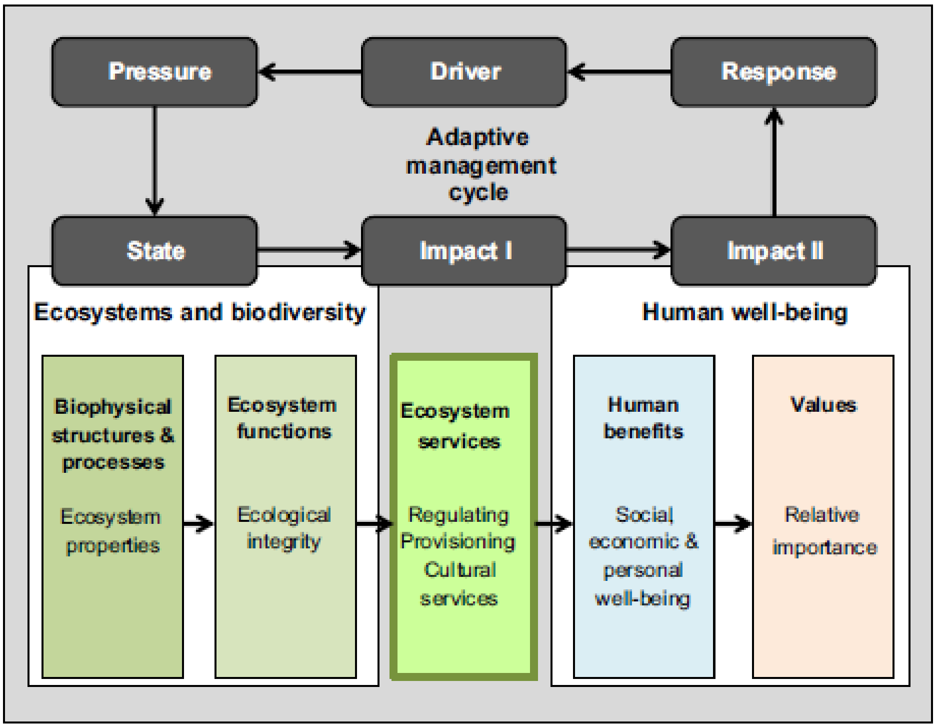

Figure 3
Ecosystem services linked to the DPSIR framework (Müller and Burkhard, 2012)

This approach seems to have several advantages: the idea of ecosystem services, being flows from ecosystems that are turned into human benefit and ultimately values, are accommodated, and the causal link to drivers and pressures are retained. When ecosystem services are explored in today's state-of-the-art (see following sections), it will also appear that this approach supports integrated assessments ensuring comprehensiveness and integration.

3 Ecosystem services and their classifications

Essential to the Ecosystem Approach is the understanding of how ecosystems contribute to the well-being of humans (Hattam et al., 2015). Thus which services ecosystems provide – free of charge – to human kind. The first notion of ecosystem services mentioned in literature can be traced back as early as 1949 to Aldo Leopold's Sand County Almanac (Haines-Young and Potschin, 2010b). The term "ecosystem services" however was only coined some 30 years later by Ehrlich and others (Haines-Young and Potschin, 2010b). In the following, extant classifications of ecosystem services and their application to the marine environment are reviewed

3.1 Existing ecosystem service classifications

The first worldwide assessment of ecosystem services and the implications ecosystem change has for human well-being was carried out by over 1300 scientists between 2001 and 2005 in the Millennium Ecosystem Assessment (MA) (MA, 2005; Haines-Young and Potschin, 2010b). The MA defines ecosystems services as *the benefits people derive from ecosystems*. It distinguishes between provisioning services (e.g. food, water, and timber), regulating services (for example climate regulation through carbon sequestration) and cultural services, which can be of recreational, aesthetic or spiritual nature. Underlying these services are the supporting services such as primary production and soil formation, which are essential for providing the other three services. The MA showed that around 60% of the assessed ecosystem services are being degraded and used unsustainably (MA, 2005). The use of ecosystems and their services has led to net gains in human well-being and economic development but only at the costs of the environment (MA, 2005). The benefits future generations may gain from ecosystems will be substantially diminished if the unsustainable use of ecosystems continues and it has already led to mostly irreversible losses of biodiversity (MA, 2005).

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative to "make nature' values visible" by quantifying the benefits of biological diversity and costs of biodiversity loss (TEEB, 2010). It places ecosystems and biodiversity and the inherent biophysical structures, processes and ecological functions at the basis of ecosystem service generation (De Groot et al., 2010). Thereby TEEB follows the notion of an ecosystem cascade (Figure 4) that was introduced by Haines-Young and Potschin (2010b). They argue that biodiversity is not a service itself but rather determines the provision of ecosystem services. The services are generated by biophysical structures and processes stemming from living organisms and their interactions with each other and abiotic materials (Haines-Young and Potschin, 2010b). Following this definition, the supporting services used by the MA become redundant and TEEB excludes this class of services. Instead, another class of habitat services is introduced. The reason to include habitat services was to stress the importance of different ecosystems to sustain particular life-stages of migratory species and the unique importance of some ecosystems to support genetic diversity (De Groot et al., 2010).

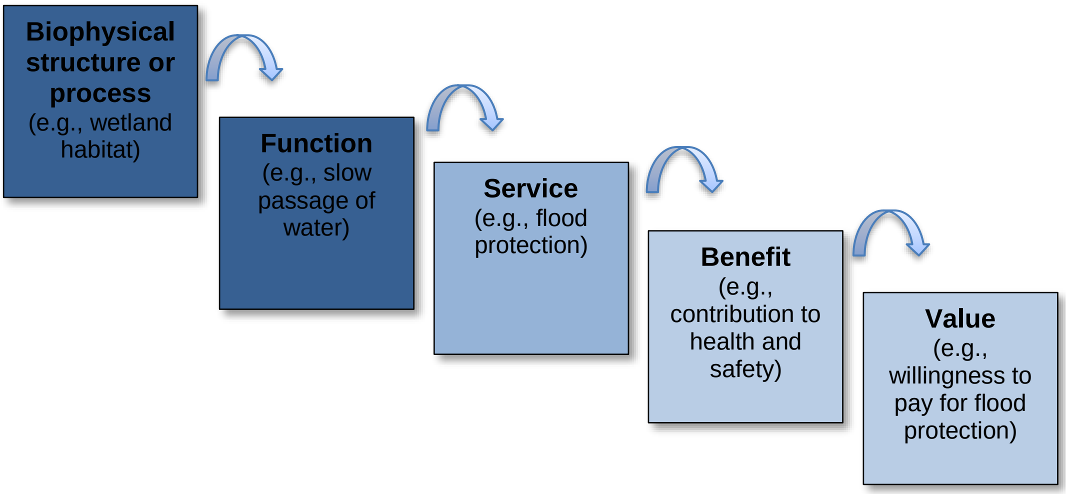

Figure 4
The ecosystem cascade, adopted from Potschin-Young et al. (2018)

