CHAPTER B.III.

Co-benefits (ecosystem services) of measures to consolidate the Natura 2000 network

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III.1 Introduction

Humankind is very much dependent on its environment: it provides its food, air, water, energy, it provides inspiration and the sense of place and it sustains biodiversity. These benefits for people are described as 'ecosystem services'. The concept of ecosystem services originated from the early 1970s, but gained increased popularity after publications in the early 1990s (Costanza et al., 1997; De Groot, 1992).

Ecosystem services are increasingly integrated in land use planning. Various countries have incorporated them in their national assessments, following the MAES process which requires countries to make national assessments of Ecosystem services (Maes, Paracchini & Zulian, 2013; Pérez-Soba et al., 2015). The Natura 2000 network, both habitats and species, have an important role in delivering ecosystem services (IPBES, 2018; Ziv et al., 2018).

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Ecosystem Services

Ecosystem Services are "*the benefits people obtain from ecosystems. Ecosystem Services include provisioning services such as food, water, timber, and fibres; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling*" (*MA, 2005*).

This classification, however, is superseded in IPBES assessments by the system used under "**nature's contributions to people**". This is because IPBES recognises that many services fit into more than one of the four categories. For example, food is both a provisioning service and also, emphatically, a cultural service, in many cultures.

The most commonly used classification of ecosystem services in the EU is: The Common International Classification of Ecosystem Services (CICES). This classification is developed from the work on environmental accounting undertaken by the European Environment Agency (EEA).

Figure III.1

Examples of Ecosystem services
(PBL, WUR & CICES, 2014)

Land-use change is the major direct driver of the loss of both biodiversity and ecosystem services in Europe (*IPBES, 2018*). Natural resource extraction, pollution (nutrients, pesticides and (micro)plastics) and invasive alien species are other major threats. Declining biodiversity is an important risk factor for a constant delivery of ecosystem services during changing conditions (*Vos et al., 2014, Science for Environment Policy, 2015*). For example, man makes use of honey bees for the pollination of orchards, however, wild bees can take over the pollination of orchards at higher wind speeds (*Brittain et al., 2013*). The decline of so many wild species makes our economy, and in particular farming systems, very vulnerable.

Area, spatial structure, abiotic conditions and the age of Natura 2000 habitats are also relevant (*Vos et al., 2014*). In general, Natura 2000 sites in a favourable status deliver more ecosystem services than those in an unfavourable status (*Maes et al., 2012*). Provision and regulating ecosystem services in Natura 2000 sites depend particularly on vegetation structure and land cover, while socio-cultural services and some regulating services depend on particular species (*Bastian, 2013*).

III.1.1 What is the relevance of Ecosystem services for site managers?

Ecosystem services are a tool to improve the link between the site managers on the one hand, and citizens, businesses, policy makers and governments on the other. This could increase the appreciation and understanding of nature and its conservation. It can also strengthen arguments for funding of conservation and restoration measures. However, it is not that easy for the site managers to identify and demonstrate the ecosystem services their site provides.

Often there is not enough knowledge and capacity among site managers to translate the existing scientific knowledge on ecosystem services into practical approaches and factual arguments. This is equally a challenge for deciding on or prioritizing the most appropriate management actions in a management plan; reporting on the benefits of a LIFE project; or communicating ecosystem services to the visitors and the general public.

All measures and management decisions that site managers take can cause possible trade-offs between different ecosystem services (*Schröter et al., 2019*). For example, felling trees may be needed for the restoration of heathland habitat but may reduce the potential of carbon sequestration in that area. Synergies between Natura 2000 measures and ecosystem services are also possible, for instance restoring wetlands can contribute to water regulation and (drinking) water production. Cultural services are often neglected by decision makers or site managers of SPAs. To combine these services successfully with biodiversity goals, beneficiaries should be incorporated into the design and management of the Natura 2000 network (*Science for Environment Policy, 2015*).

The Millennium Ecosystem Assessment concluded that 60% of ecosystem services are being degraded or used unsustainably, often resulting in significant harm to human well-being (*MA, 2005*). A study by *Ziv et al. (2017)* revealed that use of ecosystem services affected bird conservation more negatively by use of water, wild food and recreation in the Mediterranean region than in other European regions. Livestock and fodder production are the most positively featured ecosystem services, especially in Boreal and Alpine SPAs, probably due to extensive land use, while intensive land use in Western Europe leads to negative effects of livestock and fodder production. In Mediterranean countries, agricultural abandonment contributes to carbon sequestration (*Novara et al., 2017*).

