RECONNECTING NATURAL AND CULTURAL CAPITAL

CONTRIBUTIONS FROM SCIENCE AND POLICY

Maria Luisa Paracchini, Pier Carlo Zingari, Carlo Blasi (Eds.)

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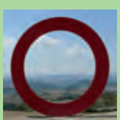

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Operationalising ecosystem services: advancing knowledge on natural and cultural capital

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Introduction

Contact with nature induces many different feelings, both positive and negative. On the negative side, people can suffer from allergies from flowering plants, many insect species can cause physical harm or spread disease (Lyytimäki and Sipilä, 2009) and some parks in cities can hide social dangers (Bixler and Floyd, 1997). Alternatively, when people are asked to close their eyes and think of something positive, they often see meadows and oceans, trees and dolphins. Connections between forests and timber production, as well as fish populations and food security, are widely understood. However, few people know, for example, that having close contact with the natural environment raises your immunological tolerance against inflammatory diseases such as allergies and cancer (Hanski et al., 2012). In wider society, the links between the structures and processes of nature, and between natural capital and the ecosystem services essential for human well-being, are often poorly understood.

The structures and processes linked with natural capital can be explained in many ways. In our work, ecosystem services and their operationalisation are the bridge from natural capital to human well-being. We base our conclusions on research carried out in the EU-funded OpenNESS project [(1)], and suggest a five-step path for better understanding of how natural capital and the ecosystem services that flow from it are important to human

[(1)] http://www.openness-project.eu

well-being. Finally, we emphasise the role of natural capital in finding innovative solutions to environmental problems and societal challenges in the form of nature-based solutions (NBS), which build on, and contribute to, the transition towards a bio- and circular economy. Understanding natural capital and ecosystem services provides the basis for thriving cultural capital in its broad meaning, by strengthening society's ability to make wise decisions concerning our relationship with natural capital.

Cascading links between ecosystems and human society

Different metaphors can be used to ascribe meaning and importance to nature. The metaphor of 'natural capital' is increasingly used in research and policy focused on the links between ecosystems and human well-being, which makes the case for the need to protect and manage 'natural capital' alongside the other 'capitals' on which society depends—manufactured, financial, human and social, with the last two including, importantly, cultural capital (Costanza et al., 2007; Zorondo-Rodríguez et al., 2016). For example, the importance of investing in green and blue infrastructure [2], such as lakes, sea shores, green walls, parks and forests, is now recognised for its contribution to people's health, safety and well-being, such as by reducing the risks and costs of flooding and mitigating the effects of climate change (Elmqvist et al., 2015).

The many ways that nature can contribute to our well-being are covered by the concept of ecosystem services. Stocks of natural capital produce flows of ecosystem services. Although the definition of natural capital includes both renewable resources such as plants and animals and non-renewable resources such as minerals, ecosystem services themselves relate only to renewable natural resources. However, non-renewable aspects of natural capital, such as mineral nutrients, may help to underpin the delivery of ecosystem services.

The field of ecosystem services has developed rapidly as a result of major international initiatives such as the Millennium Ecosystem Assessment [3] and The Economics of Ecosystems and Biodiversity (TEEB) [4] initiative. The newly established Intergovernmental Platform on Biodiversity and Ecosystem Services [5] will be important in continuing this work. To use this concept effectively and to empower cultural capital we need novel approaches that help us acknowledge and classify these services, including standards for defining, quantifying and/or qualifying ecosystem services so that we can share data, value the services and monitor how policies are impacting on the ability of nature to contribute to human well-being.

It is especially important to classify the services that ecosystems provide and the way they benefit people. This is necessary so that we can account for services in an accurate way and properly value them. To help with these kinds of problems, a Common International Classification of Ecosystem Services (CICES) [6] has been developed as one of the key standards. CICES has been adopted as the basis for the mapping of ecosystem services under the EU biodiversity strategy [7]. Much of the development has been carried out by the OpenNESS project, which has, among other things, tested the standardised approaches, applied CICES at different scales and in different contexts and created a web-based tool for policy advisers and managers to help them navigate between different classification systems [8]. In addition, the OpenNESS project has provided ways of helping people to

[2] http://ec.europa.eu/environment/nature/ecosystems/studies.htm
[3] http://www.millenniumassessment.org/en/index.html
[4] http://www.teebweb.org
[5] http://www.ipbes.net
[6] http://cices.eu
[7] http://biodiversity.europa.eu/ecosystem-assessments/european-level
[8] http://openness.hugin.com/example/cices

visualise the idea of ecosystem services so that they can apply it more easily in their work.