The formerly "supporting services" are still included in the cascade but they represent the underlying biophysical structures and processes or the ecological functions derived from them. The functions are defined as the capacity of a structure or process to provide an ecosystem service (Haines-Young and Potschin, 2010b). Wetlands as a biophysical structure for example have the capacity to slow down surface waters, which is the ecological function of that habitat (Haines-Young and Potschin, 2010b). However, this function is only considered an ecosystem service if it provides benefits to humans as this is the fundamental notion of ecosystem services. Elaborating on the example of the wetlands, this means that "flood control" is only an ecosystem service if people do benefit from it, even if it is just a perceived benefit. The cascade also proved to avoid double counting of ecosystem services in economic valuation (which was a major critic of the MA) due to the clear distinction between ecological phenomena (the functions), their contribution to human well-being (the services) and the generated benefits (De Groot et al., 2010).

The cascade also illustrates how ecosystem services can promote comprehensiveness in assessments, in terms of providing information for the assessment of both environmental, economic and social impacts of new maritime activities. The environmental dimension can be assessed from structure, process and functions, while economic and well-being impacts are derived from the value attached to ecosystem service benefits. It is also possible to assess social impacts in further analyses of whom the ecosystem services benefit, e.g. in a socio-economic or socio-spatial perspective.
The main purpose of the development of the ecosystem service concept has been the prospect of valuation of non-marketed benefits, and thereby improving the potential to integrate assessments of different types of benefits such as cultural and provisioning services.

It can be argued that the ecosystem cascade is closely related to the concept of intermediate and final services. Intermediate services are generally defined as those services that were formerly referred to as supporting services in the MA but also some regulating services can be intermediate services (Costanza, 2008). Final services on the other hand are the final "products" that can be directly utilized by humans. The UK National Ecosystem Assessment (UK NEA) also distinguishes between intermediate services (or ecosystem processes, both terms are used interchangeably) and final ecosystem services (Mace et al., 2011). Some ecosystem services, however, are context-specific and can be intermediate services in some cases and final services in others (Potschin-Young et al., 2017). Wild species diversity for example is an intermediate service of the final ecosystem service of food. On the other hand, it can also be a final provisioning service when species diversity is used as a source for bioprospecting or natural medicine (Mace et al., 2011). Simply adding the value of intermediate and final services would then lead to double counting (Costanza, 2008). To avoid this the UK NEA only values the final ecosystem services (Mace et al., 2011). Whereas the concept of intermediate and final services was deemed helpful by Haines-Young & Potschin (2010b) in the beginning, the authors recently argued that it actually obscures "our understanding of the biophysical conditions necessary for different kinds of services" (Potschin-Young et al., 2017, p.124). They argue that ecosystem services can only be final services, whereas the term intermediate services actually refers to those factors that determine the capacity of ecosystems to generate the services (Potschin-Young et al., 2017). Therefore, they propose the term "ecosystem function" as used in the ecosystem cascade as a way to better understand the functional traits of species and ecosystem properties that give rise to ecosystem services (Potschin-Young et al., 2017).

TEEB makes a clear distinction between services and benefits, and defines ecosystem services as *the direct and indirect contributions of ecosystems to human wellbeing* (TEEB, 2010). In the TEEB definition as well as in the ecosystem cascade, the ecosystem services are the pivot that link the underlying ecosystem processes and functions to the benefits humans can gain from ecosystems (Potschin and Haines-Young, 2016). Benefits are thereby understood as something that changes people's well-being, which can include people's health and security, their social relations or the choices they can make (Potschin and Haines-Young, 2016). Ideally, an assessment of human well-being encompasses both economic, social and personal well-being (Busch et al., 2011). In the early versions of the ecosystem cascade benefits were equated with (mostly) monetary values (Haines-Young and Potschin, 2010b). Subsequently, however, it has been suggested that benefits and values should actually form separated boxes in the cascade since the same benefit can be very differently valued by different groups and in different places (Potschin and Haines-Young, 2011). Furthermore, the values do not have to be of monetary nature but can also include social, health or intrinsic values (Liquete et al., 2013) and some prioritization methods such as multi-criteria analyses do not even require monetary values. The diversity of values that may be attached to the same ecosystem services by a wide range of people is stressed by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Pascual et al., 2017). IPBES argues that this diversity, which is ascribed to 'nature's contributions to people', and which stems from different worldviews and social groups, should be incorporated into decision-making in order to find more equitable and sustainable solutions (Pascual et al., 2017).

A classification put forward by the European Environmental Agency aims at building on accepted terms and categorizations of ecosystem services; it can be used to "translate" between existing classifications such as the MA, TEEB and national assessments, and seeks to be compatible with the framework of the UN System of Environmental-Economic Accounts (SEEA) (Haines-Young and Potschin, 2010a, 2016). This Common International Classification of Ecosystem Services (CICES) defines ecosystem services as *the contributions ecosystems make to human well-being*, arising from the interaction of biotic and abiotic processes (Haines-Young and Potschin, 2010a). They are the final outputs or products from ecological systems (Haines-Young and Potschin, 2012). CICES reduces the ecosystem service classes to three by excluding supporting services and merging the regulating services and habitat services of TEEB to one class called regulating & maintenance services. The habitat services are thus not treated as a "service" at the highest level but rather as a subset of the regulating and maintenance services, capturing those aspects that are important for the regulation of the biotic environment (Haines-Young and Potschin, 2010a). CICES uses a five-level hierarchy to structure the ecosystem services, which allows for different levels of aggregation. The first level is the section (e.g. provisioning services), followed by the division (e.g. nutrition), group (e.g. biomass), class (e.g. crops) and class type (e.g. wheat). Depending on the required level of detail, one can choose the appropriate level.

