Report on the use of CICES to identify and characterise the biophysical, social and monetary dimensions of ES assessments

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ESMERALDA

Enhancing ecosystem services mapping

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Preface

ESMERALDA is a Supporting and Coordination Action aiming at helping EU member states to fulfil their obligations under the EU Biodiversity Strategy Target 2, Action 5. In order to fulfil these tasks, the project is organised in four key activity phases of which the first two “Networking and stakeholder involvement” as well as “Developing flexible tools for mapping and assessment” have successfully been started and carried out during the first 18 months of the project. This report provides an insight into the work directed towards developing an integrated assessment framework in ESMERALDA WP4, and especially the role that CICES can play in this process.

In preparing this document we acknowledge the valuable input from participants at two workshops held in 2016, in Copenhagen and in Nottingham (see MS19 and MS21 reports respectively). We also acknowledge the European Environment Agency who co-sponsored the workshop in Copenhagen and their permission to use the results of the 2016 Survey of CICES users.

Summary

The aim of this Deliverable is to report on the use of the Common International Classification of Ecosystem Services (CICES) to characterise the biophysical, social and monetary dimensions of ecosystem assessments, and to identify how it can be further developed to support the needs of the user community.

CICES was developed in the context of work on the revision of the System of Environmental and Economic Accounting (SEEA) that is being led by the United Nations Statistical Division (UNSD). However, it has also been used widely in ecosystem services research for designing indicators, mapping and for valuation. In the EU, it is being used as the basis of the mapping work that is being done in support of Action 5 of the EU Biodiversity Strategy to 2020, under the MAES Programme.

This report describes the structure and conceptual underpinning of CICES, and reviews the challenges that arise in designing a classification system of this kind. These challenges include the problem of scope, the extent to which 'final ecosystem services' can be defined operationally, and how benefits and uses of services can be distinguished from services so that assessments can be based on sound quantitative data. The review of CICES draws on a review of the published literature and a survey of users. The conclusions drawn from this review were both extended and tested through two workshops with the user community in 2016.

The results of our work show that there is an extensive and established user base for the current version of CICES, and that it has a number of advantages for users in terms of its hierarchical structure, logic and coverage, as well as the potential it offers as a standard. The review has identified some shortcomings, however, many of which can be overcome by the development of guidelines and the provision of examples of different applications. These shortcomings, nevertheless, also point to the need to revise the present structure of the Classification, especially in the area of cultural ecosystem services.

A systematic review of the wider ecosystem service literature has provided further insights into the ways in which CICES might be improved. This work has looked at whether the CICES classes are to narrow or too broad, and whether there is a need to provide better guidance at sub-class (Class-type level). Taken in conjunction with the other work discussed here, the review demonstrates that CICES can serve as an effective indicator framework.

Our review concludes with a discussion how within ESMERALDA an integrated assessment framework can be built, and what role CICES might play. In the light of the needs identified it is recommended that:

- While CICES is already successful in fulfilling this role as a common framework for discussion and analysis, there is scope for improving the guidance associated with so that it can be applied more easily and effectively.
- CICES has already been used as the framework for translating between different classification systems and the development of this kind of approach as part of the extended guidance is an essential next step for the ESMERALDA/MAES community. Targets for integration include classifications of ecosystems, functions, benefits and beneficiaries.
- In order to assist with the development and comparison of methods to quantify the biophysical, social and monetary dimensions of ecosystem assessments, the creation of a

library of ‘CICES-consistent indicators’ is confirmed as an essential part of future work in ESMERALDA. Such a library would provide a useful entry point for those undertaking an integrated assessment of some kind.

The findings of this Deliverable will be used to shape on-going discussions in ESMERALDA that will be taking place in the context of the next series of ESMERALDA project workshops being organised by WP5 during 2016-17. The objective of these meetings will be to test a first version of the methodology for mapping and assessment of ecosystem services. Close engagement with this work will ensure that specific guidelines required for CICES are fully integrated into the wider outcomes of ESMERALDA. The outcomes will be reported in the final DDeliverable4.1 due in month 42, July 2018.

1. Introduction

1.1. Background

Categorising and describing ecosystem services (ES) is the basis of any attempt to measure, map or value them; in other words to undertake an ecosystem assessment of some kind. It is the basis of being transparent in what we do, so that we can communicate our findings to others, or test what they conclude. In this Deliverable we examine the role of the *Common International Classification of Ecosystem Services* (CICES) to support this categorisation and communication process. In particular we examine how it can contribute to the development of *integrated assessment frameworks*, which is one of the key outcomes planned for WP4 of the ESMERALDA Project.

A critical review of CICES is especially important within ESMERALDA because the classification has been adopted as part of the framework for the overall MAES Initiative. The experience gained through the work of ESMERALDA will help develop guidelines so that CICES might be used more effectively in the future. The research will also feed into the current initiative to consider whether on the basis of current experience any revision of the classification is necessary.

1.2. Aim of the Deliverable

The aim of this Deliverable is to report on the use of CICES and to characterise the biophysical, social and monetary dimensions of ecosystem assessments.

To do so, the Deliverable draws on the experience gained in developing CICES and uses it to reflect on the difficulty of designing a classification system that is simple and transparent to use, but which also fulfils the crucial needs of integrated assessment by addressing cross-scale issues and linking up analyses across the biophysical, social and monetary domains. A particular question that will be explored is whether CICES in its present or modified form is able to provide a multi-purpose classification, able to support ecosystem service mapping, valuation and accounting needs, as well as deliberative and participatory work with stakeholders.

1.3. Structure of the Deliverable report

The structure and present status of CICES is described in Part 2 of this Deliverable report, which also sets out the conceptual basis of the classification. In Part 3, we describe the work that has been undertaken in the internal consultation process of ESMERALDA on the biophysical, social and monetary dimensions of mapping and assessment, and the lessons for the use of CICES that can be drawn from it. This work draws on material from two workshops held as part of the ESMERALDA Project during 2016.

One of the key contributions made by CICES that is identified in Parts 2 & 3 is that CICESCICES can serve as a framework for the development of indicators. However, it is recognised that it cannot encompass all relevant knowledge of the broad field of ES assessment. Thus the lessons from the internal consultation process are complemented by a systematic review exercise in Part 4. This work allows a more detailed exploration of issues and the identification of a range of metrics that might be used by the MAES community in their future work; the outcomes will provide an input into the development of a 'CICES-consistent indicator library' that could be used in mapping and assessment work.

The work reported here was undertaken during the first phase of the ESMERALDA Project, and so it is still at a preliminary stage. This document is therefore an 'interim' Deliverable. Final conclusions and recommendations will require further effort and will be provided at the end of the project in month 42 (respectively July 2018). Part 5 nevertheless draws together the interim findings and identifies the next steps for work within ESMERALDA.

2. CICES Structure and Applications

2.1. History and current context

A number of different typologies or ways of classifying ecosystem services are available, including those used in the Millennium Ecosystem Assessment (MA) and The Economics of Ecosystems and Biodiversity (TEEB), and a number of national assessments, such as those in the UK and Spain. The problem with them is that they all approach the classification problem in different ways, and so they are not always easy to compare.

In order to try to partly overcome this 'translation problem', the *Common International Classification of Ecosystem Services* (CICES) was proposed in 2009 and revised in 2013 (Haines-Young and Potschin 2013; Potschin and Haines-Young, 2016). It was designed to help people measure and assess ecosystem services. Although it was developed in the context of work on the revision of the System of Environmental and Economic Accounting (SEEA) that is being led by the United Nations Statistical Division (UNSD), it has also been used widely in ecosystem services research for designing ES indicators, ES mapping and for ES valuation. In the EU it is being used as the basis of the mapping work that is being done support of Action 5 of the EU Biodiversity Strategy to 2020, under the MAES Programme (see: http://biodiversity.europa.eu/maes). It will also be the basis for INCA, a project of the European Commission to develop natural capital accounts.

The current version of CICES (V4.3) was published at the beginning of 2013. It is therefore now timely to gather information on how it has been used and the issues associated with its application. This will partly be done through the ESMERALDA Project, but also through the independent work being led by the European Environment Agency as part of its input to the MAES process itself and the development of ecosystem accounting methods with partners such as the UNSD. Recent efforts to gain an insight into this collective experience have been two workshops organised through the auspices of ESMERALDA, and the survey of CICES users undertaken for the EEA. The workshops and the questionnaire were deigned to identify the kinds of guidance that people might need in using CICES, and to look at whether any changes in the CICES structure might be required to make it more useful. A further issue was to understand better any requirements for CICES to be linked to other classification systems for habitats or ecosystems on the one hand, and benefits and beneficiaries on the other. The results of these wider consultations will be summarised in this Report and used to inform the recommendations made on next steps.

2.2. CICES Structure

The current version of CICES was published at the beginning of 2013. The classification is provided in full in Appendix 1, and summarised at the class level in Table 1. The structure of CICES is illustrated in Figure 1.

In CICES, provisioning services are the material and energetic outputs from ecosystems from which goods and products are derived. The regulating services category includes all the ways in which ecosystems can mediate the environment in which people live or depend on in some way, and benefit from them in terms of their health or security, for example. Finally, the cultural services category identified all the non-material characteristics of ecosystems that contribute to, or are important for people's mental or intellectual well-being. As Figure 1 shows, CICES is hierarchical in structure, splitting these major 'sections' successively into 'divisions', 'groups' and 'classes'.

Table 1: Correspondences between CICES v4.3 Classes the typologies of the MA and TEEB.

CICES v4.3 Class		MA	TEEB
1.1.1.1	Cultivated crops	Food	Food
1.1.1.2	Reared animals and their outputs		
1.1.1.3	Wild plants, algae and their outputs		
1.1.1.4	Wild animals and their outputs		
1.1.1.5	Plants and algae from in-situ aquaculture		
1.1.1.6	Animals from in-situ aquaculture		
1.1.2.1	Surface water for drinking	Water	Water
1.1.2.2	Ground water for drinking		
1.2.1.1	Fibres and other materials from plants, algae and animals for direct use or processing	Fibre, Timber, Ornamental, Biochemical	Raw materials, medicinal resources
1.2.1.2	Materials from plants, algae and animals for agricultural use		
1.2.1.3	Genetic materials from all biota	Genetic materials	Genetic materials
1.2.2.1	Surface water for non-drinking purposes	Water	Water
1.2.2.2	Ground water for non-drinking purposes		
1.3.1.1	Plant-based resources	Fibre	Fuels and fibres
1.3.1.2	Animal-based resources		
1.3.2.1	Animal-based energy		
2.1.1.1	Bio-remediation by micro-organisms, algae, plants, and animals	Water purification and water treatment, air quality regulation	Waste treatment (water purification), air quality regulation
2.1.1.2	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals		
2.1.2.1	Filtration/sequestration/storage/accumulation by ecosystems		
2.1.2.2	Dilution by atmosphere, freshwater and marine ecosystems		
2.1.2.3	Mediation of smell/noise/visual impacts		
2.2.1.1	Mass stabilisation and control of erosion rates	Erosion regulation	Erosion prevention
2.2.1.2	Buffering and attenuation of mass flows		
2.2.2.1	Hydrological cycle and water flow maintenance	Water regulation	Regulation of water flows, regulation of extreme events
2.2.2.2	Flood protection	Natural hazard regulation	
2.2.3.1	Storm protection		
2.2.3.2	Ventilation and transpiration	Air quality regulation	Air quality regulation
2.3.1.1	Pollination and seed dispersal	Pollination	Pollination
2.3.1.2	Maintaining nursery populations and habitats		
2.3.2.1	Pest control	Pest regulation	Biological control
2.3.2.2	Disease control	Disease regulation	
2.3.3.1	Weathering processes	Soil formation (supporting ES)	Maintenance of soil fertility
2.3.3.2	Decomposition and fixing processes		
2.3.4.1	Chemical condition of freshwaters	Water regulation	Water
2.3.4.2	Chemical condition of salt waters		
2.3.5.1	Global climate regulation by reduction of greenhouse gas concentrations	Atmospheric regulation	Climate regulation
2.3.5.2	Micro and regional climate regulation	Air quality regulation	Air quality regulation
3.1.1.1	Experiential use of plants, animals and land-/seascapes in different environmental settings	Recreation and ecotourism	Recreation and tourism
3.1.1.2	Physical use of land-/seascapes in different environmental settings		
3.1.2.1	Scientific	Knowledge systems and educational values, cultural diversity, aesthetic values	Inspiration for culture, art and design, aesthetic information
3.1.2.2	Educational		
3.1.2.3	Heritage, cultural		
3.1.2.4	Entertainment		
3.1.2.5	Aesthetic		
3.2.1.1	Symbolic	Spiritual and religious values	Information and cognitive development
3.2.1.2	Sacred and/or religious		
3.2.2.1	Existence		
3.2.2.2	Bequest		

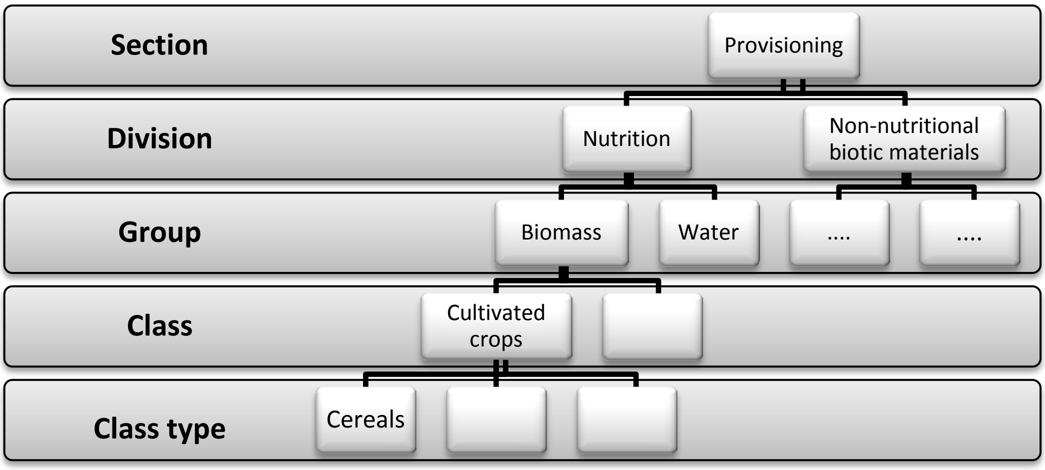

Figure 1: The hierachical structure of CICES (Potschin and Haines-Young, 2016a)

The hierarchical structure was designed to deal with the fact that in working with ecosystem services different people were working at different thematic and well as spatial scales; with this kind of structure it was intended that users could go down to the most appropriate level of detail that they require, but then group or combine results when making comparisons or more generalised reports. There was also an attempt to make it more comprehensive than the classifications used by the MA or TEEB, and to include categories such as biomass-based energy that were not explicitly included in these typologies. The broader range of categories at the detailed class level was intended to enable translations between different systems to be made; a simple prototype tool for helping people cross reference some of the more widely used classification systems has, for example, now been developed[1]. Table 1 also shows the equivalences between CICES and the MA and TEEB categories.