The economic value of Ecosystem Services has been estimated to be 223–314 billion Euros per year and far outweigh management costs (*Science for Environment Policy, 2015*). However, balancing costs and benefits is complex as costs are often paid by the community while both communities and businesses benefit from the ecosystem services they provide, and both can contribute to the drivers that put Natura 2000 areas and the services they deliver at risk. A short introduction video to the world's ecosystem services is found here.

Effects of use of ecosystem services on conservation goals also differ between habitats: grazing of livestock and production of fodder and crops have only positive effects in marine/intertidal habitats, but negative impact on agricultural or forest habitats (Table III.1). Regulating services benefit intertidal and heathland habitats, but are a threat for other habitats. The effects of recreation or collecting wild food reveal to be negative in all habitats (*Ziv et al., 2018*):

Impact	Measure
+	fishponds, crops, coastal fields, reforestation, meadows and traditional land use provide bird habitat
+	reforestation increases carbon sequestration and (on flood plains) water retention
+	hunting prevents damage to forest by reducing game animals and anglers help to protect food sources
-	intensive aquaculture and agriculture reduces or damages nesting and food habitat
-	fibre or wood production can lead to invasion of exotic trees and/or disturbance or loss of habitat
-	conversion of natural habitat into multifunctional or agricultural habitat causes habitat loss
-	water energy plants or flood defences disturb fluvial ecosystems and cause noise pollution
-	recreation disturbs birds and habitats, ammunition of hunters poisons birds of pray

Table III.1
Examples and synergies and trade-offs, as reported by SPA managers. (*ZIv et al. 2017*)

In the paragraphs below the opportunities and trade-offs for restoration of rivers and wetlands and coastal habitats are presented. Paragraph III.4 presents the relation between ecosystem services and climate measures, while III.5 has a focus on the relation between ecosystem services and Natura 2000 connectivity restoration measures. At the end key findings and recommendations, and suggestions are made for websites or organisations that can provide further information.

III.1.2 Policies and Ecosystem Services

Ecosystem services are implicitly mentioned by Action 5 of the EU Biodiversity Strategy 2020. In particular Target 2 requires the restoration of at least 15% of degraded ecosystems to sustain the supply of services (*European Commission, 2011b*). Also the EU Biodiversity Strategy 2030 emphasizes the the "protection and restoration of biodiverse areas with high ecosystem services and climate mitigation potential (*European Commission, 2020*).

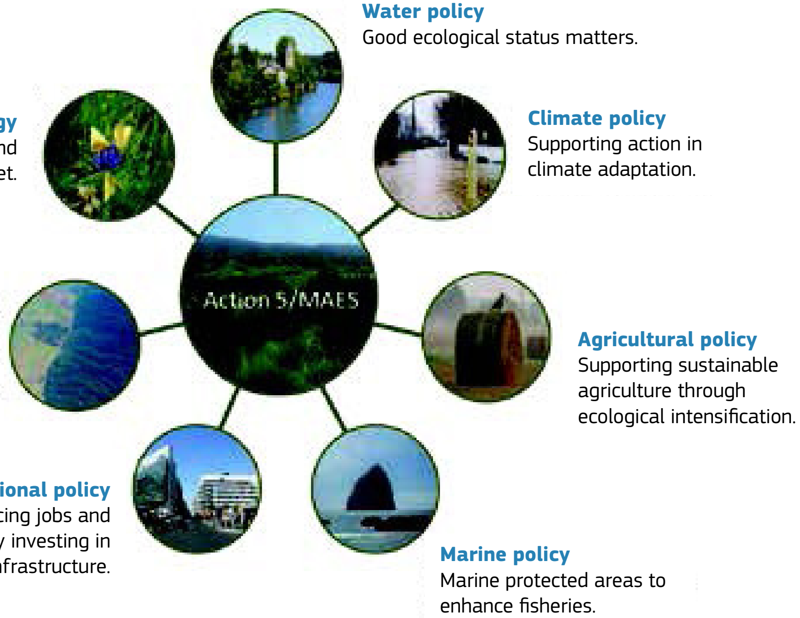


Figure III.2

Example to illustrate inputs of Action 5 into other policies (*Maes et al. 2014*)

The Biodiversity Strategy 2030 mentions specifically its increased support for the IPBES process. It underlines the importance of conserving and restoring land rich in ecosystem services (*European Commission, 2020*).