In addition to the ecosystem outputs from living organisms and ecological processes, CICES also considers abiotic outputs such as sand and gravel, wind and wave energy. These abiotic outputs are, however, not considered as ecosystem services but as natural resources and are included in a supplementary classification (CICES V4.3). Lillebø et al (2017) for example uses CICES' ecosystem services classification along with the abiotic supplementary to assess the contribution of natural capital to Blue Growth activities. Thereby two elements of natural capital are recognized, one stemming from ecological systems and processes and the other one from the sub-soil assets and abiotic flows, creating ecosystem services and abiotic outputs, respectively, from which humans can benefit (Lillebø et al., 2017). Contrary to that van der Meulen et al. (2016) argue that abiotic outputs should be an inherent part of ecosystem service classifications to facilitate better planning and decision making. Abiotic outputs such as sediments and so called „carrier" services (e.g. the role of rivers for transportation) are in particular mentioned since those are essential for generating benefits to humans (van der Meulen, Braat and Brils, 2016).

The MA, TEEB and CICES are the three main ecosystem service classifications (Table 1). With regard to definitions the MA differs the most from the other two classifications, whereas the main difference between CICES and TEEB lies in use of the habitat service category. CICES, on the other hand, is the most complex with its use of a five-level hierarchy, which allows different users (e.g., in the fields of accounting and mapping, respectively) to choose their required level of detail. The three classifications form the basis for most ecosystem service assessments, and even though they are generally applicable to all ecosystems, the focus is clearly on terrestrial ecosystem services

Table 1

Differences between the three main ecosystem service classifications

	MA	TEEB	CICES
Definitions	*The benefits people derive from ecosystems*	*The (in)direct contributions of ecosystems to human well-being*	*The contributions that ecosystems make to human well being*
Categories	Supporting services	X	X
	Provisioning services	Provisioning services	Provisioning services
	Regulating services	Regulating services	Regulating & maintenance services
	Cultural services	Cultural services	Cultural services
		Habitat services	X
Complexity	Low *All categories are on one level (risk of double counting) and services are equated with benefits*	Medium *There is a distinction between services and benefits and the underlying processes and functions generating the services*	High *The distinctions are the same as in TEEB (with the exception that habitat services become part of the regulating services). In addition, the services are structured in a five-level hierarchy.*

3.2 Marine ecosystem services and indicators

The assessment of marine and coastal ecosystem services is not very well developed. This is due to the low spatial data availability, and the three dimensional environment but also due to classification systems developed mainly for the terrestrial environment (Liquete et al., 2013). One of the first classifications for the marine environment was developed by Beaumont et al. (2007). They use a modified version of the MA and, in addition, include a class, which they call “option use value”. The definition of this is that there are services of future unknown and speculative benefits. This additional ecosystem service has not become accepted, however, possibly because if option use (as a person’s willingness to pay for safeguarding the option to exploit a natural resource in the future) should be included, it should rather be accounted for in the valuation of ecosystem services than being a service itself (Böhnke-Henrichs et al., 2013).

A comprehensive review of coastal and marine ecosystem services assessment research is provided by Liquete et al (2013). The review showed that 68% of the papers did not follow any standard classification, whereas 15% followed the MA, 3% the Beaumont et al. (2007) classification and the rest used other sources. Liquete et al. (2013) compares the MA, TEEB, CICES and Beaumont et al. (2007), and use these as a departure to create an integrated classification, which follows CICES general structure and applies specifically to marine and coastal ecosystems. The CICES structure was chosen for its compatibility with SEEA and for its flexibility to switch between different levels of complexity (Liquete et al., 2013). The linkage between biodiversity and ecosystems to human well-being is also established via the ecosystem cascade. Since the direct quantification of ecosystem services is in most cases not possible, the development of indicators or proxies becomes a necessity. Liquete et al. (2013) provides a list of indicators compiled from literature, grouped under provisioning, regulating and maintenance, and cultural services. Instead of one indicator for each service, a distinction is made between indicators for the providing capacity of the service, the flow of the service and the benefits, i.e. for different compartments of the cascade.

Taking a slightly different approach, Böhnke-Henrichs et al. (2013) selected ecosystem service indicators that can directly be linked to the marine ecosystem state. The objective was to define indicators, which can reflect ecosystem state changes that are caused by changes in marine management or spatial planning. The proposed classification is derived from TEEB and distinguishes between provisioning, regulating, habitat and cultural & amenity services. Since only ecosystem service types that can reflect ecosystem state changes are included, uses of marine ecosystem types which do not reflect changes in ecosystem states are not considered (such as wind energy or non-renewable energy). It is recommended, however, to distinguish between state-dependent ES and state-independent activities (drivers and pressures) to facilitate trade-off analyses between the development of those activities and environmental protection (Böhnke-Henrichs et al., 2013). In a comprehensive analysis, trade-offs would also occur between the different state-dependent ES (Lester et al., 2013).

Generic classifications and lists of indicators proved to be useful as a starting point for ecosystem service assessments in specific regions or for case study purposes (Mononen et al., 2016). It is clear that they have to be adapted to the specific site as not all ecosystem services are present in different regions. Therefore, an iterative process should be adopted where the chosen classification and lists of indicators undergo alterations and additions until a suitable set of ecosystem services and indicators is derived that is tailored to the area in question (Hattam et al., 2015). Hattam et al. (2015) for example used the TEEB classification as a starting point and identified in an expert workshop a set of generic indicators, which was subsequently tailored to the Dogger Bank in the North Sea.

In a similar way, the European Commission Working Group on Mapping and Assessment of Ecosystems and their Services (MAES) took CICES as point of departure, tailored it to coastal and marine ecosystems and applied the framework in different case studies. The MAES marine pilot case studies covered various coastal and marine areas throughout Europe and workshops were held to gain insight into practitioners' views on the usability of the classification (Lillebø et al., 2016). The general consent was that the CICES framework provides a good starting point to assess ecosystem services but it has to be tailored to the regional or local scales. Some ecosystem services that are not considered important at European level are very important for local communities and therefore any classification must accommodate the addition of specific ecosystem services when necessary. Comments from the workshop participants revealed that there were also some challenges regarding the distinction between biological mediated processes underpinning ES and the abiotic outputs from the natural system (Lillebø et al., 2016). Some participants preferred to define abiotic ecosystem components also as ecosystem services. In the MAES Marine Pilot only the ecosystem outputs depending on living processes were considered, but it is acknowledged that an additional classification for abiotic outputs can be useful, especially for supporting ecosystem management and governance (Lillebø et al., 2016). The distinction between the capacity, flow and benefits of ecosystem services also proved to be challenging for some participants, giving rise to problems concerning the selection of appropriate indicators (Lillebø et al., 2016).