In order to build a generally applicable classification, the higher categories in CICES were intended to be exhaustive, in the sense that they were sufficiently general to cover all the things that people recognise as ecosystem services in the broadest sense. We recognised from the outset, however, that the system also ought to be open-ended to allow users to nest what was particularly relevant to them into the system at some level. Thus the class types were not specified; instead the assumption was that, given the general structure, users could place the specific things that they were measuring or interested into one of the existing classes.

2.3. Conceptual framing and its implications for integrated ecosystem assessments

CICES is not an arbitrary classification – but is underpinned by a conceptual framework known as the 'ES cascade model' (Potschin and Haines-Young, 2016). A review of the cascade is necessary to understand the context in which CICES is set, in relating to the needs of integrated assessment, and the other tools that need to be developed and used alongside CICES to make a full assessment.

Many people work with the definition of ecosystem services used in the MA, which describes them simply as 'the benefits that ecosystems provide to people' (MA, 2005). Others, however, follow the definition of TEEB, which views them as 'the direct and indirect contributions of ecosystems to

[1] See: http://openness.hugin.com/example/cices

human well-being' (De Groot et al., 2010). If we read these definitions carefully then it is clear that they are quite different in terms of what they take services to be: according to TEEB, services give rise to benefits, whereas in the MA they are the same thing. To add to this confusion we might note that both categorisations take the ideas of 'services' and 'goods' to be synonymous. Unfortunately, not everyone looks at things in this way. For example, in the UK National Ecosystem Assessment (UK NEA) (Mace et al., 2011), 'goods' and 'benefits' are taken to be identical, representing categories of things that people assign value to; they are taken to be quite distinct from services, which are seen as the ecosystem outputs from which goods and benefits are derived (Mace et al., 2012).

Do these differences in the way we categorise ecosystem services, goods and benefits really matter? Well, it depends on one's perspective. Some have argued that one of the important characteristics of the field of ecosystem services is that many different disciplines have come together to explore the insights that the concept offers for understanding the relationships between nature and society. It is this diversity that explains the different approaches that people have taken to categorising ecosystem services. They have also argued that the multiple interpretations that people bring to the concept are especially important, because it is a 'boundary object', that is an idea that can be adapted to represent different perspectives while retaining some sense of continuity across these different viewpoints (Abson et al., 2014).

Boundary objects are especially important in multi- or trans-disciplinary situations, because they create the space in which novel discussions and research interactions can occur. The dynamic, multi-faceted nature of the ecosystem service community is certainly part of its fascination. However, these 'boundary objects' are not useful when it comes to the problem of naming, describing and measuring things apparently as fundamental as 'ecosystem services'. When we start to think about this issue, then we start to appreciate the alternative perspective on the problem of whether the differences in the way differences in the way we categorise ecosystem services, goods and benefits really matters.

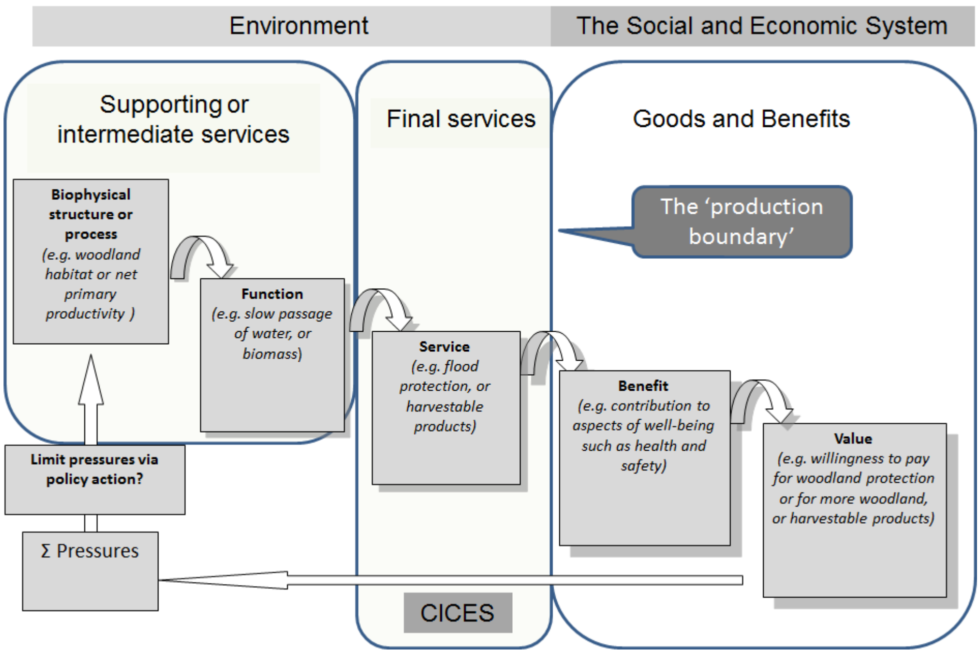

Figure 2 The cascade model (Potschin and Haines-Young, 2016a)

The links between people and nature are, however, complex, and so it is hardly surprising that people have defined ecosystem services in different ways. Some think of ES as the benefits that nature provides to people, like security and the basic material we need for a good life. Others view ES as the contributions that ecosystem make to such things. For the moment it is sufficient to note that despite differences in the way ES are defined most commentators agree that there is some kind of ‘pathway’ that goes from ecological structures and processes at one end through to the well-being of people at the other (Figure 2). This idea can be represented in terms of what we call the ‘cascade model’. It is a way of expanding thinking about ecosystems to include people, in which it might be described as a ‘socio-ecological system’. Finding out how these socio-ecological systems work and how we can act to sustain them are core issues in the field of ecosystem services. The task not only involves the study of ecology, but also such things as the social practices, governance and institutional structures, technology and, most importantly, the things people value.

To see something of the way socio-ecological systems work it is useful to ‘unpack’ the cascade model to see how the elements are related. Ecosystem services are at the centre of the cascade model, which seeks to show how the biophysical elements of the socio-ecological system are connected to the socio-economic ones; ecosystem services are at the interface between people and nature.

The ‘ecosystem’ is represented by the ecological structures and processes to the far left of the diagram. Often we simply use some label for a habitat type, such as woodland or grassland, as a catch-all to denote this box, but there is no reason why we cannot also refer to ecological processes, such as ‘primary productivity’ as something that can also occupy this part of the diagram. In either case, given the complexity of most ecosystems, when we want to start to understand how they benefit people, then it is helpful to start by identifying those properties and characteristics of the system that are potentially useful to people. This is where the idea of a ‘function’ enters into the discussion. In terms of the cascade model, these are taken to be the ‘subset’ characteristics or behaviours that an ecosystem has that determines or ‘underpins’ its capacity to deliver an ecosystem service. Some people call these underpinning elements ‘supporting’ and ‘intermediate’ services, depending on how closely connected they are to the final service outputs; we believe, however, this terminology deflects attention away from the important characteristics and behaviours of an ecosystem that generate different services. Thus using our terminology for one of the examples in Figure 2, the primary productivity of a woodland (i.e. an ecological structure) generates a standing crop of biomass (i.e. a functional characteristic of the woodland), parts of which can be harvested (as a ‘provisioning’ service).

In the cascade it is envisaged that services contribute to human well-being through the benefits that they support; for example by improving the health and safety of people or by securing their livelihoods. Services are therefore the various ecosystem stocks and flows that directly contribute to some kind of benefit through human agency. The difference between a service and a benefit in the cascade model is that benefits are the things that change well-being and which people assign value to; they are therefore synonymous with ‘goods’ and ‘products’. The cascade model suggests that it is on the basis of changes in the values of the benefits that people make judgements about the kinds of intervention they might make to protect or enhance the supply of ecosystem services; this is indicated by the feedback arrow at the base of the diagram. The important thing to note about ‘values’ is that they can be expressed in many ways; for example, alongside monetary values people can express the importance they attach to the benefits using moral, aesthetic and spiritual criteria.

Despite the simplicity of the cascade model it is useful in highlighting a defining characteristic of an ecosystem service, namely that they are, in some sense, final outputs from an ecosystem. They are 'final', in that they are still connected to the ecological structures and processes that gave rise to them, and final in the sense that these links are broken or transformed through some human interaction necessary to realise a benefit. Often this intervention can take the form of some physical action such as harvesting the useful parts of a crop. The interaction might also be non-material and more passive involving, for example, by enjoying the reduction or regulation of some kind of risk (flood risk is the example shown in Figure 2), or the intellectual or spiritual significance of nature in a particular cultural context. Thus services are at the point where the 'production boundary' is crossed between the biophysical and the socio-economic parts of the socio-ecological system.

Although Figure 2 places CICES at the interface between the biophysical and socio-economic components of the 'socio-ecological system', it is important to note that measurement and ultimately assessments of the status of those services may not be confined to this central part of the diagram. While a key task is to identify appropriate metrics that can be used to quantify each service, it might well be the case that measures of structure and process, ecological function, benefit and value are also needed, or can be used instead as proxies to find out what is going on. The extent to which CICES therefore provides both a rigorous framework for assessing services and a thematic list of ecosystem outputs that need to be explored in some way through a variety of different types of measures is a question that will be explored in Part 4 of this Deliverable report.

2.4. Current status of CICES

Given that the current version of CICES was released in 2013, there has been sufficient time for people to apply the framework and to report on their experience. The 2016 Survey of CICES users identified a number of publications and a more extended literature review has identified others; at the time of writing, the body of peer-reviewed literature that underpins CICES V4.3 exceeds forty publications.

In relation to the status of CICES and its role in ESMERALDA, it is important to note that V4.3 forms part of the mapping framework proposed to support the EU's Biodiversity Strategy to 2020 (MAES 2014; see also Maes et al. 2012). The second report of the Mapping and Assessment of Ecosystem Services (MAES) Working Group uses the CICES classes to identify a range of indicators that can be used for mapping and assessment purposes[2]. This approach has been further tested in Maes et al. (2016), who identified several issues in using CICES as a common framework for indicators across different ecosystems. The ways in which CICES classes could be assigned to ecosystem types was also examined and alternative approaches for handling ground water, for example, were discussed.

The use of CICES as a template for indicator development has also been taken up more widely in the literature. It has, for example, been used as the basis for the German TEEB study (Naturkapital Deutschland – TEEB DE, 2014) as well as the German National Ecosystem Assessment screening study, NEA-D (Albert et al., 2014). It has also been refined at the most detailed class level to meet the requirements of the ecosystem assessment in Belgium (Turkelboom et al., 2013). Mononen et al. (2015) used CICES to develop an indicator framework at the national scale in Finland, Kostrzewski et

[2] see also: http://biodiversity.europa.eu/maes/#ESTAB (accessed 30/01/2016)

al. (2014) describe how it was used to help define metrics that could form part of the Integrated Environmental Monitoring Programme in Poland. Kosenius et al. (2013) describe other work in Finland on forests, peatlands, agricultural lands, and freshwaters, and found that - when defining indicators - the classification developed in CICES was useful because “it divides ecosystem services to concrete and at least to some extent measurable categories” (Kosenius et al., 2013, p.26).

While being useful in their own right, the studies that have used CICES V4.3 as an indicator framework are valuable more generally because they provide evidence on the extent to which the classification captures the full range of services; key design criteria for CICES have been that, for at least in the upper levels of the hierarchy, the categories should be ‘comprehensive’ and ‘complete’ (Haines-Young and Potschin, 2013). A key conclusion that one may take from a review of the papers cited above is that no key gaps were identified; the comprehensive nature of CICES is a particular point emphasised by Grizzetti et al. (2015) in their guidelines developed through the MARS (Managing Aquatic ecosystems and water Resources under multiples Stress) Project. Arovuori & Saastamoinen (2014) have also supported the comprehensive nature of the classification. These and other studies (e.g. Stępniewska, 2014; Mizgajski, 2012) also indicate the versatility of the overall structure of the classification. However there has been no systematic analysis on the practical usefulness of CICES as an indicator template so far, and so this gap has been addressed in ESMERALDA (Milestone 20; see also Part 4 of this Deliverable).

In terms of flexibility and being able to construct reporting categories appropriate to different types of application, the value of the hierarchical structure of CICES has been noted in a number of studies. In their work on ecosystem services in tourism and recreation, for example, Kulczyk et al. (2014) showed how the categories at the Division level could be used to report on different dimensions of tourism and recreation, and that “common classifications” such CICES, allow “easy communication and comparisons within different contexts” (Kulczyk et al., 2014. p. 87). By contrast, Helfenstein and Kienast, (2014) used the hierarchical structure in a more flexible way in their analysis of ecosystem service state and trends at regional to national levels in Switzerland. These researchers used CICES to define eight categories of ecosystem services: provisioning services, biodiversity, water regulation, cultural services, climate regulation, soil preservation, mitigation of natural hazards, and air quality regulation. They found it “more practical” to use various levels in the CICES hierarchy than to adhere to one, but noted that “their entirety, our selected ecosystem services cover all CICES classes except disease control and ones pertaining to marine ecosystems” (Helfenstein and Kienast, 2014, p. 12).