An example of this is the cascade model (Figure 1). It shows the flow of ecosystem services from the stock of natural capital. You can see how ecosystem services relate to the ecological structures and processes of natural capital and how services link to benefits and values. The challenge is to develop conceptual models that clearly show people how ecosystem processes, services and benefits link to human well-being, and in turn how human actions and management affect ecosystem processes and the related ecosystem services (Langemeyer et al., 2016).

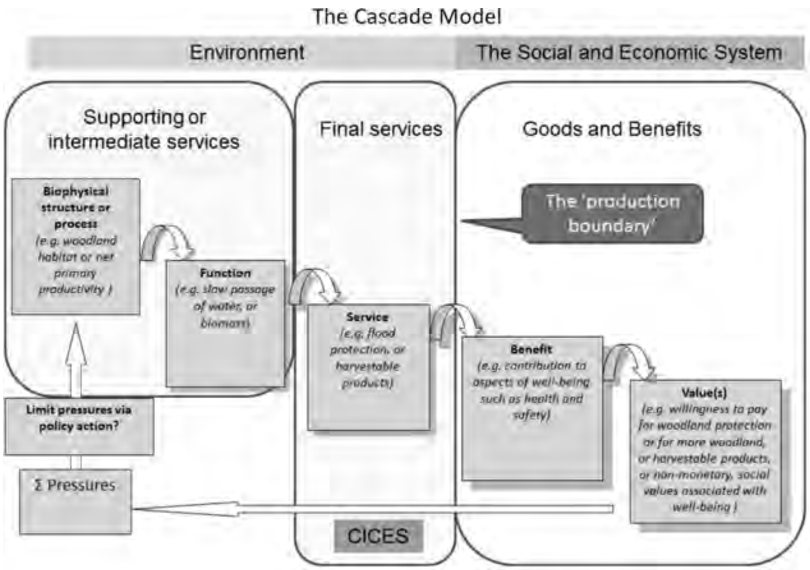

Figure 1

The figure clarifies the terminology that is used in relation to the ecosystem service concept. CICES provides a typology of so-called final services that contribute directly to material goods or non-material benefits. The latter sit on the other side of the production boundary in the sense that the outputs are no longer closely connected to ecosystem structures and processes, but form products or conditions that are of value to people in some way. The ecological structures and functions that underpin the delivery of these final services are sometimes referred to as 'intermediate' or 'supporting services'. The figure has been modified from Potschin and Haines-Young (2011).

Supply of ecosystem services from natural capital

As indicated in the earlier sections, natural capital underpins the provision of ecosystem services, and many of these are being affected by human activities. Natural capital is composed of living organisms (e.g. plants, animals, fungi, bacteria), as well as non-living natural components including air, water, rock and soil. The state of natural capital has been assessed at the global level through the Millennium Ecosystem Assessment (2005) and is assessed every 5 years at the European level by the European Environment Agency (2015) [9]. Although there are signs of improvement in particular areas, the general picture painted by these assessments is of a steady decline in natural capital due mainly to human pressures on the environment.

We urgently need to understand how the state of natural capital affects the supply of ecosystem services on which we all depend. A more specific awareness of these key interrelationships is crucial for developing effective management and policy strategies. The OpenNESS project investigated this by systematically reviewing the academic literature (780 articles) on the links between natural capital and ecosystem services. We studied four provisioning services (food crops, water supply, freshwater fishing and timber), seven regulating services (climate regulation, air quality regulation, flood protection, erosion protection, water quality regulation, pollination and pest control) and two cultural services (species-based recreation, such as nature watching, and aesthetic landscapes) (Harrison et al., 2014).

Based on the OpenNESS analyses, several aspects of natural capital are identified in the literature as being important for delivering ecosystem services. For most regulating services, the main factor cited is simply the physical amount of vegetation within an ecosystem. This is determined by a range of attributes, including the area

[9] http://www.eea.europa.eu/soer-2015/europe/natural-capital-and-ecosystem-services

and type of habitat, vegetation productivity, biomass, species size, growth rate and age of the ecosystem. For example, the area of forest in a catchment plays a major role in determining peak river flow after heavy rain, with older and larger trees generally intercepting more rainfall and thus providing better flood protection.