The above mentioned examples show that different studies use indicators for either all steps of the cascade or just for some selected cascade steps, depending on the focus. An assessment based on an ecological perspective mainly requires indicators for biophysical structures and processes, the ecological functions and ecosystem services (Müller and Burkhard, 2012). An ecosystem service assessment with a societal perspective, on the other hand, focuses on indicators for service provision, human well-being and the valuation of the benefits. Van Oudenhoven et al. (2012) for example developed indicators for ecosystem properties, functions and services to assess effects of land management on ecosystem services. Böhnke-Henrichs et al (2013) on the other hand tried to gather indicators reflecting the ecosystem state. Liquete (2013) and MAES (Lillebø et al., 2016) aim at covering both ends of the cascade by using indicators for ecosystem function, service flow, and human benefits. Mononen et al (2016) developed indicators for biophysical structures, functions, benefits and values, arguing that these four together provide an indication of the service at hand. In literature, the same indicators are sometimes used to reflect different steps of the cascade. Liquete (2013) and MAES (Lillebø et al., 2016) for example use monetary values as an indication for benefits while according to Potschin and Haines-Young (2016) there should be separate indicators for benefits and values. It shows that a clear definition and description is required for the different steps of the cascade.

3.3 Ecosystem services and maritime spatial planning

While the concept of ecosystem services and the selection of indicators is increasingly implemented in studies, there is less literature on the use of ecosystem services in maritime spatial planning. Maritime activities are dependent on the natural capital of the seas and the associated ecosystem services and at the same time they create considerable pressures that impact the marine environment and its ability to provide those services (Ivarsson et al., 2017). Maritime spatial planning intends to ensure sustainable economic activities within the natural limits of marine ecosystems (Ivarsson et al., 2017). The modelling and mapping of ecosystem services can be a way to support this endeavour (Guerry et al., 2012). It can serve to inform marine planners about the likely outcomes of different planning alternatives and their impacts on economic or social well-being (Guerry et al., 2012; Arkema et al., 2015). Using the ecosystem service approach in marine spatial planning implies the allocation of space to the full range of services and requires a trade-off analysis among services as they are often interdependent and the use of them can be mutually exclusive (Lester et al., 2013). The approach, however, can also reveal cases where a service or a bundle of services can be maintained or even increased without any cost to other services, and through this, it can help to alleviate conflicts between user groups (Lester et al., 2013). Knowledge about the spatial distribution of ecosystem services and benefits is thereby an important aspect. It has to be known where the ecosystem services are located and where the benefits are received (Hasler et al., 2016). It is suggested that marine and coastal "hotspots" could be identified to indicate areas that are especially important for a number of ecosystem services (Hasler et al., 2016). A classification of marine ecosystem services is thereby the first necessary step. The absence of classification and typology specified to the marine environment can lead to very different service definitions in neighbouring planning units and hamper the exchange of lessons learned between different case studies (Böhnke-Henrichs et al., 2013). There are some examples where ecosystem services have been embedded in marine spatial planning, on a case study basis or in national plans. At the west coast of Canada, the marine InVEST tool (Integrated Valuation of Ecosystem Services and Tradeoffs) has successfully been applied in the assessment of multiple services and the ecosystem service approach was able to inform decision-making in the MSP process (Guerry et al., 2012). The national plan for Belize's coastal zone was drafted based on models of service provision by important marine features (corals, mangroves and seagrasses) to engage stakeholders and it was felt that the resulting plan provided a better alternative than what could have been achieved by solely focusing on conservation or development goals respectively (Arkema et al., 2015). An ecosystem service trade-off analysis incorporated into a MSP process in Massachusetts Bay minimized conflicts among offshore wind energy, commercial fishing and the whale-watching sector and maximized sector values (White, Halpern and Kappel, 2012). In Europe, the Nordic Council of Ministers developed a tool, where environmental pressures are linked to maritime activities based on definitions laid down in annex III of the EU Marine Strategy Framework Directive (2008/56/EC). The environmental pressures are then associated to affected ecosystem services in the respective policy area, which facilitates the assessment of ecosystem service changes and trade-offs among services (Ivarsson et al., 2017).

4 Proposal for a modified CICES framework

Ecosystems are the dynamic complex of plant, animal and microorganism communities together with the non-living environment interacting as a functional unit (MA, 2005; van der Meulen, Braat and Brils, 2016). Taking this definition of ecosystems provides a ground for perceiving abiotic (physio-chemical) processes and components as a natural element of the 'capacity' section of the ecosystem service cascade. So far, most definitions of ecosystem services have explicitly referred to its linkage to living processes. CICES for example recommends to regard ecosystem outputs "as things fundamentally dependent on living processes" [(Haines-Young and Potschin, 2012), p.3], even though it is recognized that ecosystem services arise from the interaction of biotic and abiotic processes (Haines-Young and Potschin, 2010a). For the purpose of BONUS Basmati, we propose to define ecosystem services as the direct and indirect contributions of ecosystems to human well-being, as CICES does, but emphasizing that ecosystems consist of both living and non-living parts. Therefore, in our definition ecosystem services do not have to be traced back to living processes (Haines-Young and Potschin, 2010a) but include abiotic ecosystem outputs as well. As van der Meulen et al. (2016) recently argued: "A complete classification system for ES that includes abiotic flows would better reflect the complete bundle of benefits that ecosystems provide and will support practitioners to make well informed decisions and optimize design of nature-based solutions" [(van der Meulen, Braat and Brils, 2016), p.4]. Thereby the abiotic process or component can play a double role. It may generate a service, when, for example sediment dynamics play a role in the provision of regulating services such as flood safety, and it may be a service itself, e.g. sediment might be a provisioning ecosystem service (formed by sediment producing processes), when it is extracted for construction purposes (van der Meulen, Braat and Brils, 2016). The need to take into account abiotic ecosystem outputs when assessing different planning scenarios has been recognized before (e.g. Böhnke-Henrichs et al., 2013) but to our knowledge, it has not been included in any ecosystem service classification as yet. CICES only provides a supplementary classification for abiotic outputs as mentioned above. This supplementary classification has for example been used by Lillebø et al. (2017) to assess which ecosystem services and abiotic outputs, from what they term the "marine natural capital", underpin the maritime activities targeted by the EU Blue Growth Agenda (COM/2012/0494).

Because of its flexibility, its consideration of abiotic outputs and its wide application, especially in Europe, we propose to use the CICES classification as a starting point for the ES classification used in BONUS Basmati. Using CICES as a starting point has been proven to be successful in previous studies e.g. (Lillebø et al., 2016; Mononen et al., 2016) and its flexibility allows for modifications. The first modification we propose is the inclusion of abiotic ecosystem outputs into the main ecosystem service classification. It affects mainly the provisioning services and among those the non-living materials from the oceans which are beneficial to humans. This is the first proposal for an ecosystem service framework and is still being discussed in the BONUS Basmati project – therefore, further modifications may occur at a later stage, where we will for example discuss how we address 'space' in the framework.