Although the upper levels in the CICES hierarchy are designed to be complete and comprehensive, flexibility in dealing with locally or application-specific ecosystem services was built into the system by allowing users to define categories that were relevant to them at the ‘class type’ level. Categories at the sub-class level would ‘inherit’ the general properties of the hierarchical levels above, but then have specific names and definitions specific to the place or type of application involved. The work of Saastamoinen (2014) has described how this can be done in relation to the work in Finland on peatlands, agricultural lands, and freshwaters; Alahuhta et al. (2013) considers the specific case of freshwaters in more detail. The creation of policy-relevant sub-classes using CICES, as part of a broader mapping and ecosystem assessment done in the context of MAES, is also illustrated by the work in Ireland, described by Medcalf et al. (2016).

While the applications of CICES suggest that the current framework is appropriate for many uses, it is also clear that we need to think carefully about how such systems can be developed. For example, the work of Armstrong et al. (2012) and Liquete et al. (2013) suggest that it may need to be adapted to ensure that it is suitable for the assessment of marine and coastal ecosystems, or integrated more closely with typologies for describing underlying ecosystem functions. It is the case that marine interests were probably under-represented in the consultations that led to the current version, and that in marine situations many of the services that are meaningful in a terrestrial context, do not apply. Winkler and Nicholas (2016) have identified terminological issues relating to the way CICES deals with cultural ecosystem services, based on their study of ecosystem services in vineyard landscapes in England and California.

A particular issue relating to the way categories in CICES are famed relates to the extent to which they unambiguously represent 'final services'. This is an issue that will be explored in section 2.5 of this Report. In the context of this review of what of the published literature, it is interesting to note the work of Liquete et al. (2016). These researchers examined the link between ecosystem services and biodiversity, with a view to understanding whether the "maintenance of nursery populations and habitats" can be regarded as a final service in marine ecosystems, or an intermediate one. Their conclusion is that it can be regarded as a final services when it can be linked to a concrete human benefit, but that it is not when used with indicators of general biodiversity or ecosystem condition. In short, their conclusion suggests that in defining final services, 'context matters'. Other work that also suggests this conclusion includes that of Saarikoski et al. (2015), who looked at a range of definitional issues through the lens of the boreal forests. The implication of such work is that better guidance on how the notion of a 'final ecosystem service' can be applied using CICES is probably required.

A key task in any indicator mapping or account application is the ability to assign services to particular ecosystem types that can be used as some kind of mapping of accounting unit. Our review of the available literature suggests that making such assignments have been relatively unproblematic, in so far as there is little reference to any significant issues. The hierarchical structure of the classification appears to allow some adjustment of the generality of the categories from CICES used to represent services to the geographical scale of the investigation; fundamentally, flexibility is achieved by using different metrics to represent the services, the choice being dependent on such factors as data available, selected methods and analytical context. They key point here is that the definitions of the CICES classes are sufficiently broad to allow 'interpretation', but sufficiently specific to ensure that ultimately people in different studies 'measure the same thing'. At present it is difficult to make a judgement on this issue from the available literature, and so it has been taken forward as one of the issues to explore further in the case study work undertaken in ESMERALDA.

Although CICES was designed with accounting applications in mind, the ability to use the classification structure to build appropriate and meaningful reporting and analytical units for more general kinds of work, is perhaps one of its major contribution to the wider ES community. A particular feature of many of the published studies has also been the extent to which CICES can help make an *integrated* assessment of some kind. Within the ESMERALDA project, we take 'integrated' to mean a number of things. At the most basic level it entails making an assessment of an *individual service* based on the interrelationships between the biophysical, social and monetary dimensions that affect supply and demand, and therefore to bridge the different elements of the cascade and communicate the result in a holistic way. In addition it is also fundamentally taken to imply an assessment that is able to look at and communicate the *relationships between services* (or within 'bundles' of services) so that patterns of 'trade-off' and 'synergy' can be identified, as well as the factors that drive ecosystem change. Finally, an integrated assessment is one that can bring together and represent at different spatial and temporal scales.

Examples of published work involving CICES that has facilitated an integrated approach therefore take various forms. Santos-Martín et al. (2013) have used CICES to examine the relationships between ecosystems and human wellbeing in Spain. The Classification has been used as the basis for developing or comparing indicators of ecosystem service supply and demand; this type of work includes that of Castro et al. (2014), Kosenius et al. (2013), von Haaren et al. (2014) and Tenerelli et al. (2016). The latter used CICES as a way of categorising crowd-sourced indicators, derived from 'go-sources images', for cultural ecosystem services for mountain ecosystems.

The use of CICES in relation to the analysis of the drivers of ecosystem change, is illustrated by work such as that of Maes et al. (2015) who have examined how current patterns of land use change have impacted upon on the aggregated provision of eight ecosystem services at the regional scale of the European Union, measured by the so-called 'Total Ecosystem Services Index' (TESI8). Vidal-Abarca et al. (2014) have used the Driver-Pressure-State-Impact-Response (DPSIR) framework alongside CICES to examine fluvial ecosystems and social systems in Spain. The assessment of green infrastructure based on the analysis of ecological networks and ecosystem services represented by CICES has been described by Liquete et al. (2015). Elsewhere, Bürgi et al. (2015) have used CICES in a historical context to examine how ecosystem service output had changed for a Swiss landscape since about 1900. The classification framework was used to code the reports from archive sources about whether things that we would now regard as ecosystem services were documented as important in past periods, with a view to understanding what this can tell us about scenarios of future change.

The uses of CICES to undertake ES trade-off and marginal change analyses at European scales is illustrated by the work of Haines-Young et al. (2012), who used scenarios to explore how the functional and geographical linkages between services would play out under a range of future conditions. A more extensive trade-off analysis based on current information was done by Lee and Lautenbach (2016), who have undertaken a quantitative review of relationships between ecosystem services in the context of multi-functional land systems. They used CICES to analyse 67 case studies that studied 476 pairwise combinations of ecosystem services, seeking to find evidence for "trade-off", "synergy" or "no-effect". They found that there appeared to be synergistic relationships were most frequently observed between different regulating services and between different cultural services, whereas the relationship between regulating and provisioning services tended to be one of trade-off. What is of particular interest in terms of understanding the contribution of CICES, however, is that the hierarchal structure was a valuable characteristic of the system, both in terms of making a comparative study and of analysing cross-scale patterns.

Despite the fact that CICES was initially developed to address accounting needs, there are relatively few published studies that describe these types of application. However, the potential has been discussed. Liquete et al. (2013), for example, undertook a systematic review of literature on marine and coastal ecosystem services, and concluded that by using the general structure of CICES, an integrated MCES classification for marine and coastal ecosystems could be created that could be linked with the framework of the UN System of Environmental-Economic Accounts (SEEA) and with standard product and activity classifications, such as the International Standard Industrial Classification of All Economic Activities, the Central Products Classification, and the Classification of Individual Consumption by Purpose. This they thought would be valuable for making progress in the context of these ecosystems. Schröter et al. (2014) have also sought to explore the accounting applications through their work in Telemark, Norway. The argued that to take accounting applications forward, there is a requirement for clarity of concepts for monitoring purposes, accuracy and appropriateness of indicators at broad spatial scales, given limitations of data, and the spatial explicitness of ecosystem services. Their work illustrated that using CICES as a framework, a set of spatial modelling methods could be combined that enable the analysis of the capacity and flow of ecosystem services at a broad scales, and that these metrics could be allocated to relevant spatial units to meet the needs of ecosystem accounting.

Our review of recent literature suggests that while the current version of CICES clearly works for many purposes, given the importance of categorising ecosystem services in clear and transparent ways, the development of this and other systems needs to be reviewed constantly as our needs and concepts evolve. They are essential tools for our mapping and assessment work. Crossman et al. (2013) for example, have suggested that a classification, such as CICES, might form as part of a more general systematic approach or 'blueprint' for mapping and modelling ecosystem services. Busch et al. (2012) have also argued that it is important to develop classification systems, such as CICES, that are 'geographically and hierarchically consistent' so that we can make comparisons between regions, and integrate detailed local studies into a broader geographical understandings.

2.5. Challenges

Socio-ecological systems are, of course, more complex than Figure 1 suggests, especially when seeking to understand the balance between the capacity of ecosystems to supply a service and the demand for it. However, this simple diagram helps us understand that all the different elements of the cascade need to be considered if we want to appreciate what an ecosystem service really is and how it connects people and nature. We need to map and measure indicators across the entire pathway to build up a complete picture. The left hand side of the cascade captures the important elements that determine the capacity of ecosystem to supply services, while the right hand side aspects of the demand for them. And understanding the balance between them is at the heart of the contemporary sustainability debate, and key to our understanding of the way people and nature are linked. Current experience suggests there are a number of challenges around the problem of classifying ecosystem services; we can reflect upon them by reference to CICES.

Experience in trying to work with CICES across different application areas has demonstrated how difficult it is to categorise 'final ecosystem services' in a uniform and unambiguous way. Final services, according to Boyd and Banzhaf (2007), are the 'end-products of nature'; they argue that it is important to define them clearly to avoid the problem of 'double counting' when we value. More formally, these authors suggest they 'are components of nature, directly enjoyed, consumed, or used to yield human well-being'. The implication is that we should avoid trying to value the processes or ecosystem components that underpin them, not because they are unimportant, but because their value is already embodied in this final output.

The difficulty of this idea of final services posed when working on CICES has been that it is clear that, to some extent, what constitutes a final service is context-dependent. Take the case of the regulating service categorised in CICES as 'pollination'. On the face of it, it looks like a thing that has more of an underpinning or supporting role rather than being a 'final service'. However, on closer scrutiny the answer is 'it depends'; certainly pollination is an important input to a number of provisioning services such as fruit production. However, encouraging pollinator species in our gardens, whether they benefit us by pollinating our fruit or not, can also be regarded as a final service. In this context, pollinators are another iconic group of species that we want to conserve or encourage, like farmland birds, for example. Also in a horticultural situation it might be useful think of pollination as a final service in some analyses, say where the contribution of natural pollinators is supplemented by the artificial introduction of pollinators by farmers, and we seek to understand precisely what the scale of the contribution from the ecosystem is. The point here, in relation to CICES is that the list of services in the classification are more a set of potential final services and whether they are or are not has to be determined by the circumstances in which the classification is being applied. There probably is no definitive list of things that we can unambiguously categorise as 'final services'. Any future version of CICES would have to help people navigate some of these issues when they seek to describe and measure ecosystem services.

As CICES is an overarching classification scheme, trying to encompass all domains of nature and society, creating a universally appropriate and consistent hierarchy structure is a considerable challenge. There are an infinite number of diverse interactions between nature and society, and it is not trivial to find appropriate organizing principles and levels of detail across all major scientific domains affected. Furthermore, in many domains there is no "natural order" among the potential dimensions (e.g. a provisioning service can be used for nutrition, material or energy; can be plant-based, animal-based or abiotic; can be cultivated or come from the wild; etc.). Fortunately, the lack of a predetermined "natural order" also means that any sensible classification system can be sufficient, and be used in various practical assessment contexts.

A second related challenge in designing CICES, concerns the scope of the classification. During the consultation processes that gave rise to CICES there was considerable debate about whether abiotic ecosystem outputs like wind or hydropower, or minerals like salt, should be categorised as 'ecosystem services'. In the end, the augment that the category 'ecosystem services' should be restricted to those ecosystem outputs that were dependent on living processes won the day. The telling point was that a key feature of the concept was that it helps make the case for the importance of biodiversity, and to include other things that are not dependent on living processes would dilute it. The problem is, of course, that these abiotic ecosystem outputs are not unimportant, discussion of them will still involve trade-offs etc., and in any case lay people often do not see the different between these products of nature and those dependent on biodiversity.

The point about scope that can be illustrated from the example of CICES is that to some extent these kinds of decision are arbitrary, and have to be guided by the kinds of purposes that people want to apply the system too. The arbitrary nature of these decisions is illustrated, for example, by the place of water in CICES. Water is indeed an abiotic ecosystem output – but it is included in the classification as a provisioning service. Water quantity and quality of water can be regulated by living processes and these kinds of thing ought to feature somewhere in the classification. However, strictly speaking, living processes do not 'produce' water, and so it should probably be excluded from the classification as a provisioning service. However, the people consulted when V4.3 was developed felt it was too important not to be included.

One of the final challenges that we encountered in designing CICES is closely related to the difficulty that people have in distinguishing services and benefits. The distinction is a difficult one to make because it involves deciding where the 'end-product of nature' is transformed into a good, a product or a benefit as a result of human action of some kind. Take the case of crops standing in a field. In CICES V4.3 these would be regarded as a final ecosystem service because they are still connected to the ecological processes associated with the farmed landscape that produced them. That crop can then be turned into a product by harvesting it. While many ecosystem service applications also regard crops in a field as examples of a provisioning service, this is at odds with those developing accounting applications who argue that outputs from ago-ecosystems represent a form of 'co-production' by people and nature, and that the contribution of nature is already built into the value of the crop. They argue that the final service in this situation is nutrient cycling and the other ecological properties of the system that make copping possible. Thus, according to the concepts underpinning the System of Integrated Environmental and Economic Accounts (SEEA), outputs like crops, plantation timber, and aquaculture, are considered benefits produced as a combination of final ecosystem services and human inputs; according to the way national accounts are constructed only things whose growth is dependent on 'natural processes can be categories as an 'ecosystem service'.

The difficulty that the strict SEEA formulation in the 'Central Framework' seems to pose is that at a time when we are seeking to make sure that the value of nature is fully taken into account, the criterion of reliance on 'natural processes' would seem to exclude much of what goes on across the majority of landscapes not only in Europe but also elsewhere. Agro-ecosystems my not be natural, but they do still depend on ecological processes, and so it is this dependency or connection that perhaps we should emphasise and take account of. The challenge for valuation is to disentangle these two types of input, and to do so, we argue that cultivated crops and reared animals should be fully recorded at least in physical terms so that judgements about the importance and value of different inputs can be made in a transparent way. Given the difficulties of disentangling the contributions of ecosystems and human-derived capital, it is proposed in CICES that we follow the 'harvest approach'[3] described in the SEEA EEA guidelines, which takes the measurement of ecosystem services as equivalent to the amount of the crop that is harvested, irrespective of the extent of management of its growth. The SEA-EEA guidelines suggest that:

> *"…..it may be appropriate to apply the harvest approach for cultivated crops and other plants, based on the assumption that the various flows, such as pollination, nutrients from the soil, and water, that constitute inputs into the growth of the mature crop are in fixed proportion to the quantities of harvested product*" (SEEA EEA para 3.30).