For provision of agricultural products, fish and timber, and for pollination, pest regulation and species-based recreation, the presence and abundance of particular species (such as food crops or iconic wildlife) or functional groups (such as pollinating insects) is critical. Species traits such as size, growth rate or predation behaviour are important for determining which are the most effective contributors to the ecosystem service.

Finally, diversity plays an important role. This includes species richness (the number of species present), population diversity (variation within a species), functional diversity (the mix of different characteristics such as deep- and shallow-rooted trees), structural complexity and landscape diversity. Diversity can enhance a wide range of services, including timber production, climate regulation, pest regulation and pollination. It contributes to these services in two ways: niche complementarity, where efficiency is maximised because organisms occupy different ecological niches; and the selection effect, where the presence of more species improves the chance that one of them will be a high performer. Both of these mechanisms are shown to be important in different circumstances. Species richness and structural diversity also increase human enjoyment of species-based recreation and landscape aesthetics. Crucially, diversity also plays an important role in ensuring long-term resilience to environmental change, hence contributing to the insurance value of ecosystems (Green et al., 2016).

In some cases there can be negative impacts or trade-offs between ecosystem services. One commonly cited example is the negative effect of fast-growing timber plantations on water supply in dry regions; this is the flip side of the service that forests provide for flood protection. However, this is very context dependent. There are also examples of forests enhancing water supply through improved soil infiltration or fog capture. Other examples include negative impacts of invasive alien species, such as managed bees out-competing wild pollinators, or introduced fish wiping out native fish.

Human activities are shown to have a range of positive and negative impacts on ecosystem service delivery, and many studies cite a mix of both. Negative impacts are often linked to human use of provisioning services, either through the over-extraction of resources or through the addition of inputs such as fertilisers, which improve short-term food and timber production but have negative impacts on other services such as water quality and freshwater fishing. However, there are also many examples of ways in which protection, restoration and sustainable management of habitats can actively enhance ecosystem service delivery. This is particularly important because we know very little about the existence of thresholds and tipping points beyond which natural capital would degrade irreversibly.

Understanding the links between natural capital and ecosystem services can enhance cultural capital, for example by helping decision-makers to identify opportunities for protecting and enhancing vital ecosystem services, by giving a frame for traditional knowledge and by minimising the negative impacts of trade-offs between services. Although we will never have perfect knowledge of the complex processes and interactions within ecosystems, we know enough to understand that we need to work harder at maintaining diverse, healthy ecosystems that will continue to deliver vital services into the future, as explained in Figure 1.

Demand for ecosystem services

The previous section covered the way in which natural capital supplies ecosystem services. This section describes the way in which those services provide benefits to people to meet societal demands, arising either

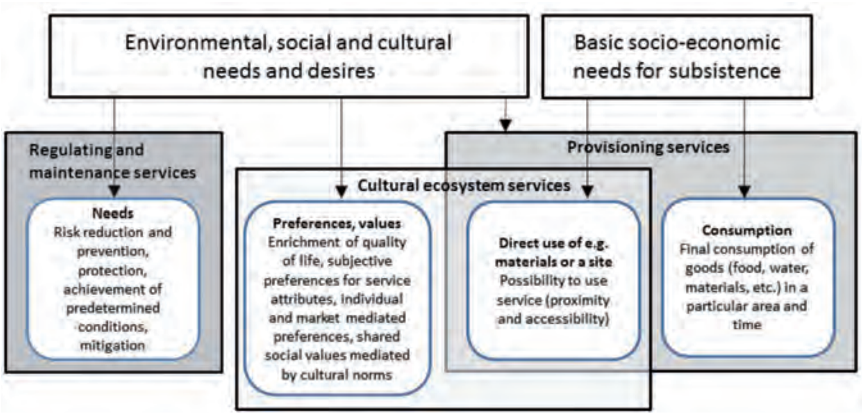

Figure 2

Categories used to assess demand for ecosystem services (modified from Wolff et al., 2015).

directly from people or via public policy regulations and environmental policy targets. The demand for natural capital and associated ecosystem services can be related to three main types of societal needs and desires (Figure 2).