The proposed framework does not foresee any changes at the highest level of the CICES classification (Table 4). The main sections remain the provisioning, regulating & maintenance, and cultural services. The definitions for the three ecosystem services are adopted from CICES [(Haines-Young and Potschin, 2012), p.10]:

- Provisioning services: "Includes all material and energetic outputs[5] from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacture. Both biotic and abiotic outputs are covered […]".
- Regulating and Maintenance services: "Includes all the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people, i.e. all aspects of the 'ambient' environment; these are ecosystem outputs that are not consumed but affect the performance of individuals, communities and populations and their activities."
- Cultural services: "Includes all non-material ecosystem outputs that have symbolic, cultural or intellectual significance."

At the next hierarchical level, the divisions also remain the same as in CICES (Table 4).

Table 4

The modified CICES framework

CICES section	CICES division	CICES group	CICES class
Provisioning	Nutrition	Biomass	Wild plants, algae and their outputs
			Wild animals and their outputs
			Plants and algae from in-situ aquaculture
			Animals from in-situ aquaculture
		Water	Sea water used for drinking (after desalinization)
		Mineral	Minerals used for nutritional purposes
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing
			Genetic materials from all biota
		Water	Surface sea water for non-drinking purposes
		Substrate	Non-metallic raw materials
			Metallic raw material
	Energy	Biomass-based energy sources	Plant-based resources
			Animal-based resources
		Hydrophysical energy	Wave & tidal energy
Regulating & maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems
			Dilution by marine ecosystems
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates
			Buffering and attenuation of mass flows
		Liquid flows	Hydrological cycle and water flow maintenance
			Flood protection
	Maintenance of physical, chemical,	Lifecycle maintenance, habitat and gene pool protection	Maintaining the gene pool
			Maintaining nursery populations and habitats

[5] The definition might be slightly adapted at a later stage if it is deemed necessary to include additional abiotic services

	biological conditions	Biological control	Maintaining a balanced food web
		Sediment formation and composition	Decomposition and fixing processes
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations
			Micro and regional climate regulation
			Air purification
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environment al settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings
			Physical use of land-/seascapes in different environmental settings
		Intellectual and representative interactions	Scientific
			Educational
			Heritage, cultural
			Entertainment
			Aesthetic Landscape/Inspiration
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environment al settings]	Spiritual and/or emblematic	Symbolic
			Sacred and/or religious
		Other cultural outputs	Existence
			Bequest

At the “group” level, we propose the first modifications in order to facilitate the inclusion of abiotic outputs in the main framework. For the provisioning services, this mean that the division “nutrition” not only include biomass and water but also minerals such as salt. Though it might not be applicable in the Baltic Sea region, other sea regions do receive benefits from the extraction of sea salt (e.g. the Ria de Aveiro coastal region in Portugal (Sousa et al., 2016)). Other services in the provisioning nutritional services are however not applicable at all in the marine or coastal environment and have therefore been excluded from the framework, including cultivated crops, reared animals and their outputs and ground water for drinking. Contrary to the MAES marine pilot which also excluded surface water for drinking, we propose to leave it and rename it *sea water*, which can be used for drinking after desalination and further processing. The original CICES division “material” includes biomass and water. In the “biomass” group we suggest that the class “fibres and other materials from plants, algae and animals for further use or processing” should be merged with “materials from plants, algae and animals for agricultural use” to one class that encompasses both. Otherwise there should be a distinction of fibres and materials used for all different kinds of purposes (e.g. extra classes for agricultural/ornamental/medicinal/cosmetic materials), which we do not deem necessary. In the group “water”, the class “surface water for non-drinking purposes” is kept as sea water can be used for industrial purposes. “Ground water for non-drinking purposes” is, however, excluded as it is not applicable in marine areas. In addition to biomass and water, we propose to include substrate as a group and to further distinguish between non-metallic materials and metallic materials. Non-metallic material may include sand, gravel and rocks that are used for construction or sea defences. Non-metallic material refers to poly-metallic nodules, cobalt-rich crusts and poly-metallic massive sulphides that provide rare earth elements and other commonly used industrial metals such as chromium, nickel, zinc, molybdenum, lead and tungsten (Lillebø et al., 2017). The inclusion of substrate as a marine ecosystem service is eligible as it forms an inherent part of most marine habitats. For the division “energy” we propose to keep the biomass-based energy sources (both plant-based, e.g. algae, and animal-based, e.g. whale blubber, though the latter is hardly used nowadays) and exclude the mechanical energy as it only applies to terrestrial animals used for physical labour. As an addition, we propose hydro-physical energy such as wave and tidal energy. Both the energy inherent in waves and tides has an influence on marine habitats and the lives of marine organisms. The anthropogenic extraction of that energy can have impacts on the marine environment through changed hydrodynamics and the resulting impacts on regional sediment dynamics (Neill, Robins and Fairley, 2017).

The first division of the regulating and maintenance services is the “mediation of waste, toxics and other nuisances” with the groups “mediation by biota” and “mediation by ecosystems”. At the class level it is distinguished between filtration/sequestration/accumulation by marine organisms and ecosystems. We suggest to only keep the class filtration by ecosystems as it can be difficult to attribute filtration or sequestration capacities only to marine organisms whereas the class ecosystem encompasses both the organisms and habitats. Mediation by ecosystems also includes the class “mediation of smell/noise/visual impacts” which should be excluded as it is not applicable in the marine environment. The same applies to the group “gaseous/air flows” in the division “mediation of flows”. In the MAES marine pilot the class “hydrological cycle and water flow maintenance” is also excluded but we suggest to keep it as it can entail the maintenance of deep channels by coastal currents or the effect of macroalgae on localized current intensity (Böhnke-Henrichs et al., 2013). In the division “maintenance of physical, chemical and biological conditions”, we propose several changes at the group level. First, we recommend renaming the group “pest and disease control” to “biological control” and having a class of “maintaining a balanced food web”. In the MAES marine pilot some of the participants found “pest and disease control” misleading (Lillebø et al., 2016); biological control, on the other hand, should be more clear and we propose to adopt the description of Böhnke-Henrichs et al. (2013), which refers to the maintenance of natural healthy population dynamics and food web structures and flows by marine ecosystems. The next group in the CICES classification is soil formation and composition. We suggest to call it sediment formation and composition and to exclude the class “weathering processes” as these do not represent a service in the marine environment. The group “water conditions” should be excluded. The class “chemical condition of freshwaters” has to be excluded for obvious reasons, and there are good reasons to exclude the class “chemical conditions of salt water”. Sousa et al. (2016) for examples argues that the proposed indicators rather reflect an ecosystem status (the level of eutrophication) and not the provided service and therefore exclude this class, and we suggest to do the same. The last group in the division “maintenance of physical, chemical and biological conditions” is “atmospheric composition and climate regulation”. In addition to the classes “global climate regulation” and “micro and regional climate regulation”, we propose to include the class “air purification”. This is in line with Böhnke-Henrichs et al. (2013), who define air purification as the removal of pollutants like fine dust and particulate matter from the air by marine ecosystems. This class should explicitly exclude carbon dioxide, however, as this is covered by the class global climate regulation.