The way that the SEEA attempts to categorise ecosystem services is legitimate and rational, given the perspective of the people. The point we want to make is noting the issue that classification systems inevitably depend on the ways the groups involved view the world; the paradigms that they

[3] As opposed to the second approach recognizes the extent of management of growth by defining some crops as natural and others as cultivated, following the logic underpinning the determination of the SNA production boundary (SEEA-EEA, para 3.25.

inhabit. Reflecting on the design of the current version of CICES we conclude that we need to be much clearer developing a terminology that distinguishes services from the benefits that are associated with them in different situations, and that probably we need a more comprehensive system for categorising benefits as well as services. The example of the 'FEGS' system developed by the US-EPA (Landers et al., 2016) suggests that there may be scope in looking at the way services, benefits and beneficiaries are aligned in different classification systems, so that a more complete picture can be established. Since it is clear that the 'end-products of nature' can give rise to multiple benefits, and that different groups may value in different ways, future categorisation systems probably need to be much more sophisticated in the way they help us to conceptualise these things. These issues will be explored in the final phase of ESMERALDA.

These challenges have provided the backdrop for the specific work being undertaken in ESMERALDA on CICES and how it can support integration of the biophysical, social and monetary dimensions of ecosystem assessments. Much of this has been progressed through workshops that have brought together members of the consortium and others working on these topics. The outcomes are discussed in the next part of the Deliverable report.

3. Characterising the biophysical, social and economic dimensions of ES assessments

3.1. Introduction

As part of the on-going work of ESMERALDA we have held a number of meetings during 2016, with consortium members and others, on the general issue of integrated mapping and assessment in MAES, and on the use of CICES in particular. The work on CICES has partly been undertaken in collaboration with the European Environment Agency (EEA), in conjunction with an on-going initiative to examine the case for revising CICES V4.3. This section of section of the Deliverable describes outcomes of these workshops.

3.2. Customisation of CICES across Member States

A workshop on the customisation of CICES was held at European Environment Agency between 25th and 26th February 2016; it formed Milestone 19 of ESMERALDA (see Potschin and Haines-Young, 2016b). The aim of the 'Copenhagen Workshop' was to take stock of the experience gained in using the current version of CICES V4.3 for accounting, mapping and assessment, and to advise on the objectives for any future revision and the development of guidelines to help people apply it effectively within the context of ESMERALDA and the EU MAES process. The workshop drew on interim results from the current consultation on CICES that was due to be completed in April 2016 (see below).

The workshop was organised by University of Nottingham (WP4 leader on Ecosystems Service Assessment Methods) and hosted by the European Environment Agency. Eighteen experts from ten different European countries attended the meeting; they included members of the ESMERALDA consortium as well as members of the wider ecosystem service community; all had experience in using CICES or had worked on classification issues.

The workshop focused on two main areas for discussion. The first sought to draw on the experience of using CICES by those attending the meeting, and to reflect on some interim results from the on-going survey of CICES applications. The second looked at CICES as an indicator framework and some of the key messages that can be taken forward in developing guidelines for using the current or revised version of the classification in the future.

3.2.1. Using CICES for mapping and assessment

The key points that emerged from the discussion around the issues of using CICES for mapping and assessment were that there was a need for better guidance in using CICES both in its current form and especially if there is a revision. It was suggested that any guidance could usefully be provided (for example in the form of a MAES report) and that future work within the ESMERALDA project could inform and test the development of these guidelines.

In terms of ***provisioning services*** it was noted that in using CICES many people start at the class level rather using the groupings at the higher levels in the hierarchy, and so there should be some attempt to make the descriptors less abstract at an early stage. It was also suggested that it should be recognised that the classification is used in different domains and so there should be some attempt to reflect this in potential alternative terminologies; for example there might be scientific descriptors as well and more popular terms as equivalents. A numerical coding for all services in the CICES hierarchy was also recommended as useful.

For ***regulation and maintenance services***, it was noted that it might be useful to make guidance context- (biome) specific, by for example, providing guidance for marine applications, or by including examples of services for different biomes. In the context of marine ecosystems it was argued that assessments are often best made at the group level and so better guidance was needed here, especially in relation to the distinction between 'intermediate' and 'final' services. It was concluded, however, that for marine context there should be no attempt to remove services that are potentially 'intermediate' from the CICES class list, even if the goal is to focus on 'final services'. This is needed to ensure comprehensive coverage in all types of application.

In relation to ***cultural services***, it was agreed that there was a pressing need to clarify the terminology in relation to the service/benefit distinction. It was also agreed that the cultural dimension of all services needed to be explained as part of clarifying what cultural services actually are. In terms of suggestions for revision people felt that the split between physical and intellectual services at the group level was unclear, and that some other formulation such as 'proximal' and 'remote' interactions might be more helpful; scale might provide another potential approach to differentiating cultural services. In terms of definitions it was suggested that it might be worth stressing that these kinds of service ***shape*** our cultural environment, and so descriptors might try to capture the more 'active' or 'doing' aspects.

3.2.2. Using CICES as an indicator framework

The discussions focussed on reviewing the ways in which CICES has being used to create indicator frameworks or metrics that could be used in mapping and assessment, and indeed accounting, work. The workshop drew on the results of the case study analysis that has been undertaken within ESMERALDA[4] that has looked at around 60 applications. The analysis found that not only did methodologies of mapping and assessment vary across Member States, but also that knowledge of the ecosystem service concept and the way they are classified also differed. However, in terms of the classification system used, CICES was the most frequently applied. Regional scale applications were also the most common. In terms of the focus of the studies, the majority (49%) looked at the biophysical dimension and on the capacity of ecosystems to supply services. Within provisioning services, the top three were cultivated crops, fibres and other materials and ground water. For regulating and maintenance services, the most common were global climate regulation, flood protection and filtration/sequestration. Within the cultural services section, the most frequently assessed were aesthetic, physical use of landscape and seascapes, and heritage. A key conclusion to emerge was that while a range of indicators based on CICES that were identified only few could be used for reporting under Action 5 of the EU Biodiversity Strategy, and that further work was needed to ensure better coverage.

Further background for the discussions on indicators was provided by reviews of studies in Finland and Germany. Subsequent discussions confirmed the earlier conclusion that there was a need for

[4] Santos-Martin F. et al. (2016): Individual consortium interviews to assess the status of their mapping and assessment activities Milestone 15. EU Horizon 2020 ESMERALDA Project, Grant agreement No. 642007.

revision of the current version of CICES, or at least the clarification of terms etc. so that it can be applied more easily. It was felt however, that the role of CICES as a translator should be maintained and strengthened, and that perhaps it could also help translate between application contexts as well as between ecosystem service classification systems. The idea of 'application masks' was suggested as an option in relation to this. It was recommended that 'CICES masks' that could be applied in different biomes (e.g. marine) as well as different types of application (e.g. accounting, assessment etc.).

In terms of using CICES as an indicator framework, it was generally confirmed that while ecosystem services are the focus, indicators across the range of variables included in the ES cascade, for example, would be needed in different applications and that their relation to the CICES classes could be clarified. Such an approach is illustrated by the work of Mononen et al. (2015). It was felt that there was a particular need to help people to differentiate or to assess ecosystem service supply and demand metrics. However, it was suggested that if indicators are suggested alongside the CICES classes, they should not be used as part of the definition. CICES should not be presented as a 'comprehensive indicator framework'; rather people should be able to apply CICES independently of any suggested metrics.

A key point that emerged from the discussion on indicators was that while CICES can support a variety of different tasks (accounting, assessment, communication, scoping), given that its origins lie in the EU/EEA accounting work and the UN System of Environmental-Economic Accounting Experimental Ecosystem Accounts (SEEA EEA), any revision should ensure that as a minimum those needed are fulfilled. There was some concern that the focus on accounting might make CICES too restrictive and undermine its multi-purpose use. However, it was stressed that accounting is much more than monetary valuation, and that applications linked to biophysical and social measures can be supported, and this could be emphasised in any set of guidelines.

3.2.3. Conclusions from 'Customisation of CICES'

Across the whole workshop, a key message to emerge was the need to provide guidelines to users of CICES. In many respects, some of the current problems of application arise from the lack of guidelines for the current version. The strong recommendation from the group was that rather than developing the guidelines ***after*** the revision process had been completed, the development of guidelines should be seen as ***part of*** that processes of revision. In this way issues could be identified early on and strategies for overcoming them presented in a more transparent way. It was recommended that the work undertaken by the EEA and ESMERALDA in the short term should provide a 'road-map' for the development of these guidelines. Although the guidelines might eventually be published as a MAES Report, it was felt that web-based support was probably also needed.

3.3. CICES User Survey 2016

As part of the wider work surrounding the development of CICES in the context of experimental ecosystem accounting, a survey of people using CICES or concerned with ecosystem service classification was undertaken in the first quarter of 2016[5] (Haines-Young, 2016). The aim was to draw on the body of experience that has been built up since the release of V4.3 in 2013, and to identify where its strengths and weaknesses are, and potentially how the structure might be improved. People who had not used CICES but who had used other classification systems were also encouraged to complete the survey. Altogether, 327 people attempted the questionnaire from which there were 222 useable responses, in the sense that they provided answers to some or all of the questions posed in the main body of the survey; 125 (59%) recoded that they were CICES users and 87 (41%) that they were not.

A clear message that emerges from the questionnaire was that there appeared to be an established user-base for CICES; much broader than had, for example, been anticipated in the workshop on customisation (Section 3.2 above). In terms of application area, the majority of users selected 'mapping and ecosystem assessment' (77%), followed by 'valuation' (37%) and 'the development of indicators' (35%); only 19% selected environmental accounting[6]. The responses of people using CICES confirmed that its key advantages were its logic, the flexible hierarchical structure, its comprehensive coverage and the potential that it offered as a standard. While users also identified difficulties in working with the classification, the comments suggest that many of these could potentially be overcome by providing better guidance and examples. The kinds of issue that these examples need to illustrate include the links to underlying structures, processes and functions, and the links to benefits and beneficiaries. It seems apparent that whether or not formal classifications of benefits and beneficiaries are developed in the future, these examples could serve to help users of CICES in the short to medium term. The important analytical issues that need to be considered include the problem of 'double counting' and how to handle it in the classification, and how the classification might support the analysis of 'trade-offs'.

The results of the Survey confirmed the findings of the 'Copenhagen Workshop', namely that the classification of cultural ecosystem services in the current version of CICES is an area of concern. Also echoed were the findings that for the marine sector, that a better explanation of that constituted a final service in different types of environment might be necessary. A conclusion to emerge from the analysis of responses was that to support the wider range of uses that the current version of CICES has, it would be advantageous to have a less technical set of descriptors and service names that could be used with non-experts during, say, a participatory process. While it seems unlikely that a lay version of the classification could replace the more technical one (given the need for better definitions suggested by a number of respondents), the ability to have consistent but customised naming conventions that suit a wider range of applications would seem useful. The approach could also be used to cross-reference service categories that make more sense in the context of specific ecosystem types, such as marine.

In terms of developing CICES further it emerged that there was a major of respondents in favour of better integrating the classification of abiotic ecosystem outputs into the system. Making a link to classifications of benefits and beneficiaries was also strongly emphasised. The process of revising

[5] see also www.cices.eu

[6] The survey identified nearly 40 published papers and links to other sources describing work based on CICES; many of these have been used in the literature review presented in Part 2. They also provide a useful starting point for developing a set of examples around which strategies for handling analytical and conceptual issues can be described.

CICES V4.3 is, however, on-going and it is not anticipated that final proposals will be made until the end of 2016. Nevertheless, it has been agreed with the EEA that recommendations for modifying the structure of CICES and any draft guidelines can be examined by the ESMERALDA consortium, so that they can be made as operationally robust as possible. This strategy will usefully support the current phase in the ESMERALDA work programme which is testing analytical methods across a range of different case studies.

3.4. Flexible methods for ecosystem service mapping and assessing

The ESMERALDA workshop on 'flexible methods' held in Nottingham between 14th-15th April 2016 ('Nottingham Workshop') was designed to address a much wider range of issues than the those relating to CICES (see Potschin et al., 2016c), nevertheless less its outcomes are highly relevant in the context of the current Deliverable and so are discussed here. In the long term, the ambition is to understand how these flexible methods built towards the creation of a suite of integrated assessment tools and concepts that can be used by EU Member States to fulfil the requirements of the MAES Process.

The specific aims of the 'Nottingham Workshop' were to develop a common understanding within ESMERALDA on methods for mapping and assessing ecosystem services, and how these could be assigned to the 'tiered approach'. It was also designed to identify the relationships between ES, ecosystems, scales and specific methods and the potential linkages between methods across the biophysical, social, and economic domains. The extent to which CICES can be used to support and operationalise these various methods was one of the key points in the discussions.