Ecosystem service maps can help to identify areas of high potential for ecosystem services delivery or for demand for ecosystem services, as well as where possible conflicts may occur. Information on ecosystem services is essential for developing comprehensive and strategic development plans (*Albert, Geneletti & Kopperoinen, 2017*).

The Commission's Communication on Green Infrastructure (COM(2013) 249), explains its principles and promotes investments within and outside Natura 2000 and other protected areas. It defines Green Infrastructure [see Chapter B.II] as "a strategically planned network of natural and semi-natural areas but also other environmental features designed and managed so as to deliver a wide range of ecosystem services."

Mapping and assessment of ecosystem services is not only important for advancement of biodiversity objectives, but is strongly related to the implementation of other related policies, including water, marine, climate, agriculture, forestry as well as regional development (*Burkhard & Maes, 2017*; *Maes et al., 2014*) (Fig. III.2). Ecosystem service mapping and assessment results can support sustainable management of natural resources, to be applied in development of nature-based solutions, contribute to spatial panning as well as environmental education.

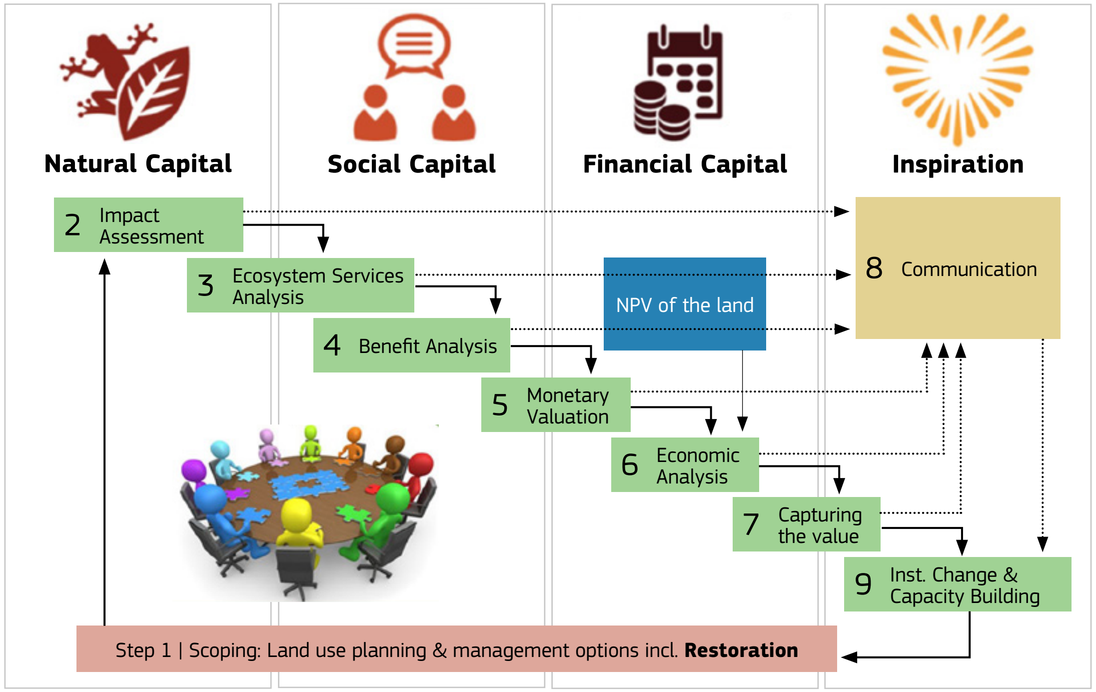
A webinar organised by the OPPLA project on how ecosystem services are included into policy can be found at: oppla.eu/did-you-miss-operas-webinar-how-ecosystem-services-included-policy.

III.1.3 Tools

There are many tools and approaches for an integrated ecosystem services assessment, such as InVEST (WWF, Stanford), TESSA (Birdlife International, WCMC) or Grace (IUCN), to mention a few. The approach presented here is from the Ecosystem Services Partnership, which is a network that connects 3000 people and 45 organizations from more than 70 countries (www.es-partnership.org).