First, there is the demand for consumption or direct use of natural goods and services in a particular area. This is motivated by the basic socioeconomic needs for subsistence, such as food, water, other materials or shelter, and is mainly related to provisioning ecosystem services. The second type of demand highlights the social and cultural values that people attach to ecosystem services, either based on individual preferences or through shared social understandings (Kenter et al., 2015; Chan et al., 2012). The motivation for these is the social and cultural well-being connected to subjective needs, such as religion, education and leisure, and this type of demand relates especially to cultural services, but also to provisioning services, for example cultural preferences for certain types of food. The third type of demand is connected to risk reduction, which is motivated by the basic environmental needs of the whole society. These include the good quality of the environment and its components, as well as the reduction of risks, such as those associated with flooding, landslides or pollution levels. This demand is related mainly to regulating services.

Demand for ecosystem services stems from many groups: local people (individuals, families, small communities), larger segments of society (nations, countries, regions) and specific users (owners, managers, business sector). Multiple uses raise concerns of overuse. It should, however, be noted that cheap supply of certain goods may lead to excessive consumption (Baró et al., 2015). For example, the amount or quality of consumed food does not necessarily reflect the amount or quality needed to keep people healthy, not least because much of it is wasted. There are considerable mismatches in the availability of, and accessibility to, natural capital. This is closely related to environmental justice, which reflects the fair share of not only negative environmental impacts, such as exposure to pollution and risk (as the main subject of past decades' concern), but also ecosystem benefits (Gómez-Baggethun et al., 2013).

Policies as key drivers of change in natural capital

The previous sections showed how ecosystem services cascade from natural capital and how supply and demand play a key role in understanding the link between natural capital, ecosystem services and human well-being. In this section we elaborate on the factors that change the capacity of ecosystems to provide services and benefits to humans. There is a plethora of natural or human-induced factors that directly or indirectly cause changes in natural capital stocks and the ecosystem services they generate. Direct physical or biological drivers such as climate and land use influence ecosystem processes. Indirect drivers in turn operate more diffusely by altering one or more direct drivers; these include demographic, economic, sociopolitical, science and technology, and cultural drivers. These developments or trends can take place at all spatial scales.

Cultural capital, including human attitudes and knowledge about natural capital and ecosystem services, plays a key role in influencing these drivers of change. This is expressed partly through the formulation of policies at various administrative levels. This section examines the extent to which EU policies explicitly address the drivers of change in ecosystem services, based on an analysis of 11 EU policies (Table 1) carried out in the OpenNESS project (Schleyer et al., 2015; Bouwma et al., 2017).

The analysis covered several policy fields, ranging from biodiversity and water policies to climate policies and policies for rural and urban areas, as well as a mobility and infrastructure-related policy. It revealed that natural capital and ecosystem services are reflected in policy definitions, objectives or instruments to very different degrees. Only five of these policies actually refer explicitly to either ecosystem services or natural capital. These are the biodiversity strategy, the forest strategy, the green infrastructure strategy, the most recent revision of the common agricultural policy and the marine strategy framework directive, the last being the first EU policy to feature ecosystem services and natural capital explicitly (introduced in 2008). In all investigated policies in which ecosystem services are explicitly mentioned, usually all ecosystem services categories (provisioning, regulating and cultural) are referred to, as well as biodiversity. Some policies, such as the climate change adaptation strategy and the thematic strategy on the urban environment, mention ecosystem services and natural capital indirectly, i.e. they contain terms such as soil function or climate regulation that can be regarded as regulating ecosystem services, but there is no explicit reference in the text to ecosystem services.

It appears that regulating ecosystem services are exemplified—directly or indirectly—in considerable detail and are much more differentiated than all other categories of ecosystem services. Their importance is often highlighted in a sense that these ecosystem services are essential to maintain sustained flows of provisioning services. Furthermore, there are quite a few specific regulating services that either deal with climate change (e.g. climate regulation, flood prevention) or are related to health issues (e.g. clean air and water, noise buffering, air purification), reflecting the high societal importance attached to these issues. To some extent, however, this might also be because, for some of these regulating services, for example carbon sequestration and water quality and quantity, there are fairly accurate proxies available to assess ecosystem services delivery. Cultural ecosystem services, in turn, are only specified if ecosystem services and natural capital are mentioned explicitly. They are also considered in much less detail, and the focus is usually on tourism and recreation, perhaps because these services are empirically and conceptually easier to identify and measure than, for example, spiritual services. However, some of the policies, such as the green infrastructure strategy and the forest strategy, address local lifestyles and rural communities, which can be considered to address people's cultural attachment to the ecosystems addressed by these policies.