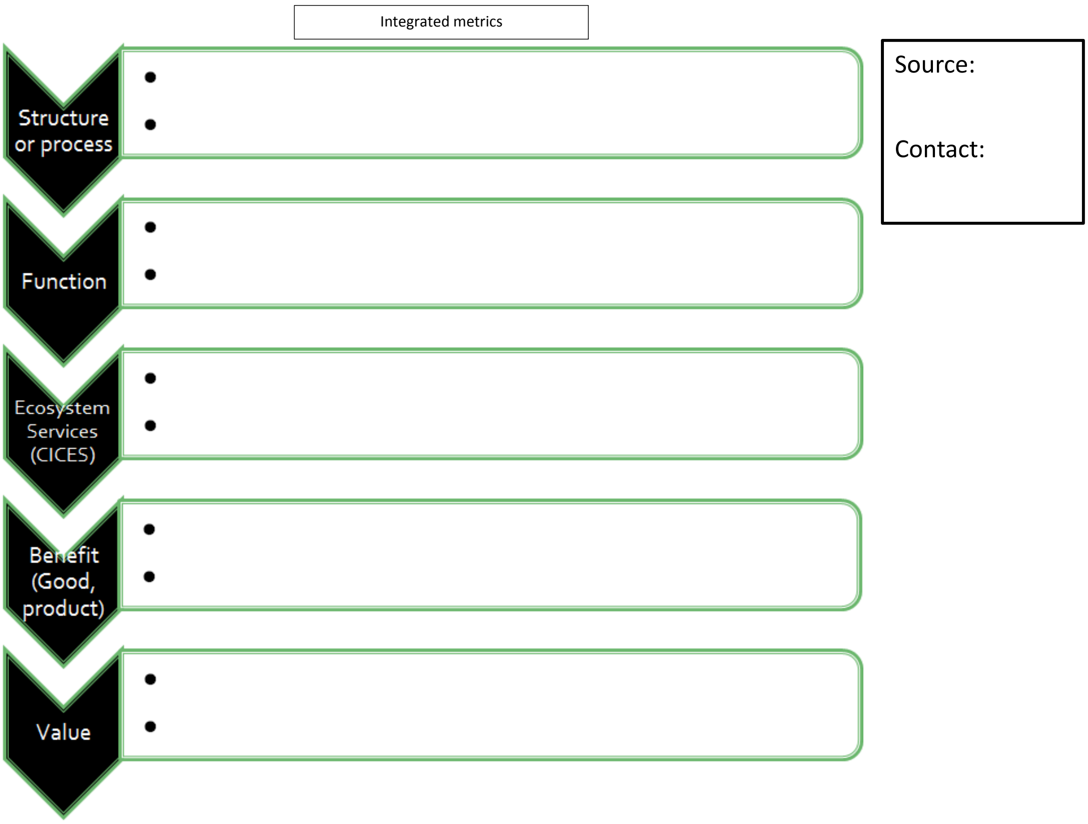

Figure 3: Template used to collect information on integrated CICES metrics at the workshop

3.4.1. Ecosystem services and their quantification

The workshop began with an introductory session on ecosystem services and their quantification, and in particular how CICES can be used to help identify what is potentially being measured. The issue is especially important in that experience suggests that often 'ecosystem service flows' cannot be measured directly, but instead characterised by using proxies that give insights into the capacity of ecosystems to supply services, or the demand for, or use of, services by people. The discussions therefore examined the extent to which CICES can provide a framework that can be used to capture different sorts of metrics and how they relate to each other in an 'integrated assessment'.

It was generally agreed that, taken together, the cascade model and CICES provide a framework for 'quantifying' and 'qualifying' ecosystem services. Quantification is clearly a pre-requisite for developing metrics or indicators that can be used both for mapping and ecosystem accounting. The contribution in terms of 'qualification' was emphasised in order to highlight the fact that the cascade and the classification itself provide a set of concepts and descriptors that can be used to engage stakeholders in discussions about ecosystem services. It was noted and accepted that while CICES is not the only 'entry-point' for mapping and assessment, it can provide a way of making comparisons and cross-references.

To help people to use CICES it was suggested that links to 'real indicators' were needed; an exercise undertaken in the break-out session identified a number of examples that could be used in this context. The template used is shown in Figure 3, and the results tabulated in Appendix 2. The aim of the exercise was not so much to identify 'relevant' indicators for the services that were suggested by the participants, but to examine if and how they could be seen as *integrated* measures across all the elements of the ES cascade, in the sense that they all measured different aspects of the *same* service, and hence could be used to triangulate the judgements made about its status and trends. The workshop identified 28 examples that can be followed up in future work.

In reviewing the examples, participants reported that in general it was possible to think of integrated measures across the biophysical, social and economic dimensions of the ES cascade, but that most of the examples were at the class level; in the future is was suggested that it may be useful also provide to illustrations of how metrics and indicators could be constructed at the division and group levels. Such examples could be used to illustrate how these upper levels in the classification can be used to define more aggregated types of metric that can also be used in mapping and assessment work. The need for better guidance and examples was highlighted through an example involving the use of CICES to classify 'purification'. Experience suggests that the category is too complex to be assessed at the class level, and that perhaps mapping needed to be done using more aggregated metrics for representing categories at the group or division level. It was also recognised, however, that for some applications, further flexibility could also be highlighted by showing how sub-classes could be added below the class level to better take account of local issues.

The participants recommended that guidance should be developed to better communicate flexibility for applications, for example by providing a wider range of names for services at the class level so that the classification can be adapted to local needs. CICES might also be translated into other languages, and in this context resources might need to be found to harmonise the translated names and descriptors. The need to tailor CICES so that it can better be used to assess the variety of ES associated with both terrestrial and marine ecosystems was also considered. It was suggested, for example, that customised versions could be developed for specific habitats/ecosystems (e.g. urban) or more general set of 'biophysical classes'.

While it was acknowledged that CICES can help users simplify the complexity around defining and measuring ecosystem services, it was also pointed out that understanding the supply and demand side is not always 'linear', and can become complex when you have to incorporate all the ES cascade components into the assessment. In terms of helping people pursue 'an ecosystem approach' it was argued that this might limit its use if we really are aiming to provide information for decision making; a particular issue identified was to ensure that there was consistency between legal and administrative requirements and measures at different levels of the ES cascade.

Further complexity in the application of CICES was noted because some felt that certain CICES categories were "inherently inseparable", such as 'timber' and 'fuelwood', or mediation at the 'species' and 'ecosystem' level. Other difficulties were identified around those services that are simply 'closely related' such as 'honey' and 'pollination', or where one service was provided by a number of species (i.e. multiple ecological 'structures', in terms of the ES cascade model). The extent to which the issue of the level of 'human input' needed to be considered when defining an ecosystem service was also discussed using the example of where ecological pest control was used, but based on an introduced species.

Participants felt that either better guidance on how to handle these issues was needed or the structure of the classification might need to be modified. Other complexities that also needed to be considered were those relating to how to handle temporal fluctuations in ES, related say to timber provision and flood control at different levels of the ES cascade; it was suggested that some of these difficulties might be resolved by clarifying how the capacity to supply a service and the actual provision relate to each other, and what these two characteristics mean in terms of developing metrics for assessment purposes.

The discussion noted a number of other issues that might be addressed in providing guidance for those using CICES in the context of ESMERALDA. The difficulties of classifying cultural ecosystem services at the division, group and class levels were suggested as especially problematic. Help where proxies (such as species abundance) are used as indicator for ES (or habitat quality) might also be needed so that people have sufficient ecological information to be able to apply or to interpret metrics appropriately.

The extent to which the need to assess ecosystem services as bundles posed particular problems for CICES was considered, and some felt that the 'cross linkages' between some of the services in CICES were not covered particularly well. The example given was the cultural dimension of some provisioning services such as hunting or collecting wild plant food. These kinds of situation, it was pointed out, open up the danger of 'double counting' especially where the distinction between services and benefits is not sufficiently well taken into account. This was illustrated by reference to the case of marine ecosystems that provide nursery habitats, a regulating service, but also food as a provisioning service through fish stocks. A further example was that of mapping ecosystems services associated with forests, where there was an overlap between timber provisioning and the regulation of climate through carbon sequestration.

The breakout sessions generated a number of examples that can be used in any future guidance to illustrate how metrics can be used to characterise the different cascade elements. The examples can show how proxy measures at the function or structure and process level relate to a service, or how a suite of measures that can be used to make a more robust assessment of status and trends. This material will be used both as an input into the guidelines being developed for CICES and as an input into the development of the more comprehensive 'library of CICES-consistent indicators' that is also being developed as part of ESMERALDA Milestone 20. The outcomes of all this work will be reported when this Deliverable is finalised in July 2018.

3.4.2. Biophysical, social and monetary measurement methods

After the initial session, the Nottingham Workshop focussed more generally on the identification of a suite of 'flexible methods' that could be '*applied in all EU members states, including the outermost regions, marine areas and specific biomes'* (ESMERALDA Objective 5, DoA, p. 8). Despite such a broad methodological focus, the outcomes are nevertheless relevant to this discussion on CICES in a number of ways. On the one hand, they allow guidance to be extended to identify what methods have or can be used for the measurement of specific indicators. On the other, they allow us to look critically at what the different methods are *measuring* in terms of a particular service.

The Nottingham Workshop attempted to gain an overview of what methods, models and tools are currently being applied in case study work by ESMERALDA partners. The aim was to identify what the advantages, disadvantages and problems were with different methods, and what the reach of the different applications was. To do this, a series of matrices were defined that could be used to record the information provided by participants. The information recorded in the methods matrix is shown in Table 2. In the current context, the important thing to note is that all examples are cross-referenced to CICES classes, and the links between these classes, ecosystem types, methods and metrics can be traced.

Table 2: Fields used to define 'methods matrix'

	Field
1	Example application
2	Name of reporter
3	Location
4	Ecosystem Type(s)
5	Ecosystem Service(s) (CICES class)
6	Scale (local, national, …)
7	Method(s)
8	Variable (used to measure ES)
9	Strength of method
10	Weakness of method
11	Tier 1-3
12	Links to biophysical methods
13	Links to social methods
14	Links to economic methods
15	Comments

Using this matrix, breakout sessions spanning biophysical, social and economic methods were organised, and this enabled 150 examples to be documented. The material was further refined after the workshop and checked by the participants who provided it.

In order to identify the expertise available within the consortium, a further matrix was created, this time cross tabulating the CICES classes with the 'mapping tiers' that have been used to characterise the work in ESMERALDA. This matrix has also undergone further elaboration since the workshop and will be reported as part of WP3.

The documentation and guidance on methods that can be developed from these materials will be presented as part of WP3, and the final stages of the WP4 programme will consider how these fit together to enable an integrated assessment to be made. At this preliminary stage, however, a number of initial conclusions can be drawn in relation to CICES.

First, that participants found it relatively easy to cross reference their work to the different categories in CICES, even though they may not have used the classification initially for their work. The value of CICES as conceptual framework for making comparisons and standardising results therefore appears to be supported. Second, that there is a significant body of case study information that can be drawn upon to develop future guidance that covers a range of biophysical, social and economic applications. Moreover, there appears to be good coverage of the major ecosystem or habitat types found in Europe. Third, there is a prospect that the on-going work on CICES-consistent indicators and metrics can be underpinned by guidance on what methods are available for quantification. A particular area where it was agreed that further work was needed was on the links between methods, especially between those dealing with the biophysical and economic aspects of mapping and assessment. It was acknowledged that, while the linkages between socio-cultural and economic assessment also need to be explored, preliminary results suggest that this appears to be less challenging. The workshop confirmed, however, that in all areas operational progress continues to be limited by data availability and data quality issues.

4. CICES: Understanding the practitioners' perspective

As part of the ESMERALDA work Programme, a systematic review on ecosystem service indicators is being undertaken and will be presented as Milestone 20 (MS20, CICES consistent library of indicators for biophysical, social and economic dimensions). Since much of this work is relevant to this discussion on the role and structure of CICES, we draw on the preliminary findings of this work so that a more complete picture can be developed. The systematic review provides insights on many of the design issues discussed here, such as consistency and the optimal level of detail. Critically, however, it does so from a practical perspective. The broad aim of the systematic review is to examine the extent to which CICES 4.3 conforms to the current practice, or more specifically to determine whether there are:

- any CICES classes that are indistinguishable from a practical assessment perspective, and hence to determine whether the classes are too narrow;
- any CICES classes that where the practice distinguishes subtypes, and hence to determine whether the classes are too broad; and,
- any ecosystem services identified in the assessment literature that are not covered by CICES, and hence better understand its claim to be 'comprehensive'.

This pragmatic and systematic analysis therefore complements the more participatory approaches discussed in Part 3.

4.1. The systematic review approach

It can be expected that papers in the peer-reviewed ecosystem service research literature provide examples of work that is both practically effective and scientifically sound, and to represent the pool of available methods and common forms of assessment. Published ES studies therefore represent an important resource for developing a comprehensive overview of the current 'state of the art'. In this Deliverable report we present the most CICES-relevant findings from the systematic review described and discussed more in detail in the ESMERALDA Milestone report MS20 ("CICES consistent library of indicators for biophysical, social and economic dimensions").

In the work for the MS20 Report, the review focussed on the individual ecosystem service metrics (indicators) used in the papers, and constructed a database describing their use. Thus, each paper included in the review was represented by multiple lines in the resulting database. To extract information from the papers used in the study, reviewers were asked to read the definitions of the indicators and the underlying ecosystem service provided in the paper, and link them to the classes in CICES v 4.3, taking care to follow the original logic and intentions of the authors. All CICES 4.3 classes that matched or partially matched the definition or interpretation of the indicator used by the authors were noted. Thus in the case of a specific paper, a single service (CICES class) could be assessed by several indicators, and a single indicator could represent several CICES classes at the same time (i.e. there could be 'many to many' relationships).

Altogether the systematic review has analysed 85 papers, 21% of which involved ecosystem service mapping, 48% involved assessments, while the remainder were mainly concerned with indicator development papers. From these papers 439 ES indicators were identified. None of the studies reviewed referred to CICES explicitly, so all the links between CICES classes and the indicators assessed were to be established by the reviewers.

4.2. Results

4.2.1. Similarities between CICES classes

To study the similarities and overlaps between CICES 4.3 classes we first assigned a simple similarity metric (Jaccard, 1912), which measures the proportion of "shared indicators" among all indicators for either CICES class to all pairs of CICES classes. The similarity values indicate the degree to which any pair of CICES classes is handled jointly; a very high similarity scores is a sign that the pair in question is effectively indistinguishable. To visualize and analyse the similarity patterns, we applied simple hierarchical clustering (single link) and forced network graphs in R (hclust & forceNetwork in package networkD3, Gandrud et al., 2016).The results are shown in Figures 4 and 5. Only those 39 CICES classes that were covered by at least 5 different papers were included in the analysis. To simplify the discussion of the results, we make use of the four-digit CICES class notation, which is introduced in Table 1 and Appendix 1. As Figures 3-4. demonstrate, there are a several clusters of CICES classes that are strongly interlinked:

- ***Bio-remediation and water quality maintenance services*** (2.1.1.1, 2.1.1.2, 2.1.2.1, 2.1.2.2, 2.3.4.1[7]): are frequently assessed together under different names (e.g. nutrient retention: Grossmann et al., 2012; Boerema et al., 2014, potential risk of pesticide residues: Bjorklund et al. 1999, waste treatment and water purification: Calvet-Mir et al., 2012; Trepel, 2010). This link is perhaps not surprising because most of these indicators try to capture the ecosystem's ability to buffer the harms that intensive agriculture poses to surface and ground water. Since bioremediation is meant to denote the processing of waste the implication of this finding is perhaps that guidance is required on how to separate this class from those relating to water quality regulation.