Regarding the cultural services there are two main divisions. The first one covers the physical and intellectual interactions with biota, ecosystems, and land-/seascapes and the second one spiritual, symbolic and other interactions. Both refer explicitly to the environmental settings that generate cultural services. CICES recommends “that cultural services are primarily regarded as the physical settings, locations or situations that give rise to changes in the physical or mental states of people, and whose character are fundamentally dependent on living processes; they can involve individual species, habitats and whole ecosystems” [(Haines-Young and Potschin, 2012), p. iv]. We propose to keep this definition with the modification that it can also include settings/locations/situations that are not dependent on living processes. Thus, it also includes sea caves, sacred rocks and other physical structures and spaces, which are only considered in the supplementary abiotic classification in the original CICES framework. There has been some discussion of cultural services, especially with regard to recreation. The MA, TEEB and earlier versions of CICES include recreation and tourism or recreation and leisure as an ecosystem service. However, subsequent consultations on CICES revealed that recreation should rather be regarded as a benefit which arises from the physical and cultural setting of characteristics of the ecosystem (Haines-Young and Potschin, 2012). At the group level, we do not propose any modifications, only at the class level we suggest that the class “aesthetic” should explicitedly refer to the aesthetic enjoyment of landscape and in addition include “inspiration”. CICES does include the artistic representation of nature as an example for “aesthetic” but a class of “aesthetic landscape/inspiration” would clarify that it also incorporates inspiration for culture, art and design and the enjoyment of views for example. At class level, one ecosystem service is “existence” and the example provided refers to the enjoyment provided by wild species, wilderness, ecosystems and land-/seascapes. Whereas we do not object to “existence” as a service, we want to clarify that it is an indirect mental enjoyment through one’s awareness and appreciation that marine species and ecosystems exist somewhere, without necessarily having interacted with them physically or intellectually.

4.1 Indicators based on the cascade framework

The cascade is not only useful for structuring the flow of ecosystem services; it also provides the basis for an indicator framework that can be linked to the DPSIR and other impact assessments (Potschin-Young et al. 2018).
Instead of one indicator for each ecosystem service we propose to distinguish between indicators for the capacity, service, benefit and value, which is in line with the ecosystem cascade (Haines-Young and Potschin, 2010b). The capacity step encompasses both the structure/process and the function, which has been done in other studies as well to indicate the potential supply of ecosystem services

(Potschin-Young et al., 2018). If needed, the capacity section can be subdivided again in the case studies. It is not implied that all case studies in the BONUS Basmati project should assess ecosystem services based on each level of the cascade. Rather, it stresses the importance of clearly identifying to which level of the cascade the assessment reaches – does it only include the capacity of ecosystems to provide ES or are does it go as far as valuing the services? The indicators used in literature often cover different steps of the cascade without, however, clearly identifying the respective step, which is a major deficiency. To avoid this, we propose to use a common definition of the cascade – the one provided by Haines-Young and Potschin (2010b). It should be slightly adapted, however, to clarify that it includes abiotic outputs as well. We propose to define the capacity as the subset of the interactions between biophysical or geo-/hydro -physical structures, biodiversity and ecosystem processes that support the ecosystem capacity to provide a service (Potschin and Haines-Young, 2013). Ecosystem services are the "the contributions that ecosystems (whether natural or semi-natural) make to human well-being; their fundamental characteristic is that they retain the link to underlying ecosystem functions, processes and structures." (Potschin and Haines-Young, 2013) The benefits refer to changes in human well-being and are "the direct and indirect outputs from ecosystems that have been turned into products or experiences that are no longer functionally connected to the systems from which they were derived." (Potschin and Haines-Young, 2013). The importance of the benefits may be valued in terms of economic, social, health or intrinsic values (Potschin and Haines-Young, 2016).

4.1.1 Indicators from scientific literature

We gathered indicators from a number of different references and aimed at evaluating to which of the four cascade steps they belong (see supplementary material). References from the period 2013-2017 were selected, starting with the comprehensive review of Liquete et al (2013). The focus was on those references that provided additional lists of indicators and covered different steps of the cascade. The quality of the indicators has not been assessed yet. This will be done in the form of a structured questionnaire that BONUS Basmati researchers will be asked to fill in. The list of indicators is supposed to serve as an inspiration for BONUS Basmati project partners for the selection of case study specific indicators, at which point the quality of the indicators will be assessed as well. Indicators were gathered from a number of sources, which specifically collected indicators for marine ecosystem services. Those include: the MAES marine pilot (Lillebø et al., 2016), Liquete et al. (2013), a list of ecosystem service indicators provided by researchers from the BONUS Optimus project, Lillebø et al. (2017), Hattam et al. (2015), Böhnke-Henrichs et al. (2013), the UK National Ecosystem Assessment, workpackage 4 (Turner et al., 2014), and the HELCOM core indicators. This indicator list is presented in the supplementary material.

The first thing to note is that the MAES marine pilot and Liquete et al. (2013) use three indicator categories (capacity, flow (of the service), benefit), whereas most of the other references aimed at finding indicators solely for the services. The interpretation of the different cascade steps and the corresponding indicators is rather varied among the references. The MAES marine pilot and Liquete et al. (2013) for example do not distinguish between the benefit and value step of the cascade (Table 5). Instead, all their benefit indicators rather consequently represent monetary values. In earlier versions of the ecosystem cascade there was in fact no distinction between benefits and values, which has only been changed after acknowledging that benefits can be valued very differently by different groups (Potschin and Haines-Young, 2011). The MAES and Liquete et al. (2013) indicators for benefits were therefore put into the category values. Also, the distinction between benefits, services (or flow in the case of MAES and Liquete et al.) and capacity is ambiguous. In the MAES marine pilot wild seaweed abundance for example is an indicator for the ecosystem capacity to provide the nutritional service, and harvested wild seaweed is an indicator for the flow or the service itself. Hattam et al. (2015) on the other hand uses seaweed stock as an indicator for the service and according to Mononen et al. (2016) harvest is an indicator for the benefit. In a similar way, the UK National Ecosystem Assessment uses quantity of seaweed stock as an indicator for the final ecosystem service and the landed seafood as an indicator for the benefit (Turner et al., 2014).