Most of the direct drivers mentioned in the policy documents are specific to the respective policy, for example, over-exploitation of ecosystems (biodiversity strategy), pressure on marine resources (marine strategy framework directive), climate change (climate change adaptation strategy, renewable energy directive) and urban sprawl (thematic strategy on the urban environment). There are also some direct and indirect drivers that feature prominently in several policies, including the unsustainable use of ecosystems (habitats directive, common agricultural policy, biodiversity strategy, marine strategy framework directive), climate change (climate change adaptation strategy, forest strategy, renewable energy directive), insufficient quality of air and water (marine strategy framework directive, thematic strategy on the urban environment, water framework directive, trans-European transport network) and excessive noise (thematic strategy on the urban environment, trans-European transport network). While some policies point at specific direct drivers such as soil degradation,

Table 1

Direct and indirect drivers of change in ecosystem services and natural capital tackled by EU policies (modified from Schleyer et al., 2015).

EU policy	Direct drivers	Indirect drivers
Green infrastructure strategy	• Unsustainable use of natural resources. • Loss of natural capital.	• Over-reliance on built (grey) infrastructure. • Benefits from nature not fully appreciated by society leading to a degradation of natural capital.
Habitats Directive	• Human use of species (capturing, killing, collecting), or their habitats (destruction, disturbance).	• Low appreciation of biodiversity when areas are needed for construction or other economi development.
Biodiversity strategy	• Land-use change. • Over-exploitation of biodiversity and its components. • Spread of invasive alien species. • Pollution. • Climate change.	• Demographic change. • Lifestyle change. • Institutional drivers ('market failures'). • Economic structure: size, growth, trade.
Water framework directive	• Discharges. • Emissions and loss of priority substances. • Pollution of groundwater.	
Marine strategy framework directive	• Pressure on natural marine resources. • High demand for marine ecological services leading to unsustainable use.	
Forest strategy	• Climate change (carbon balance, weather change, and forest health risks). • Forest area change (direct and indirect) and forest use (harvest rate).	• Market demand for new and existing forest products. • Demand for energy.
Common agricultural policy/rural development regulation	• Climate change: adaptation and mitigation. • Over-exploitation of soils and water.	• Social drivers (young farmers, education). • Small farms. • Mountain areas. • Rural development. • Supply chains. • Competitiveness. • Poverty of women in rural areas.
Thematic strategy on the urban environment	• High level of traffic and congestion. • Derelict land. • Greenhouse gas emissions. • Urban sprawl. • Waste and waste-water.	• High levels of noise. • Poor-quality built environment. • Lifestyle change. • Demographic change.
Renewable energy directive	• Climate change. • Land-use change.	
Climate change adaptation strategy	• Climate change.	
Trans European transport network	• Landscape fragmentation. • Soil degradation. • Air and water pollution.	• High levels of noise.

others refer only to broader categories such as degradation of ecosystems and their services. Most of the direct drivers, however, reflect the sectoral nature of the investigated policies and are related to the main objectives pursued, such as maintenance of biodiversity (biodiversity strategy) or improvement of water quality (water framework directive). Some environment-focused policies (green infrastructure strategy, biodiversity strategy) explicitly mention socioeconomic drivers, such as changes in lifestyle and consumption patterns, as well as demographic change. Other policies like the common agricultural policy also refer to competitiveness, rural development, young farmers and poverty of women in rural areas (Schleyer et al., 2015). It is interesting to note that climate change as a (direct or indirect) driver has only featured prominently in EU policies from about 2009 onwards, with the renewable energy directive being the first of the policies covered here.