- ***Pest and disease control services*** (2.3.2.1, 2.3.2.2): these services are also frequently assessed jointly, because the ecological factors that support them (e.g. diverse and healthy ecosystems) are broadly similar, especially in the context of agricultural pests and human (or animal) diseases (Plieninger et al., 2012). Thus this distinction between pests and diseases may be seen as somewhat arbitrary, even though in cases when an assessment focusses on a single pest/ disease species of high socio-economic relevance, this distinction might be justified.

- ***Maintenance of soil fertility*** (2.3.3.1, 2.3.3.2): from a practical perspective it appears to be difficult to separate the physical (inorganic) and biological (organic) components of soil formation processes, and so some reorganisation of the classes may seem necessary here given that few published studies distinguish them.

- ***Recreational (experiential and physical) use of land-/seascapes in different environmental settings*** (3.1.1.1, 3.1.1.2): It seems that most of the studies do not appear to distinguish the experiential from the physical use of settings in the context of recreation.

[7] For coding on CICES classes see appendix 1.

- ***Intellectual representational interactions with nature*** (3.1.2.1, 3.1.2.2, 3.1.2.3, 3.1.2.4, 3.1.6): This group encompasses all scientific, educational and historical aspects of nature being our information host and heritage-keeper. This group does not include aesthetic beauty (3.1.2.5) which was one of the most "popular" cultural ES in assessments, typically addressed on its own, thus being well-separated from all the other cultural services. On the other hand the group also includes one of the experimental abiotic CICES classes (3.1.6: physical use of caves) which was also assessed frequently enough to be included into this analysis.

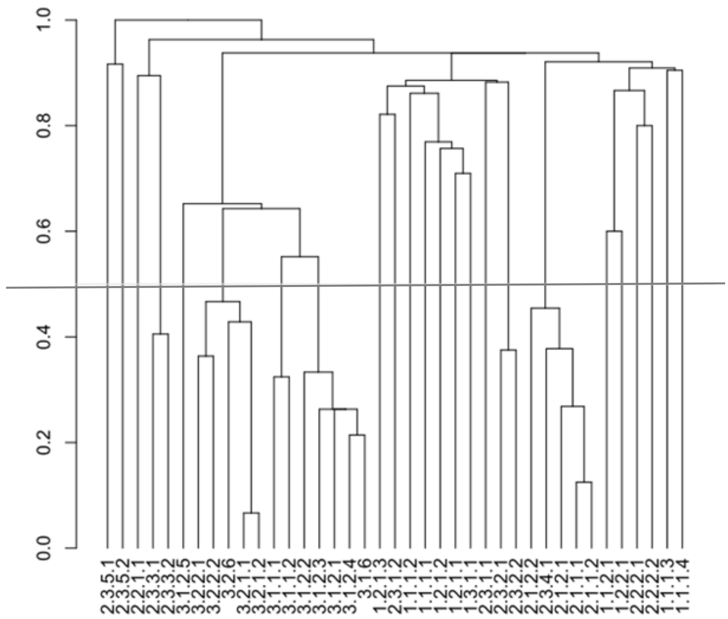

Figure 4: A hierarchical clustering (single link method) of the CICES classes based on their use similarities (the fraction of shared indicators in the published study, see text). The selected similarity level (s=0.5) for the discussion of groups is indicated with a grey horizontal line. A key to the four-digit abbreviation of the CICES classes can be found in Table 1 and Appendix 1.

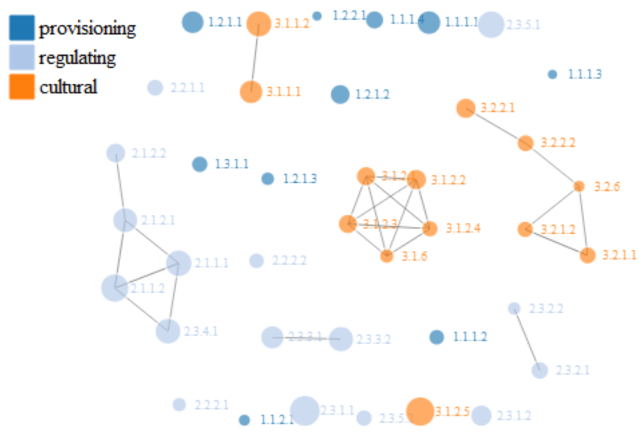

Figure 5: A graphical visualization of the links between the different CICES classes at the selected similarity threshold (s=0.5). A key to the four-digit abbreviation of the CICES classes can be found in Table 1 and Appendix 1.

- ***Spiritual, symbolic and inherent values of nature*** (3.2.1.1, 3.2.1.2, 3.2.2.1, 3.2.2.2, 3.2.6): All non-use values seem to be grouped here. As abiotic elements of the natural environment may also have very similar spiritual or symbolic significance (sacred rocks, mountains, historical places), there is the case, perhaps for a similar abiotic CICES class covering this theme.

There seem to be other groups of services which show some level of overlap (e.g. 1.1.2.1 & 1.2.2.1: water for nutrition and agriculture; 1.2.1.1, 1.3.1.1: wood for fibre/timber and fuel), which suggests that the current hierarchy levels for provisioning in CICES may not match the way people think. The perception that the “intended use” (nutrition, material, energy) comes too high in the hierarchy has already emerged several times during the CICES discussions, and these results seem to support these points.

4.2.2. Potential gaps in CICES

During the systematic review, three indicators were encountered that could be considered as ecosystem services but which were hard to fit into the categories of CICES 4.3. These included:

- ***Maintenance of traditional ecological knowledge*** (Calvet-Mir et al., 2012)**:** According to Calvet-Mir et al. (and partly to Derak and Cortina, 2014) the capacity of a traditional landscape that it can contribute to the preservation of endangered knowledge forms can be considered as an ecosystem service. With some flexibility this ecosystem service can be considered to be included into 3.1.2.3 (cultural heritage), just the examples provided need to be a bit broader to exceed the role of ecosystems as a physical container. An alternative strategy is that scientific knowledge category is expanded to also include traditional forms of knowledge.

- ***Creation and maintenance of social relations*** (Calvet-Mir et al., 2012, Plieninger et al., 2013): Some ecosystems, like parks or community gardens are places for creating and enhancing social networks. This non-material contribution of ecosystems to human well-being can be important in some contexts like urban assessments. Whether it can be accommodated into an existing class, or regarded more as an aggregate measure of benefits (contribution to well-being) of other cultural ES needs to be considered in any revision.

- ***Fire protection*** (Scholz and Uzomah, 2013): This regulating service, is actually the antagonist of a disservice (fire), which can be exerted by ecosystem components that can help to reduce fire risks (e.g. by reducing the build-up of litter). Even though this regulating service can be extremely important in some arid regions, we did not manage to find a place for it in CICES, and so this might be considered in any future revision or guidance.

4.2.3. Resolution at the class-type level

During the systematic review, the reviewers were also asked to note where they found that the indicator clearly corresponded to a specific class-type within CICES; these class-types were intended to be flexible in the sense that they could be specified by the user as the needs of their study dictated. Any finding that published papers used a finer grain resolution than the CICES class does not necessarily imply the need to modify the classification but it does provide an insight into where guidance and examples may be useful to help people apply the system. The findings are shown in Table 3.

Table 3: CICES Classes where assessment practice sees general ‘sub-types’ (i.e. the indicators in the published studies only partly cover the “scope” of the CICES class, and so might be regarded as Class-types)

CICES class		**Proposed subtypes**
1.1.1.4	Wild animals and their outputs	fish, game, shellfish
1.2.1.1	Fibres and other materials from plants, algae and animals for direct use or processing	cultivated, wild
1.2.1.2	Materials from plants, algae and animals for agricultural use	cultivated, wild
1.2.1.3	Genetic materials from all biota	medicinal
2.1.2.3	Mediation of smell/noise/visual impacts	noise mediation
2.2.2.2	Flood protection	coastal protection
2.3.1.1	Pollination and seed dispersal	pollination, seed dispersal
2.3.5.2	Micro and regional climate regulation	air quality, microclimate

5. Designing integrated assessment frameworks and the role of CICES

The aim of this draft Deliverable has been to draw on the experience gained in developing and applying CICES. The goal has been to use this experience to reflect on the extent to which it provides a classification system that is simple and transparent, but which also fulfils the needs of an integrated assessment. As we have discussed, integrated assessments are those which, as a very minimum, both address cross-scale issues and link up analyses across the biophysical, social and economic (monetary) domains. During the work reported here, however, it has become clear that the notion of what constitutes an integrated assessment has a number of interpretations, and that these need to be explored in order to better understand the context in which the use of frameworks such as CICES, and indeed measurements methods in general, are set.

The preparations for and discussions arising from the Nottingham Workshop that was described in Part 3 of this Report, identified a number of characteristics of assessments and what the notion of integration might mean. As a preliminary framework for discussion in ESMERALDA it was agreed that that assessments should be seen as a 'social' or 'transdisciplinary' process which involves the analysis and review of information derived from research. The purpose of such assessment is to help people in a position of responsibility to evaluate possible actions or think about a problem; for MAES this clearly relates to the EU Biodiversity strategy for 2020. Thus assessment is taken to mean assembling, summarising, organising, interpreting, and possibly reconciling pieces of existing knowledge so as to communicate them in ways that are relevant and helpful to an intelligent but inexpert decision-maker.

Fundamentally, in any assessment of ecosystem services, scientific evidence must be translated into information that is understandable for policy and decision making, e.g. through maps, indicators, narratives and graphs. However, for such assessments to be *integrated*, they must additionally link data and information on biophysical and socio-economic components of a socio-economic system not just with each other, but also with the societal and policy contexts in which the socio-ecological system is embedded. Ultimately the assessment must enable decision makes to examine changes in

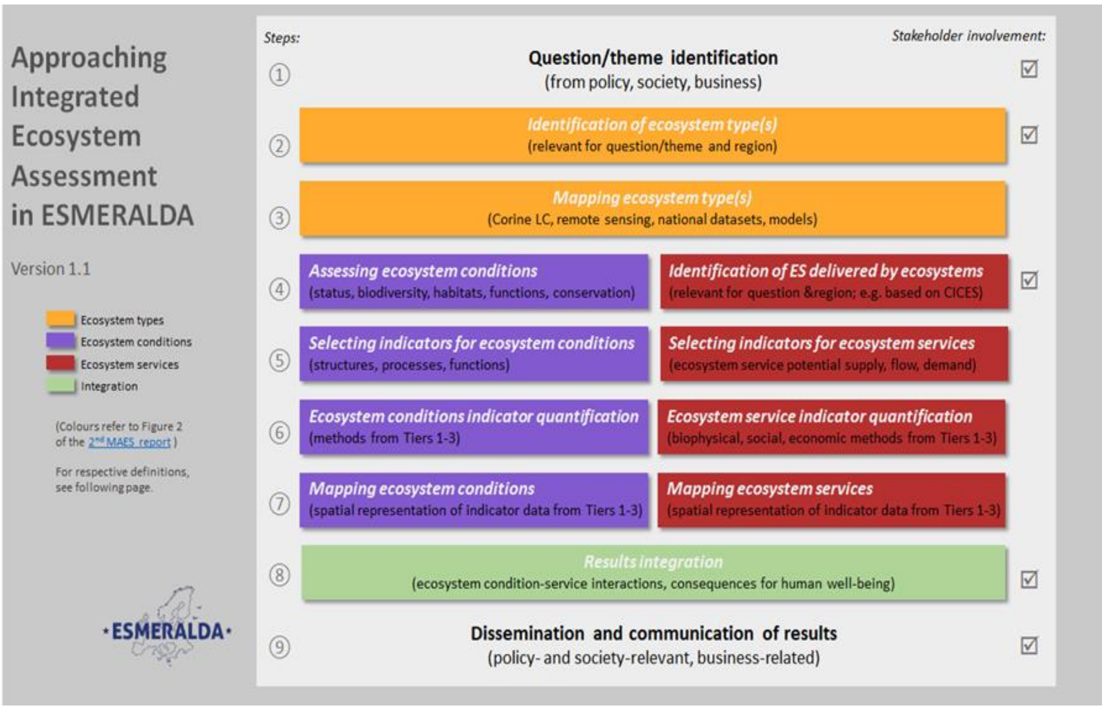

Figure 6: Preliminary framework for integrated assessments in ESMERALDA (original B. Burkhard)

biodiversity and ecosystem services against specific and measurable policy goals. The framework shown in Figure 6 was proposed as initial picture of what might be envisaged within ESMERALDA.

It is not appropriate at this stage to discuss the framework suggested in Figure 6 in detail, since this is the focus of WP4 as a whole. However, it is valuable to consider how and where tools such as CICES fit into this kind of approach, because it can give pointers to the ways in which guidance needs to be drawn up or any revisions developed.

As Figure 6 suggests, stakeholder engagement is essential throughout the whole assessment process. Assessments of the kind that concern ESMERALDA are fundamentally deliberative in character, and may involve a number of iterative cycles in order the perspective, data and analysis are fully integrated. Thus while the framework shown in Figure 6 may seem as rather linear, the key point it emphasises is that all parties need to 'talk about the same thing'. This is where CICES can clearly make a significant contribution. While the findings of this study suggest that it is already relatively successful in fulfilling this role, there is scope for improving the guidance associated with so that it can be applied more effectively to create a framework for discussion. The integration of the different perspectives of stakeholders is often an essential task in any assessment, and the ability of CICES to provide some kind of translation mechanism would be valuable in this context.