Table 5

The differences in interpreting the cascade steps

Reference	The ecosystem			The socio-economic system	
Cascade (2011) (TEEB, CICES, Mononen et al.)	Biophysical structures & processes	Function	Ecosystem services	Benefit	Value
UK NEA (2011)	Ecosystem processes/Intermediate services		Final ecosystem services	Goods	Value of goods
Liquete et al. (2013) & MAES marine pilot	Capacity		Flow		Benefits

Following the most recent version of the ecosystem cascade (Potschin and Haines-Young, 2016), harvestable products are an example of the ecosystem service, which, along with the other mentioned references, provides a good ground for arguing that the cascade steps distinctions of the MAES marine pilot and Liquete et al. (2013) should be updated. In the proposed indicator list (see supplementary material) the indicators from MAES and Liquete et al. are therefore shifted to the right of the cascade – at least for most of the provisioning and cultural services; so that for example wild seaweed abundance is actually an indicator for the ecosystem service and the harvest an indicator for the benefit. It should be noted, however, that plant and animal abundance indicators should be always related to human use in order to qualify as a service, e.g. it should be the abundance of target species. In case of the regulating services, the indicators for capacity and flow from MAES and Liquete et al. were often merged in the service category. This has been done as many of the capacity indicators rather seemed to be proxies that could be used for an indication of the services as well. As this is a work in progress, however, some changes to this distinction might occur at a later stage. Indicators provided by the other sources were in some cases also put into different indicator categories. In the BONUS Optimus project, for example an indicator for the ecosystem service *dilution by marine ecosystems* is the average beach closures per year. However, according to the definition by Potschin and Haines-Young (2016), this indicator would rather reflect a (reversed) benefit.

4.1.2 Review of HELCOM indicators with respect to CICES indicators

The HELCOM core indicators are those indicators that are commonly agreed on by the Contracting Parties of the Helsinki Convention, and which form the basis for environmental assessments. There are two types of indicators - pressure or state indicators. The pressure indicators measure anthropogenic pressure or the progress towards an environmental target. The state indicators measure the environmental status in respect to good ecological status (GES) boundary and the progress towards it and are comparable to the descriptors and indicators used for the Marine Strategy Framework Directive. Altogether, there are 34 HELCOM core indicators[6] grouped into four groups – see Table 6. The evaluation of the core indicators is updated regularly and published in reports. The data gathered for the evaluations therefore could be a valuable source for assessing ecosystem services or the capacity of ecosystems to provide services in the BONUS Basmati case studies.

Table 6

HELCOM core indicators

Biodiversity	Eutrophication	Hazardous substances	Maritime activities
Abundance of coastal fish key functional groups	Chlorophyll *a*	Hexabromocyclodocecane (HBCDD)	Trends in arrival of new non-indigenous species
Abundance of salmon spawners and smolt	Nitrogen (DIN)	Polybrominated diphenyl ethers (PBDE)	Operational oil-spills from ships
Abundance of water birds in the breeding season	Oxygen debt	Reproductive disorders: malformed embryos of amphipods	
Diatom/Dinoflagellate index	Phosphorus (DIP)	White-tailed eagle productivity	
Population trends and abundance of seals	Total nitrogen (TN)	Metals (lead, cadmium and mercury)	
Distribution of Baltic seals	Inputs of nutrients to the subbasins	Perfluorooctane sulphonate (PFOS)	

[6] http://www.helcom.fi/baltic-sea-trends/indicators

State of the soft-bottom macrofauna community	Cyanobacterial bloom index	Polyaromatic hydrocarbons (PAH) and their metabolites	
Abundance of key coastal fish species	Total phosphorus (TP)	Polychlorinated biphenyls (PCB) and dioxins and furans	
Abundance of sea trout spawners and parr	Water clarity	Radioactive substances: Cesium-137 in fish and surface seawater	
Nutritional status of seals		TBT and imposex	
Reproductive status of seals			
Zooplankton mean size and total stock (MSTS)			
Number of drowned mammals and water birds in fishing gears			

Most of the HELCOM core indicators can be linked to indicators used to describe the marine ecosystem state in the quantification of ecosystem services (Table 7). In some cases, like in the case of nutrient concentration in water or the pollutant content in marine organisms, both sets of indicators are fully comparable and are used for the same purpose, i.e., to characterize water quality.

Some other indicators have the same purpose, but have a slightly different approach. For example, oxygen concentration is used to describe the quality of nursery habitats and populations in the case of ecosystem services while an oxygen debt indicator is used by HELCOM to describe the quality of deep basins of the Baltic sea that are spawning areas for cod. Similarly, the harmful algal bloom outbreak indicator used for the ecosystem service is describing the same phenomenon as HELCOM's cyanobacterial bloom index, although indicators are calculated differently.

In some other cases, the indicators used in the HELCOM process can be used for ecosystem services, although the purpose of indicators differ. For example, the fish abundance indicator developed for ecosystem service purposes considers fish abundance as a proxy of the available service. At the same time, the HELCOM fish indicator considers fish abundance from the point of view of ecosystem health (abundance of key coastal fish species) or addresses the status of fish species (abundance of salmon and trout spawners and smolt) that are of special interest from a conservation viewpoint. Similarly, the HELCOM seal and water bird indicators are developed to describe the status of protected or endangered species, but these indicators can be used also to characterize cultural ecosystem services where indicators (Table 4) describe presence of iconic, endangered or protected species from a human use perspective.

A significant number (14) of HELCOM core indicators cannot be linked to indicators used so far to characterize ecosystem services. For some of those there is no principal restrictions to be used in the characterization of water or more precisely ecosystem quality. For example, HELCOM core eutrophication indicators like chlorophyll *a* and water clarity are describing the same phenomenon as concentrations of nutrients. Similarly, HELCOM's hazardous substances indicators that characterize biological effects of pollutants like reproductive disorders and white tailed eagle productivity can be used to characterize pollution levels (ecosystem quality) from a pollutant level perspective.

The HELCOM core biodiversity indicators that have no counterparts among ecosystem service indicator pools are rather more diverse in their purpose and application.