Towards integrated valuation

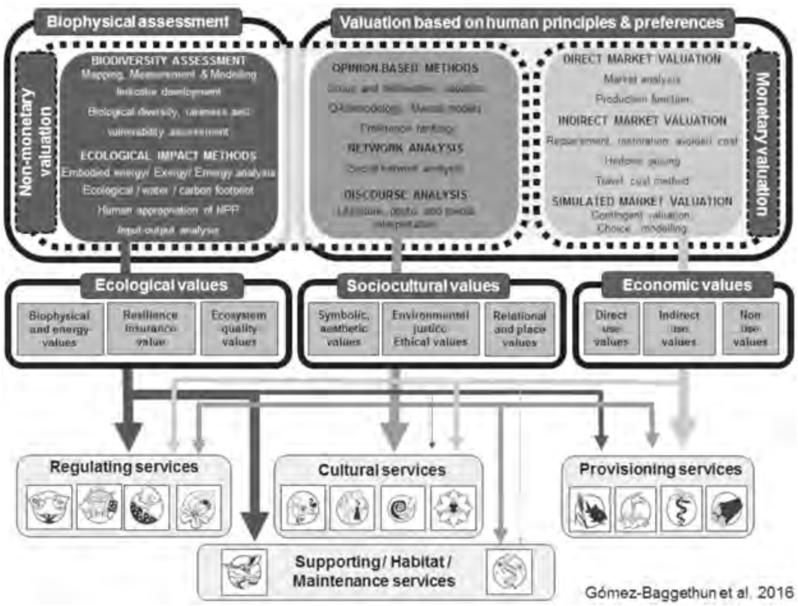

Figure 3

Concepts and methods in ecosystem services valuation (Gómez-Baggethun et al., 2016, with icons by Jan Sasse for TEEB). The upper part illustrates the divide between methods that derive values from biophysical assessments and methods that derive values from human subjectivity (including principles and preferences), and methods based on monetary and non-monetary valuation. The lower part illustrates the connection between methods, value types and ecosystem services, showing that they do not stand in a one-to-one relation.

Valuation is a key component in assessing the importance of ecosystem service supply and demand, and it is embedded in governance practices. It is thus crucial to know what to value, how to value and, in particular, how to use the entire palette of valuation methods when working with real planning and decision-making situations (Gómez-Baggethun and Barton, 2013). OpenNESS has identified and developed methods for ecosystem services valuation that cover different techniques for quantifying or qualifying ecological, sociocultural and economic values (Gómez-Baggethun et al., 2016) (Figure 3).

Valuation is inheren embedded in decision and management contexts and may thus build an indirect link between natural and cultural capital. These contexts define the purpose of valuation and generate demand for specific types of valuation results. The decision context can therefore be considered as both the starting point and the end point of integrated valuation (Figure 4). Figure 4 outlines a process that builds on the ecosystem service cascade (see Figure 1 in earlier section and Potschin and Haines-Young, 2011), motivating integrated assessment across ecological, social and economic assessment methods.

OpenNESS has produced a model for integrated assessment and valuation, defined as the process of synthesising, interpreting and communicating knowledge about the ways in which people conceptualise, understand and appraise the values of ecosystem services to facilitate informed decision-making and planning (Gómez-Baggethun and Martín-López, 2015). It departs from the assumption that different values are required to capture the multiple ways in which ecosystem services contribute to fulfil human needs and wants. The

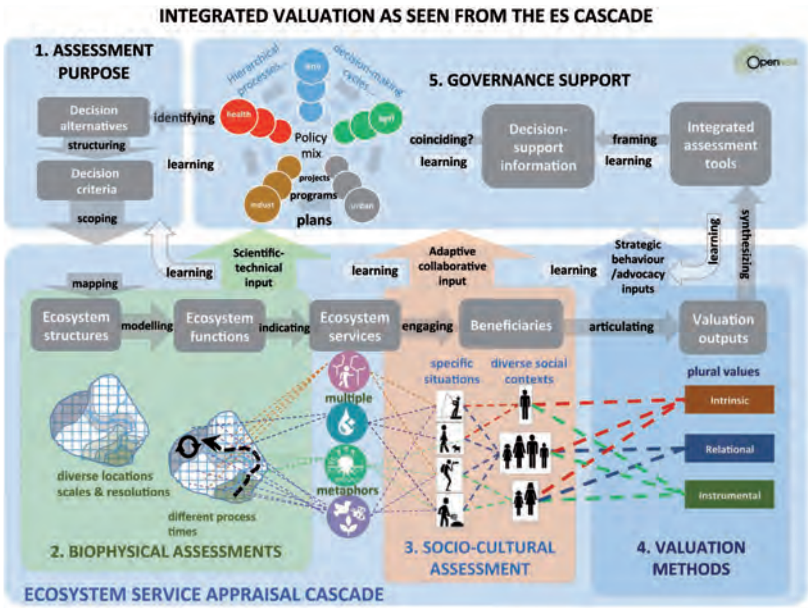

Figure 4

Ecosystem icons by Future Cities, Oslo Municipality. People icons by Shutterstock (Barton and Harrison, 2017; Kelemen et al., 2015).

model presents the purpose of conducting valuation, which relies on identifying relevant decision contexts in the project or policy cycle (including both management and policy contexts; see stages of integrated valuation process in Kelemen et al., 2015).