CICES has already been used as the framework for translating between different classification systems within the context of OpenNESS[8]. The development of this kind of web-based tools in relation to the extended guidance that we have identified as necessary in this study would seem an essential next step for the ESMERALDA community.

A second feature that emerges from a review of the framework shown in Figure 6 is that for a classification system such as CICES to be successful it must be capable of being integrated with other types of classification. It must, for example, be capable of being used alongside the classification systems used for identifying and mapping different types of ecosystem (stages 2 & 3, Figure 6). The investigation of the performance of CICES that has been reported here found no evidence that could not be used in this way. Thus, information and examples of how this integration can be achieved would seem to be a useful addition to any future guidance document. There has also already been some experimental work on linking habitat classifications to CICES classes using the same approach as the CICES translator[9]. Such tools could be employed to help users identify the evidence that others have assembled for similar ecosystems and the strength of the association between habitats and services that might be expected.

While guidance on the links between CICES and systems for classifying ecosystems is essential, as the framework shown in Figure 6 suggests, it is also necessary that users are helped to characterise ecosystem condition, in terms of the functional status of ecosystems and their underlying ecological structures and dynamics. If integration is to be achieved in the framework shown in Figure 6 (stage 8) there must be effort to bring information together from across the biophysical, social and monetary domains. As the work described in Part 3 has shown, in addition better linking to condition measures, there is also a desire from users to link CICES to classifications of benefits and

[8] See: http://openness.hugin.com/example/cices
[9] See: http://openness.hugin.com/example/habitat

beneficiaries. We have noted in this Report the possibility of developing guidance on how CICES might be used in conjunction with classifications of benefits and beneficiaries, as a result of on-going work with the EEA and the UNSD; ESMERALDA can clearly contribute to such discussions, and test the outcomes of the work, and so we recommend a watching brief on these important areas of concern.

An important overarching message that arises from this work is however, that as it stands CICES can be used as an effective indicator framework, and so provide a key 'entry point' for the process of integration in any assessment process. Future guidance on the use of CICES must be clear about the way in which service are defined, so that everyone 'talks about the same thing'. It must also help ensure that clarity is brought to the process of measurement. Thus the further development of the library of 'CICES-consistent indicators' is an essential part of future work in ESMERALDA.

In developing such an indicator library there is no intention to dictate which metrics are to be used for which service, rather to provide examples of how people have quantified the services so that the experience can be shared with others and comparisons made. While the focus must be on the services themselves, the work presented here suggests that it would be most useful to also cross-reference the library to metrics for all of the elements of the cascade, as had been done by Mononen et al. (2014). The approach is useful in the sense that it helps users understand where and how proxy measures can be used in an ecosystem assessment. Integration of indicators across the ecosystem service cascade is also a way of more fully understanding issues relating to supply and demand, and hence the overall status of the service in the context of questions about sustainability.

The findings of this study will be used to shape on-going discussions in ESMERALDA that will be taking place in the context of the next series of three workshops being organised by WP5 during 2016-17. The objective of these meetings will be to testing the first version of the methodology for ES mapping and assessment. This will enable the methods to be refined and the development of guidelines that can support the application of these methods in the context of Action 5 of the EU Biodiversity Strategy. Close engagement with this work will ensure that specific guidelines required for CICES are fully integrated into the wider outcomes of ESMERALDA, and that the experience gained in defining and measuring services and their proxies by the different methods is effectively shared with the ecosystem service community.

6. References

Abson, D. J., von Wehrden, H., Baumgärtner, S., et al. (11 authors) (2014): Ecosystem services as a boundary object for sustainability. *Ecological Economics*, vol 103, pp. 29-37.

Arovuori, K. & Saastamoinen O. (2013): Classification of agricultural ecosystem goods and services in Finland. PTT Working Papers 155,23pp. http://docplayer.fi/12241942-Classification-of-agricultural-ecosystem-goods-and-services-in-finland.html

Alahuhta, J., Joensuu, I., Matero, J., Vuori, K-M. & Saastamoinen, O. 2013. Freshwater ecosystem services in Finland. Reports of the Finnish Environment Institute 16/2013. 35 p. Available at: http://hdl.handle.net/10138/39076

Albert, C.; Neßhöver, C.; Wittmer, H.; Hinzmann, M. and C. Görg (2014): Sondierungsstudie für ein Nationales Assessment von Ökosystemen und ihren Leistungen für Wirtschaft und Gesellschaft in Deutschland. Helmholtz-Zentrum für Umweltforschung – UFZ, unter Mitarbeit von K. Grunewald und O. Bastian (IÖR), Leipzig.

Armstrong, C. W., Foley, N. S., Tinch, R., & van den Hove, S. (2012): Services from the deep: Steps towards valuation of deep sea goods and services. *Ecosystem Services*, vol 2, pp. 2-13.

Björklund, J., Limburg, K. E., & Rydberg, T. (1999): Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: an example from Sweden. *Ecological Economics* **29(2)**: 269–291.

Boerema, A., Schoelynck, J., Bal, K., Vrebos, D., Jacobs, S., Staes, J., & Meire, P. (2014): Economic valuation of ecosystem services, a case study for aquatic vegetation removal in the Nete catchment (Belgium). *Ecosystem Services* **7**: 46–56.

Boyd, J., & Banzhaf, S. (2007): What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*, vol 63, no 2, pp. 616-626

Bürgi, M., Silbernagel, J., Wu, J., and Kienast, F. (2015): Linking ecosystem services with landscape history. *Landscape Ecology* **30(1)**: pp. 11-20.

Calvet-Mir, L., Gómez-Baggethun, E., & Reyes-García, V. (2012). Beyond food production: Ecosystem services provided by home gardens. A case study in Vall Fosca, Catalan Pyrenees, Northeastern Spain. *Ecological Economics*, *74*, 153–160.

Castro, A. J., Verburg, P. H., Martín-López, B., et al. (7 authors) (2014): Ecosystem service trade-offs from supply to social demand: A landscape-scale spatial analysis. *Landscape and Urban Planning*, vol 132, pp. 102-110.

De Groot, R. D., Fisher, B., Christie, M., Aronson, J., Braat, L., Haines-Young, R., ... & Ring, I. (2010): Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In: Kumar, P. (Ed.): *The Economics of Ecosystems and Biodiversity* (TEEB): Ecological and Economic Foundations. London, Washington: Earthscan, 10-40.

Derak, M. and J. Cortina (2014): Multi-criteria participative evaluation of Pinus halepensis plantations in a semiarid area of southeast Spain. *Ecological Indicators* **43**: 56–68.

Gandrud C, Allaire J.J. & Russell K (2016). networkD3: D3 JavaScript Network Graphs from R. R package version 0.2.12, https://CRAN.R-project.org/package=networkD3.

Grizzetti, B., Lanzanova, D., Liquete, C., Reynaud, A. (2015): Cook-book for water ecosystem service assessment and valuation. JRC report EUR 27141 EN. Luxembourg, Publications Office of the European Union. doi:10.2788/67661

Grossmann, M. (2012): Economic value of the nutrient retention function of restored floodplain wetlands in the Elbe River basin. *Ecological Economics* **83**: 108–117.

Haines-Young, R. (2016) Report of Results of a Survey to Assess the Use of CICES, 2016 (Deliverable 2). Support to EEA tasks under the EU MAES process. Negotiated procedure No EEA/NSS/16/002

Haines-Young R, Potschin M (2013): Common International Classification of Ecosystem Services (CICES). Report to the European Environment Agency EEA/BSS/07/007 (download: www.cices.eu).

Haines-Young, R., Potschin , M., Kienast, F., 2012: Indicators of ecosystem service potential at European scales: mapping marginal changes and trade-offs. Ecol. Indicators 21: 39-53.

Helfenstein, J., Kienast, F., (2014): Ecosystem service state and trends at the regional to national level: a rapid assessment. Ecological Indicators 36: 11-18.

Jaccard, P. (1912): The distribution of the flora in the alpine zone. *New Phytologist* **11**: 37–50.

Kulczyk, S., Wozniak, E., Kowalczyk, M. and Derek, M., (2014): Ecosystem services in tourism and recreation. Revisiting the classification problem. Ekonomia i Środowisko, (4 [51]):

Kosenius, A. K., Haltia, E., Horne, P., Kniivilä, M., and Saastamoinen, O. (2013): *Value of ecosystem services? Examples and experiences on forests, peatlands, agricultural lands, and freshwaters in Finland*. PTT Working Papers 244. Pellervo Economic Research, Helsinki.

Landers, D., Nahil, M and C. R. Rhodes (2016): The beneficiary perspective – benefits and beyond. In Potschin, M., Haines-Young, R., Fish, R. and Turner, R.K. (eds) Routledge Handbook of Ecosystem Services. Routledge, London and New York, pp.74-88.

Lee, H., and Lautenbach, S. (2016): A quantitative review of relationships between ecosystem services. Ecological Indicators, 66, 340-351.

Liquete, C., Cid, N., Lanzanova, D., Grizzetti, B., Reynaud, A. (2016): Perspectives on the link between ecosystem services and biodiversity: The assessment of the nursery function. Ecological Indicators 63: 249–257.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., Zulian, G. (2015): Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. Environmental Science & Policy 54: 268–280.http://dx.doi.org/10.1016/j.envsci.2015.07.009

Liquete, C., Piroddi, C., Drakou, E. G., et al. (7 authors) (2013): Current status and future prospects for the assessment of marine and coastal ecosystem services: a systematic review. *PLoS One*, vol 8, no 7, e67737.

Mace, G.; Bateman, I.; Albon, S.; et al. (11 authors) (2011): Conceptual Framework and Methodology. In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge, 11-26.

Mace, G. M., Norris, K., & Fitter, A. H. (2012): Biodiversity and ecosystem services: a multilayered relationship. Trends in Ecology & Evolution, vol 27, no 1, pp. 19-26.

MAES (2014): Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. http://catalogue.biodiversity.europa.eu/uploads/document/file/1230/2ndMAESWorkingPaper.pdf

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J.P., Grizzetti, B., Drakou, E.G., La Notte, 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. http://dx.doi.org/10.1016/j.ecoser.2012.06.004.

Maes J., Liquete, C. et al. (2016): An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosystem Services 17: 14–23. http://dx.doi.org/10.1016/j.ecoser.2015.10.023

Medcalf, K, et al. (2016): *National Ecosystem and Ecosystem services Map for a Suite of Prioritised Services. Final report* commissioned by National Parks and Wildlife Service of the Department of Arts, Heritage and the Gaeltacht, Ireland.

Mizgajski A., Stępniewska M., (2012): Ecosystem services assessment for Poland – challenges and possible solutions. Ekonomia i Środowisko 2(42): 54-73, available in English on-line: http://www.fe.org.pl/uploads/ngrey/eis42.pdf

Mononen, L., Auvinen, A.P., Ahokumpu, A.L., Rönkä, M., Aarras, N., Tolvanen, H., Kamppinen, M., Viirret, E., Kumpula, T. and Vihervaara, P., (2015): National ecosystem service indicators: Measures of social–ecological sustainability. Ecological Indicators.

Naturkapital Deutschland – TEEB DE (2014): Naturkapital und Klimapolitik – Synergien and Konflikte. Langfassung. Technische Universität Berlin, Helmholtz-Zentrum für Umweltforschung – UFZ, Leipzig. Download: www.naturkapital-teeb.de.

Plieninger, T., Dijks, S., Oteros-Rozas, E. and C. Bieling (2013): Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy* **33**: 118–129.

Plieninger, T., Schleyer, C., Mantel, M. and P. Hostert (2012): Is there a forest transition outside forests? Trajectories of farm trees and effects on ecosystem services in an agricultural landscape in Eastern Germany. *Land Use Policy* **29(1)**: 233–243.

Potschin, M. and R. Haines-Young (2016a): Defining and measuring ecosystem services. In: Potschin, M., Haines-Young, R., Fish, R. and Turner, R.K. (eds) Routledge Handbook of Ecosystem Services. Routledge, London and ä New York, pp 25-44.

Potschin, M. and R. Haines-Young (2016b): Customisation of CICES across member states: workshop report. ESMERALDA Milestone 19, 13 pp plus appendices. EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007.

Potschin, M.; Brander, L.; Burkhard, B.; Geneletti, D.; Haines-Young, R.; Santos Martín, F. and P. Vihervaara (2016c): Flexible methods for ecosystem service mapping and assessing (1st version): Workshop Report. ESMERALDA Milestone 21, 50 pp. EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007.

Saastamoinen, O., 2014, December. Observations on CICES-based classification of ecosystem services in Finland. In Scandinavian Forest Economics: Proceedings of the Biennial Meeting of the Scandinavian Society of Forest Economics (No. 45): Scandinavian Society of Forest Economics.

Saastamoinen, O., Matero, J., Horne, P. et al. (7 authors) (2014): Classification of boreal forest ecosystem goods and services in Finland. Publications of the University of Eastern Finland. Reports and Studies in Forestry and Natural Sciences Number 11, University of Eastern Finland, Faculty of Science and Forestry, School of Forest Sciences

Scholz, M., & Uzomah, V. C. (2013). Rapid decision support tool based on novel ecosystem service variables for retrofitting of permeable pavement systems in the presence of trees. Science of the total environment, 458, 486-498.

Schröter, M., Barton, D. N., Remme, R. P., and Hein, L. (2014): Accounting for capacity and flow of ecosystem services: A conceptual model and a case study for Telemark, Norway. *Ecological Indicators*, vol 36, pp. 539-551.

Stępniewska, M. (2014): Resources of the Polish official statistics for valuation of provisioning ecosystem services. Ekonomia i Środowisko 4(51): 102-110, available in English on-line: http://www.fe.org.pl/uploads/ngrey/!%20eis51.pdf

Tenerelli, P., Demšar, U., and Luque, S. (2016): Crowdsourcing indicators for cultural ecosystem services: A geographically weighted approach for mountain landscapes. Ecological Indicators, 64, 237-248.

Trepel, M. (2010): Assessing the cost-effectiveness of the water purification function of wetlands for environmental planning. *Ecological Complexity* **7(3)**: 320–326.

Turkelboom, F., Raquez, P., Dufrêne, M., et al. (19 authors) (2013): CICES going local: Ecosystem services classification adapted for a highly populated country. In Jacobs, S., Dendoonker, N., and Keune, H. (eds) Ecosystem Services. Chicago, pp. 223-247.