The abundance of coastal fish key functional groups reflects the ecological state in coastal ecosystems. Although the information base or data used to calculate this indicator is the same or at least very similar to that used to calculate the ecosystem service indicator 'fish abundance', the indicator does not provide direct information on the abundance of fish species. Due to the assessment methodology, (abundance of piscivores and cyprinids or mesopredators is related to threshold values) the indicator value is displayed as ratio – above or below a threshold value.

The diatom/dinoflagellate index as well as zooplankton mean size and total stock are of relevance for the food web and thus could be used to characterize the regulation and maintenance service *maintaining a balanced food web*. However, presently no corresponding indicator could be identified from literature.

Several seal indicators are very relevant to assess seal population health status but are irrelevant for the cultural ecosystem service section since they do not provide an additional assessment value. Similarly, the HELCOM indicators *number of drowned mammals* and *water birds in fishing gear* and *trends in arrival of new non-indigenous species* are not relevant for ecosystem services, since these indicators are used to quantify impacts of specific anthropogenic activities in a form that precludes direct attribution of these effects to ecosystem services or quality of the ecosystem. The HELCOM indicator inputs of nutrients to the sub-basin is a pressure indicator and can neither be used directly to describe the environmental quality of marine waters.

The above analysis shows that some of the HELCOM core indicators are equivalents or at least very similar to the indicators used for ecosystem services, even if the latter serves broader purposes. The link to the core indicators in the assessment of ecosystem services is advantageous since the indicators are regularly monitored and updated by HELCOM contracting parties and thus form a potential data source for the case studies in BONUS Basmati. This is not only in terms of the environmental aspects underlying ecosystem services, but also the existing pressures that affect the services. In addition, the link to the Marine Strategy Framework Directive remains through the use of these indicators.

Table 7

Comparison of HELCOM core and ecosystem service indicators

Ecosystem service indicators (CICES)		HELCOM core indicators	
Section	**Indicator**	**Group**	**Indicator**
Provisioning	Fish abundance	Biodiversity	Abundance of salmon spawners and smolt
	Fish abundance per site		Abundance of trout spawners and parr
			Abundance of key coastal fish species
Regulation and maintenance	Nutrient (N and P) concentration	Eutrophication	Nitrogen (DIN)
			Phosphorus (DIP)
			Total nitrogen (TN)
			Total phosphorus (TP)
	Heavy metal and other pollutant content in marine organisms	Hazardous substances	Hexabromocyclodoceane (HBCDD)
			Polybrominated diphenyl ethers (PBDE)
			Metals (lead, cadmium and mercury)
			Perfluorooctane sulphonate (PFOS)
			Polyaromatic hydrocarbons (PAH) and their metabolites
			Polychlorinated biphenyls (PCB) and dioxins and furans
			TBT and imposex
			Radioactive substances: Cesium-137 in fish and surface seawater
	Oil spill severity	Maritime	Operational oil spills from ships
	Oxygen concentration	Eutrophication	Oxygen debt
	Harmful algae bloom outbreaks	Eutrophication	Cyanobacteria bloom index
Cultural	Presence of endangered, protected, iconic and/or rare species or habitats	Biodiversity	Distribution of Baltic seals
			Abundance of water birds in the breeding season

5 Conclusion and outlook

The ecosystem service framework presented here is the first proposal to turn one of the existing classifications into a marine-specific and MSP relevant framework that can be used in BONUS

Basmati's case studies. It is comprehensive as it can cover the three aspects of sustainable development, and it serves integration, as it allows to value benefits from profoundly different ecosystem services (see section 3.1), and thereby also to e.g. prioritize and perform trade-off analyses. CICES furthermore provides an integrated structure of the services and the five-level hierarchy ensures that the case studies can assess ecosystem services at different levels of aggregation and still remain comparable. Using the cascade provides a further structuring element, which can trace the flow of ecosystem services. The literature review showed that the cascade steps are not always clearly distinguished from each other, but need to be determined in the specific context in which it is applied. A clearly defined cascade furthermore allows the incorporation of ecosystem services into the DPSIR framework, which conceptualizes the role of human drivers as influencing the ecosystem's capacity, and the need to find management responses if impact assessments turn out in undesired ways.

This deliverable describes the first proposal for the framework, and it should be regarded as work in progress. Informal discussions within BONUS Basmati already revealed that two aspects especially need further consideration. The first one refers to the abiotic services. The novelty of the proposed ecosystem service framework is the inclusion of abiotic services in order to make it MSP relevant and one of the most critical element in any MSP endeavor is the allocation of space to maritime activities. However, so far *space* has not been incorporated into the framework. Some authors have included space as an ecosystem service but it is difficult to ascertain how it fits into the cascade – e.g. how can it be linked to the capacity section? In which ways does the marine ecosystem provide space, and how would space respond to ecosystem change? This discussion will be taken as the project progresses. Another critical aspect is the use of the framework for stakeholder involvement purposes. While CICES has been chosen as a point of departure for the framework for its flexibility and comprehensiveness, exactly this comprehensiveness has been a point of critic for being too difficult to understand for lay people. Especially the class levels should be sufficiently clear and unambiguously formulated. We realize that this can be a point of improvement for the framework, which will also be further discussed during the project's lifetime.

Just as the framework, the indicator list is also a work in progress. Indicators have not been developed or assessed during this exercise, but have been retrieved from the articles that were deemed relevant during the review process. This implies that i) more indicators may be added at a later stage (e.g. MSFD indicators for the ecosystem state could possibly be used for indicating the capacity of ecosystems to provide services) and that ii) the indicators have not yet been assessed with regard to quality criteria. Hence, the indicators on the list are not the (only) ones we propose to use in BONUS Basmati's case studies; instead, the list should be seen as a source of inspiration and reference for selecting case-study-specific indicators.

The case studies will also provide input for the further development of the framework. While the framework aims to be comprehensive, the case studies will assess those ecosystem services that are relevant for the respective geographical area and main topic. The case studies might highlight some relevant ecosystem services that should be added to the main framework and thus the case studies of WP6 will feed into WP4. The case studies all have a different focus and will use ecosystem services in different ways (the MPA case study aims at preparing an ES valuation, the aquaculture case study focuses on ES provided by mussel farms, and the transboundary tourism & shipping case study examines stakeholder views on ES). It is expected that they can provide valuable differentiated input to the framework. The development of case-study-specific indicators for ecosystem services further establishes the link to the work package on data needs and requirements (WP3) and scrutinizing the terminology used in the framework will ensure that it can be used for stakeholder purposes (WP2). The further work in WP4 thus includes the improvement and development of the framework in cooperation with other work packages. This entails also how the framework can be used in an actual ecosystem service assessment with the help of the DPSIR for example.

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