Integrated assessment and valuation emphasises that ecosystem services have plural values because they are formed by multiple social actors in specific situations with multiple time frames, rationalities and cultural backgrounds, and at diverse locations. Integrated valuation focuses on addressing this heterogeneity and plurality.

The importance of valuation for communication and learning in the decision-support process is emphasised. Decision support involves communication with, and feedback from, social actors. Integrated valuation also recognises that assessment and valuation methods are value-articulating institutions (Vatn, 2005) that are chosen by researchers with specific disciplinary training and that frame valuation information differently depending on the decision-support needs. Hence, it acknowledges that valuation methods do not simply reveal pre-existing values, but also shape values and perceptions.

Valuation contexts and decision contexts are often mismatched. Integrated valuation places emphasis on mutual learning between researchers and decision-makers to make valuation more consistent with the decision problem. Integrated valuation also emphasises feedback and iteration—biophysical assessment may be updated by learning from social assessment, which may be updated through learning from valuation, and so on. An emphasis on learning also means an increased awareness of the cost of obtaining valuation information and comparing it to the benefits of better decisions, or conversely of reducing the chance of poor decisions, such as adopting costly actions or ignoring beneficial ones.

Moving from knowledge into action

Once we understand the links between natural capital and ecosystem services, their relation to human well-being and the key drivers of change, we need to bring the knowledge into action. This is where the connection between natural and cultural capital materialises. This includes channelling all these concepts, methods, data, information and knowledge into concrete land and water management and decision-making processes. These can be embedded in existing practices or used to transform current management and policy approaches.

The first and most fundamental step in this process is engaging with public and private decision-makers and stakeholders to better understand their needs, in particular the range of policy and management problems they face in making the natural capital and ecosystem service concepts operational. Appraising the interests, values and knowledge of local and regional actors is of vital importance in determining which elements of natural capital are relevant to deliver the services and benefits expected, who is affected and what kind of trade-offs are related to alternative policies or management options.

Case studies in the OpenNESS project test the relevance and usefulness of the available assessment and valuation methods in an iterative, tailored manner. Compiling these experiences across a broad range of cases in structured, spatially explicit databases, and making them publicly available, provides a good basis for highlighting any common lessons. Stakeholder workshops using participatory modelling, mapping and problem-structuring methods have proved to be very useful for increasing the credibility, relevance and legitimacy of the assessment results on the one hand, and for incorporating local, place-based knowledge on the other hand. It is also important to engage key stakeholders in problem framing to ensure that relevant biophysical and sociocultural dimensions are included in the assessment.

In a world of exponentially growing knowledge, building communities of practice that can help process knowledge on natural capital management is vital. These networks help in the exchange and transfer of the new knowledge acquired, developing individual capacities and strengthening cultural capital. Furthermore, they identify a range of practices and innovations, as well as solutions to shared problems.

Web portals with state-of-the-art knowledge on natural capital and ecosystem services can provide a cost-effective channel of communication, enhancing the sharing and dissemination of data, information, knowledge and empirical evidence. There are a number of initiatives in this direction, including the Biodiversity Information System for Europe (BISE) and Oppla (the web-based platform developed by the OpenNESS and OPERAs projects) at the EU level, and the Natural Capital Coalition (NCC) and the Ecosystem Services Partnership (ESP) at the global level. The NCC supports the development of methods for natural valuation in business, aiming at enhancing the environmental liability of the corporate sector (Phelps et al., 2015) and creating incentives to shift its behaviour to preserve and enhance, rather than deplete, the earth's natural capital, while the ESP enhances the science and practical application of ecosystem services assessment. Oppla is an online platform that brings together knowledge about natural capital, ecosystem services and related themes from around Europe and beyond. It contains documents, worked case study examples (see Figure 5 showing the case study finder from Oppla), online tools and methods, best-practice examples, guidance tools for methods selection, videos, maps and other visualisations, services, access to expertise, networking facilities, training, educational materials, and news and events. Oppla aims to become a global networking, marketing and sharing platform for practitioners, policymakers and researchers around the world (Figure 5).