The aim of the ESP is to enhance the policy and practical application of ecosystem services for conservation and sustainable development.

The approach developed by ESP consists of nine steps (Figure III.3), supported by Annexes with specific information on how to implement each step. Both the Guidelines and supporting material are 'living documents' that will be further improved and updated in subsequent versions.



The 9 steps in the Framework for integrated ecosystem assessment and the Guidelines are briefly explained below

1 Scoping: Before starting an assessment, the scope, context and purpose of the assessment should be made clear, in close consultation with the most relevant stakeholders, to avoid collecting unnecessary data or forgetting important aspects.

2 Impact Assessment: this step involves assessing the direct impacts (positive and negative) of restoration or other interventions on the landscape, on ecosystem structure & processes (vegetation, runoff) as well as the secundary effects in terms of changes in the functioning of the landscape (i.e. the (carrying) capacity of the landscape to provide services) compared to the baseline (e.g. loss of vegetation leading to erosion and loss of productive capacity).

3 Ecosystem services analysis: effect (of restoration or other intervention) on changes in actual, and potential, use of specific ecosystem services. E.g. planting trees will reduce erosion (see step 2) thus enhancing the capacity of the landscape to provide resources (eg. wood, fruit), clean the air, provide habitat for biodiversity and increase aesthetic quality possibly providing more recreational benefits. On the other hand, it might negatively affect water availability for irrigation or consumption. Thus, the total bundle of ES should be taken into account, including trade-offs, when analysing the return of Natural Capital.

4 Benefit analysis: changes in ES as analysed in Step 3 will have effect (positive or negative) on health, livelihood, cultural identity, and other wellbeing (social & human-capital) indicators (e.g. jobs, education, security, social-cohesion). In this step these benefits are quantified in non-monetary terms. *(continues on the next page)*

Figure III.3
ESP Guidelines for Integrated Ecosystem Assessment
www.es-partnership.org/esp-guideline
(*De Groot et al. 2018*)

III.2 Ecosystem services from rivers and wetlands

III.2.1 Potential and opportunities

Under natural conditions, biodiversity hotspots are often found near rivers, their banks and floodplains. Rivers and surrounding areas represent habitats with high levels of structural and functional dynamics, primarily induced by downstream flow (*Ward et al. 1999*). Hydrological, biogeochemical and ecological functions of river ecosystems provide a set of well-known ecosystem services. In particular, flood regulation (regulating), fresh water (provisioning), nutrient cycling (supporting), recreation (cultural), habitat functions for aquatic species (partly for food, fish production), transport functions (ship traffic), among others. When ecosystems are maintained in good ecological condition, their ability to provide these services is greater, while the deterioration of aquatic ecosystems may reduce the viability of the provided services. Intact river ecosystems are more effective at processing nutrients, breaking down waste, filtering water and providing habitats for fish (*Garcia & Honey-Roses, 2014*).

However, the large majority of rivers are influenced, and to a large extent, regulated, by humans. Most floodplain areas have been hydrologically disconnected from the river by the construction of dykes, and are currently often dominated by intense human use, such as agriculture, settlements or traffic routes (*Schindler et al., 2016*) and Europe is the continent that is most affected by such activities (*Nilsson, Reidy, Dynesius, & Revenga, 2005*). Also dam construction has heavily impacted streams, e.g. in Spain, Italy and the Balkans but also in Scandinavia (*Schwarz, 2019*). Often the ecosystem services have declined as a result, or instead of providing a multitude of services these have been narrowed down to just few services (e.g. boat traffic).

River restoration can restore the river to a more natural state, with an increase in ecosystem services as a result. This is in line with the Water Framework Directive which requires countries to take measures to improve the state of the water bodies. In particular floodplain wetlands provide many ecosystem services, and restoration of rivers may increase the resilience of the system while increasing also the various ecosystem services. Ecosystem services of floodplain wetlands were priced nearly ten times higher than the value we calculated for rivers (*Szałkiewicz, Jusik, & Grygoruk, 2018*). With smart measures aimed at a multitude of services, the costs of river restoration often can be offset against the benefits and services that are provided by more intact rivers and wetlands.

A review was prepared by *Stefan Schindler et al. (2014)* of hundreds of articles on floodplain interventions (38 in total) as well as the impact of restoration measures on its service delivery potential (Annex 1). This shows for example that removal of river bank fixations (measure 7) has positive effects on 12 ecosystem services, negative only for ‘terrestrial plants/animals for food, biomass based energy, and in some cases mixed effects such as control of invasive species (Annex 1). This table gives an indication of measures that could therefore be considered for river and wetland restoration.