Vidal-Abarca MR, Suarez-Alonso ML, Santos-Martín F, Martín-López B, Benayas J, Montes C. (2014) Understanding complex links between fluvial ecosystems and society: an ecosystem services approach. Ecological Complexity 20:1-10. (IF: 2.34) DOI: 10.1016/j.ecocom.2014.07.0

von Haaren, C., Albert, C., Barkmann, J., de Groot, R. S., Spangenberg, J. H., Schröter-Schlaack, C., & Hansjürgens, B. (2014): From explanation to application: introducing a practice-oriented ecosystem services evaluation (PRESET) model adapted to the context of landscape planning and management. *Landscape ecology*, vol *29, no* 8, pp. 1335-1346.

Winkler, K.J. and Nicholas, K.A. (2016): More than wine - cultural ecosystem services in vineyard landscapes in England and California. Ecological Economics 124, 86-98. authors link: http://authors.elsevier.com/a/1SciO3Hb~0AtMh doi: 10.1016/j.ecolecon.2016.01.013

Appendix 1: CICES Coding

CICES V4.3				
Section	Division	Group	Class	Code
1. Provisioning	1. Nutrition	1. Biomass	1. Cultivated crops	1.1.1.1
			2. Reared animals and their outputs	1.1.1.2
			3. Wild plants, algae and their outputs	1.1.1.3
			4. Wild animals and their outputs	1.1.1.4
			5. Plants and algae from in-situ aquaculture	1.1.1.5
			6. Animals from in-situ aquaculture	1.1.1.6
		2. Water	1. Surface water for drinking	1.1.2.1
			2. Ground water for drinking	1.1.2.2
	2. Materials	1. Biomass	1. Fibres and other materials from plants, algae and animals for direct use or processing	1.2.1.1
			2. Materials from plants, algae and animals for agricultural use	1.2.1.2
			3. Genetic materials from all biota	1.2.1.3
		2. Water	1. Surface water for non-drinking purposes	1.2.2.1
			2. Ground water for non-drinking purposes	1.2.2.2
	3. Energy	1. Biomass-based energy sources	1.Plant-based resources	1.3.1.1
			2. Animal-based resources	1.3.1.2
		2. Mechanical energy	1. Animal-based energy	1.3.2.1
2. Regulation & Maintenance	1. Mediation of waste, toxics and other nuisances	1. Mediation by biota	1. Bio-remediation by micro-organisms, algae, plants, and animals	2.1.1.1
			2. Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	2.1.1.2
		2. Mediation by ecosystems	1. Filtration/sequestration/storage/accumulation by ecosystems	2.1.2.1
			2. Dilution by atmosphere, freshwater and marine ecosystems	2.1.2.2
			3. Mediation of smell/noise/visual impacts	2.1.2.3
	2. Mediation of flows	1. Mass flows	1. Mass stabilisation and control of erosion rates	2.2.1.1
			2. Buffering and attenuation of mass flows	2.2.1.2
		2. Liquid flows	1. Hydrological cycle and water flow maintenance	2.2.2.1
			2. Flood protection	2.2.2.2
		3. Gaseous / air flows	1. Storm protection	2.2.3.1
			2. Ventilation and transpiration	2.2.3.2
	3. Maintenance of physical, chemical, biological conditions	1. Lifecycle maintenance, habitat and gene pool protection	1. Pollination and seed dispersal	2.3.1.1
			2. Maintaining nursery populations and habitats	2.3.1.2
		2. Pest and disease control	1. Pest control	2.3.2.1
			2. Disease control	2.3.2.2
		3. Soil formation and composition	1. Weathering processes	2.3.3.1
			2. Decomposition and fixing processes	2.3.3.2
		4. Water conditions	1. Chemical condition of freshwaters	2.3.4.1
			2. Chemical condition of salt waters	2.3.4.2
		5. Atmospheric composition and climate regulation	1. Global climate regulation by reduction of greenhouse gas concentrations	2.3.5.1
			2. Micro and regional climate regulation	2.3.5.2

Coding system for CICES classes, cont.

CICES V4.3				
Section	Division	Group	Class	Code
3. Cultural	1. Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	1. Physical and experiential interactions	1. Experiential use of plants, animals and land-/seascapes in different environmental settings	3.1.1.1
			2. Physical use of land-/seascapes in different environmental settings	3.1.1.2
		2 Intellectual and representative interactions	1. Scientific	3.1.2.1
			2. Educational	3.1.2.2
			3. Heritage, cultural	3.1.2.3
			4. Entertainment	3.1.2.4
			5. Aesthetic	3.1.2.5
	2. Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	3. Spiritual and/or emblematic	1. Symbolic	3.2.3.1
			2. Sacred and/or religious	3.2.3.2
		4. Other cultural outputs	1. Existence	3.2.4.1
			2. Bequest	3.2.4.2

A complementary coding system for the CICES groups in the experimental "Accompanying classification of abiotic outputs from natural systems" in CICES v4.3

Abiotic mineral nutrition (e.g. salt)	1.1.6
Abiotic non-mineral nutrition (e.g. sunlight)	1.1.7
Abiotic metallic materials (e.g. metal ores)	1.2.6
Abiotic non-metallic materials (e.g. minerals, aggregates, pigments, building materials (mud/clay))	1.2.7
Abiotic renewable energy (e.g. wind, waves, hydropower)	1.3.6
Abiotic non-renewable energy (e.g. coal, oil, gas)	1.3.7
Abiotic mediation of waste (e.g. atmospheric dispersion and dilution; adsorption and sequestration of waters in sediments; screening by natural physical structures)	2.1.6
Abiotic mediation of flows (e.g. protection by sand and mud flats; topographic control of wind erosion)	2.2.6
Abiotic maintenance of conditions (e.g. land and sea breezes; snow)	2.3.6
Abiotic cultural: physical & intellectual interactions (e.g. caves)	3.1.6
Abiotic cultural: spiritual & emblematic interactions (e.g. sacred rocks or spaces)	3.2.6

Appendix 2: Outcome summary of CICES break out groups at 'Nottingham Workshop'

No.	Source	Contact	CICES Code	Structure/Process	Function	Service	Good/Benefit	Value	Comment
1		Mihai Adamescu	1.1.2.1. and 2.3.4.1	* Water Cycle/Eutrophication	*Water purification/water * N-concentration/ N/P ration	* chemical condition of (regulating and Maintanance and provisioning service (1.1.2.1) * Freshwater (2.3.4.1)	Drinking Water	Water costs	* how to estimate the costs? * who has to pay
2	Nedkov (2012)	Stoyan Nedkov	2.2.2.2.	Water cycle	Water distribution function of the different ecosystems in the river basin	flood protection	mitigation of the flood by reducing the water quantity during peak flow events	avoided costs of potential damages caused by floods	Mapping of flood regulation ES
3	Papiz in preparation	Stoyan Nedkov	2.1.2.1	water cycle	dilution od pollutants in river water and the soils in the floodplain	filtration of freshwater/water purification	clean water/drinking water		
4	Mapping ecosystem services at Eu scale (published in ecosystem services, issue 1)	Joachim Maes	2.1.2.1	* river network (Map) * nitrogen uptake, denitrification, burial	Nitrogen removal (ton N/ha/year) (assuming sustainability)	Nitrogen removed (ton N/km/years) (actual removal)	increased water quality (% improvement)	avoided replacement cost (€) of Nitrogen removal by constructed wetlands	filtration/storage/accumulation if ecosystems --> water purification (self purifying capacity of water bodies) --> use Nitrogen as indicator

5	Zulian et al. in Land	Joachim Maes		* species distribution (maps) * presence, absence visitation rate and flight distance	pollination potential (dimensionless between 0-1)		% crop deficit (% of yield that would be foregone if no wild pollinators are present)	value of crops due to pollination	
6	??	David Vackar	3.2.4.1	Biodiversity	trophic chains (flows)	Existence	existence value	existence value (based e.g. on choice experiment mobility etc.)	
7	Vagious	David Vackar	2.3.5.1	photosynthesis	net primary production (WDU, measurements - ORUL datasets	global climate regulation by reduction of GHG concentration	carbon storage in ecosystems	marginal abatement cost (MAC) (contribution of ecosystems to Co2 reduction and reduction of climate change cost)	
8	VITO	Steven Broekx	3.1.1.2	* available green area nearby * time distribution	* time distribution activities/attractions *spent time in area, walking/biking	* physical use of landscape	* well-being * health	*avoided heath costs * expenditures local restaurants * willingness to pay * travel costs	

9	VITO	Steven Broekx	2.2.1.1	rainfall intensity * elevation	* soil run-off * sedimentation	coastal erosion	* fertile soil, soil maintenance * sediment transport (?)	* avoided dredging * agricultural productivity * avoided damage flooding mid streams	
10	SONNAR	Katie Medcalf	1.1.1.4/2.3.1.1	flowering plants which support pollination	pollination	* Wild animals and their outputs * Wild animals and their outputs	honey	food	
11	Ireland Project	Katie Medcalf	2.3.5.1	peat with active sphagnum layer	carbon sequestration	Global climate regulation by reduction of greenhouse gas concentrations	climate stability	carbon accounting	
12	BEF-LV	Kristina Veidemane	3.1.1.1			cultural services, bird monitoring	recreation potential	visitor xxx? * WTP	
13	BEF-LV	Kristina Veidemane	2.2.1.1	accumulation and erosion of the material/sediment flow along the coastal process, formation of dunes		mass stabilization and control of erosion rates	stable coastal areas, no loss of land	potential loss of property, loss of beach	coastal ecosystems --> dunes, metrices = accumulated volume of sediments m3/m2 of dune area
14	OpenNESS Hungarian CS "Kiskunsag"	Balint Czucz		The following properties of the ecosystem: * floral abundance * floral diversity * temporal continuity if flowering *	nectar provision	honey harvest (locations of hives) --> number of families/m2	honey		

15	Niraj-MAES	Balint Czucz	1.1.1.3, 1.2.1.1. (wild)	*different ecosystems (natural, semi-natural) w collected species * biodiversity (species), ecosystem state (degradation/naturalness)	* the growth of collected species (capacity, pot supply)	*Wild plants, algae and their outputs *Fibres and other materials from plants, algae and animals for direct use or processing	local products	* income * health (medical plants) * sustenance of traditional knowledge	
16	ESP 2015	Philip Roche	2.2.1.1	* De??? --> storage, shape length * vegetation cover * rainfall	* stabilisation of soil * reduction of kinetic rain drops energy	Erosion control	* preservation of soils * reduction of rivers sediments * risk reduction		use of RUSLE model
17	TRENTO Urban case study	Chiara Cortinovis		soil cover (type of vegetation) and canopy coverage (vegetation height, etc.)	shading and evapotranspiration	microclimate regulation (cooling) [+ other regulating ES as provided by urban ecosystems]	number of people (and vulnerable people) in each class of cooling effect --> metric used to compare alternatives		
18	VITO	Inge Liekens		*different ;landscapes/ecosystems * land use	*naturalness * diversity	attractiveness of the landscape	number of visitors (based on attraction, facilities, …)	WTP/Visit	recreational value
19	Studies in USVI Bonaire ?	Pieter van Beukering		corals reefs providing hard 3 D structure in coastal waters	energy buffer function for waves	coastal protection in coastal zones	avoided damage from flooding to houses and infrastructure	number of properties x real estate values x probability of flood events	

20	Campagne, C.S. et al. (2015) The sea grass Posidania oceanica: Ecosystem services identification an economic evaluation od goods and benefit. Marine Pollution Bulletin	Sylvie Campagne				* coastline erosion protection *decrease of wave power and current * stabilization /consolidation of seabeds by sediment deposition	protection from coastal erosion	economic value in €/ha/year	* it is a particular example --> more details see
21		Paulo Borges			regulating and Maintenance	* maintaining nursery populations and habitats * flood control * water regulation/provision	* safety * water * gene pool	funds given to remove invasive plants	Island example, indicator of naturalness (based in spatial distribution of eudemonic species)
22	PhD thesis research	Zbig Szkop		urban forest (urban trees)	absorption of pollutant	* regulating services * improving air quality	* cleaner air (better air quality) * micro climate regulation	* money spent on medical care (healing people form lung problems) --> 20€ per tree * avoided costs	
23	TEEB-DE	Sven-Erik Rabe (ETH)	1.1.1.1	area of agricultural cropland	indicator - agr-environmental yield potential * natural yield capability	Cultivated crops (indicator yield index)			

24	biodiversity.fi/ecosystem services	Petteri Vihervaara/Laura M.	2.3.5.1 also usable for 1.3.1.1	ha of forest class (mapping --> statistical behind)	C sequestration rate (modelled)	(Biomass) Carbon storage [tons/ha] --> comparability IPCC accounting rules	climate regulation (expert evaluation) --> vague to measure	increased security, avoided costs, market price --> "expected to rise!" (by Head of World Bank 12.4.16)	
25	Patagonian case od OpenNESS	Graciela Rusch		area grassland cover	primary productivity	cattle, grazing pressure	meat, identity of being a cattle farmer	Pesos, money, Realising the importance of identity	
26	SH=study (in work)	Felix Mueller	2.1.1.1, 2.1.1.2, 2.1.2.1., 2.1.2.2., 2.2.1.1., 2.3.4.1, but also crop production	biotic structure, vegetation composition, land use, input, fertilization, storage leaking, runoff	all sub processes of nitrogen cycle, linked with energy and water	nutrient retention, indicated by nitrogen	* clean drinking water (ground water) * reduced eutrophication	*water cleaning plant demand, respective waste water treatment costs for respective nutrient amount	CICES should be a Lego box, --> simplify complexity, not suitable to many recent management problems
27	Urban Maes for Poland	Damiam Lowicki	2.2.2.1	the share of green urban areas	rainfall catching	Hydrological cycle and water flow maintenance	water retention, infiltration	avoid costs of water infrastructure	
28	ESP 2015 conference	Philip Roche	1.2.1.1.	forest area, tree density, tree structure, photosynthesis	* primary production * NPP	wood biomass	* timber * industry grade wood biomass		