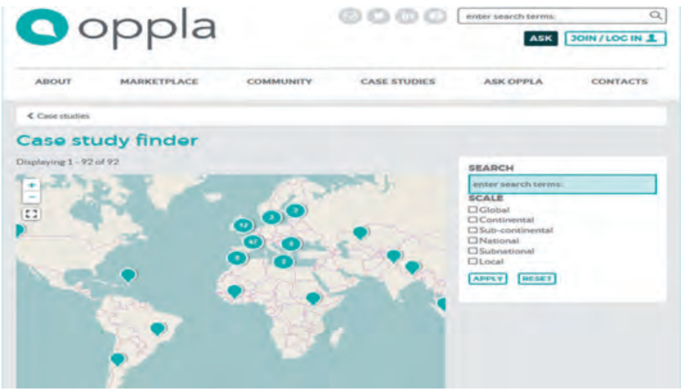

Figure 5

Oppla case study finder (http://www.oppla.eu) allowing the search for information on a broad range of case studies at multiple spatial scales.

Web portals can also support policy action. First, they offer outreach of relevant policies and instruments to a broad range of actors involved in mobilising ecosystem services. Second, they support policy coherence through integration of various policy fields and decisions more effectively, by offering services, tools and knowledge from a community representing multiple sectors and interests. They are therefore an important instrument for enhancing cultural capital regarding the management of natural resources.

Solutions to societal questions arise from knowing the essentials

One of the most concrete ways of taking advantage of natural capital and ecosystem services is to build cultural capital that provides NBS to the societal challenges we face today. These have a role to play at a range of scales (from small and practical to grand and systemic problems), not only in cities but also in a range of land uses from intensive to extensive, and from the local to the global level.

NBS have gradually been introduced to the family of concepts building on the usefulness of ecosystems to humans, including ecosystem management, nature-based interventions, bio-mimicry, and green and blue infrastructure; several of which overlap. Indeed, NBS may be seen as a 'functional umbrella' to the full range of ecosystem-based concepts (Potchin et al., 2015); and they have the broadest definitions, for example: 'NBS to societal challenges are defined as solutions that are inspired or supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help to build resilience. They bring more nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions' (European Commission expert group, 2015) [(10)].

But how can we ensure that NBS are identified and applied when and where they provide the most sustainable alternative? Pragmatically, when considering any response to a challenge, whether it be one of industrial or engineering design, or the management of a natural resource at local or global scales, one could simply ask 'is there a NBS to consider'?

This would involve assessing NBS and weighing them against other options: how cost-effective they are in relation to other solutions; whether they foster a systemic approach; whether they provide resilience in a socioecological context; and whether they promote sustainable development in all its three dimensions—social, economic and ecological.

Several examples of NBS are already being applied, such as those used in waste-water and storm-water management in urban areas, watershed management for recreational purposes and climate adaptation and forest management for combating climate change (see e.g. Kabisch et al., 2016; Narayan et al., 2016). The OpenNESS project has been working on cases that have developed these types of solutions jointly with local and regional actors (see e.g. Camps-Calvet et al., 2016; Baró and Gómez-Baggethun, in press). Many other potential solutions have been identified and are being developed as innovations for broader use, including those linked with nutrient and waste uptake for reuse from land and sea by plants. However, many more NBS await discovery. These could bring solutions, in addition to those already mentioned, to challenges linked with ageing populations, societal coherence, business opportunities in low-income communities, digitalisation, mining plastic from seas and the sharing economy.

This leads us to consider the potential of NBS to enhance resource and energy efficiency by society. In which situations could NBS enable energy to be produced and materials gained in a more eco-efficient, more sustainable and less expensive way (Maes and Jacobs, 2015)? What do NBS have to contribute to the circular economy to enhance eco-efficiency and bioeconomy in a sustainable way (Furman et. al. 2016)? With growing urbanisation, are natural capital and ecosystem services metaphors sufficiently operational concept to help achieve the transition

[(10)] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=18664&no=1

towards the prosperous and sustainable socioecological systems of the future?

The issues raised in this book chapter contribute to the knowledge base needed to answer these questions, which are so crucial for the sustainability of this planet and its inhabitants. Cultural capital is a necessity for the transition towards more sustainable paths. Although cultural capital—in all its meanings ranging from cultural values to cultural capabilities—builds on a spectrum of elements such as attitudes, behaviour and norms, the very basis of it is knowledge: the knowledge of societal problems, of natural capital, of ecosystem services and of the solutions they can provide us.

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