5 Monetary valuation: once we understand, and preferably quantified, the effects of land use change (e.g. restoration) on ecosystem services (step 3) and … … benefits (step 4) we can analyse the monetary effects using direct market values, indirect market values and non-market values to determine changes in Total Economic Value of the bundle of ES provided by the restoration activities. If so desired, the TEV can be used to calculate changes in the Capital or Net Present Value (NPV) of the land after restoration (or other land use change measures).

6 Economic analysis: this step investigates the implications of ecosystem restoration for the local/regional/national economy in terms of economic indicators, e.g. employment, increased tax revenues, corporate profits, return to investors, etc. Also the change (usually increase) in value (NPV) of the land (see step 5) should be part of the economic analysis.

7 Capturing the value: based on steps 5 and 6, which together provide information on the return of financial capital, incentives (financial or otherwise) can be developed to invest in ecosystem restoration and/or sustainable management.

8 Communicating the value (and benefits) to generate awareness and support (‘inspiration’) for the measures needed to implement the incentives, communication activities can be employed after any of the steps (e.g. simply providing information on the return of ecosystem services (step 3) and their benefits (step 4) might be enough to move to step 9 (changing institutions and behaviour) without having to go through the more complicated and time-consuming efforts to calculate monetary (step 5) and economic (step 6) effects.

9 Capacity building and institutional change: to ensure implementation of the outcome of the assessment in long term policy, institutional and management changes at relevant scale levels (e.g. ranging from local capacity building programs to national policies and institutions) are needed.

III.2.2 Example studies

Room for the river

The Dutch floodplains were dominated for centuries by farming and water management (water safety measures). In the Netherlands, the approach towards climate change and coping with floods has changed over the last two decades. Now, the overall aim is to increase multifunctionality, with flood protection and increasing biodiversity being among the most important functions, another important function is tourism.

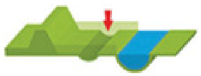
In 2007 the Government approved the Room for the River Programme for the Rhine. This plan had three objectives:

i by 2015 the branches of the Rhine must be able to cope with a discharge capacity of 16,000 m^3/s without flooding;

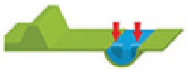
ii the measures implemented to increase safety must also improve the overall environmental quality of the river region; and

iii the additional retention area for the river, required to cope with higher discharges, will remain permanently available for this purpose.

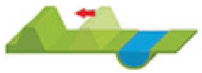
With all large projects implemented, the program was officially finalized in 2019.



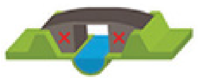
Lowering floodplains
Loweing/excavating part of the floodplain increases room for the river in the high water situations.



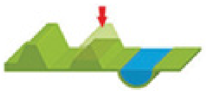
Lowering groynes
Groynes stabilise the location of the river and ensure its correct depth. However, in a high water situation, groynes may obstruct the flow to the river. Lowering groynes speeds up the rate of flow.



Dyke relocation
Relocating a dyke inland widens the floodplain and increases room for the river.

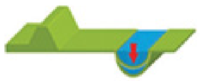


Removing obstacles
If feasible, removing or modifying obstacles in the riverbed will icrease the rate of flow.



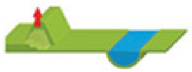
Depoldering
The dyke on the riverside of a polder is lowered and relocated inland. This creates space for excess flows in extreme high water situations

Water storage
The Volkerak-Zoommeer provides temporary water storage in extreme situations where the storm surge barrier is closed and there are high river discharges to the sea.



Deepening summer bed
Excavating/deepening the surface of the riverbed creates more room for the river.

High water channel
A high water channel is a dyke area branching off from the main river to discharge some of the water via a separate route.



Dyke reinforcement
Dykes are reinforced at given locations where river widening in not feasible.

A catalog of measures for floodplain restoration: Room for the River

Based on experiences in nature restoration, combined with hydrology needs, various floodplain restoration options were developed for the program 'Room for the River'.

In total, nine options are considered to enlarge riverbed and floodplains, including dyke relocation, depoldering, and water storage (Fig. III.3). This catalog of options has been applied in 39 projects along the river Rhine and its tributaries (read more here and here). Similarly, a restoration program was done for the river Meuse.

Figure III.4

The nine options considered to enlarge riverbed and floodplains in the Netherlands. This catalog of options has been applied in 39 projects along the river Rhine and its tributaries.

Measure	**No. of projects (Rhine & Ijssel)**	**Expected impact**				
		Multifunctional use	Biodiversity	Natural dynamics	Landscape diversity	Flood protection
Dyke relocation	5	0	+	+	±	+
Excavation of the floodplain	12	+	+	+	+	+
Depoldering	2	-	+	+	±	+
Lowering of the summer bed	1	0	0	0	±	+
Lowering the groynes	3	0	0	0	0	+
Removing obstacles	1	0	0	+	±	+
Water storage	1	+	0	0	0	+
High water channel	1	-	0	0	-	-
Dyke improvement	7	0	0	0	-	-

Table III.2

Impacts of the different measures of the Dutch 'Room for the River' Programme on multifunctional use, biodiversity, natural dynamics, and flood protection.
(Schindler, O'Neill et al. 2016)

The mixed centralized-decentralized approach in the Netherlands has been effective though in realizing many water safety projects through the stakeholders involved, partly funded through industries. However, stakeholders views and public support have been questioned (*Fliervoet et al., 2013*).

The various measures were evaluated towards the expected impact of the measures on various parameters, including biodiversity, natural dynamics and landscape diversity (Table III.2). The most beneficial measures are dyke relocation, excavation of the floodplain and depoldering (*Schindler et al., 2016*).

There is a window of opportunity to promote further the establishment of multifunctional floodplains due to the public attention generated by an increasing number of devastating floods in Europe, which underlines the failure of monofunctional approaches, and by the enhanced interest and take up of the concepts of ecosystem services and multifunctionality by recent policies (e.g. policies to support Green Infrastructure across Europe).

III.2.3 Meeting Water Framework Directive objectives and the Nature Directives

The Nature directives have many synergies with the Water Framework Directive (WFD). The main objectives of the WFD for surface waters are **1)** to prevent the deterioration of any status, **2)** to reach good ecological status and good chemical status as a rule by 2015, and **3)** to implement all necessary measures to reduce pollution. This refers to all surface water bodies, including those that form part of a Special Protection Area (SPA) under the Birds Directive and/or a Site of Community Importance (SCI) under the Habitats Directive. For groundwater the objective is to reach good quantitative status and chemical status of all underground water bodies.

Figure III.5

Baume-les-Messieurs, Natura 2000 site with vineyards situated between the limestone cliffs with important habitats and protected species like peregrine falcon.
© Theo van der Sluis

The WFD clearly mentions the protection and enhancement of the status of aquatic ecosystems and with regard to their water needs also the protection of terrestrial ecosystems and wetlands directly depending on them (Article 1). The WFD stipulates the establishment of a register of protected areas "which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water". The register must contain "areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites ..." (Annex IV, (v) WFD).

Any Natura 2000 site with water-dependent (ground- and/or surface water) Annex I habitat types or Annex II species under the Habitats Directive or with water-dependent bird species of Annex I or migratory bird species of the Birds Directive, and, where the presence of these species or habitats has been the reason for the designation of that protected area, has to be considered for the register of protected areas under WFD Art. 65. These areas are summarised as "water-dependent Natura 2000 sites". For these Natura 2000 sites, the objectives of the BHD and WFD apply (*European Commission, 2011a*).

There can be many common issues for both directives, dealing with water. There are therefore potential benefits to approaching the directives together. An example of such joint approach is the 'grip on life project', in Sweden. The purpose of the project is to increase the understanding of the two directives, defining whether objectives are in conflict or not, identify the most stringent objective, identifying common measures and actions. They did a study of the similarities and relations between the directives to define actions that would enhance river restoration and ecosystem services. Even if there are differences between the two directives, there are synergies and in many cases the objectives and measures coincide.

III.3 The services of coastal habitats

III.3.1 Introduction

Coastal habitats are hotspots of biological production and diversity in the landscape (*IPBES, 2018*). Some 40% of the Western European population is living in coastal areas (*IPBES, 2018; Schröter, Bonn, Klotz, Seppelt, & Baessler, 2019*). This has affected the services these systems provide, due to infrastructure development, pollution, habitat loss and overexploitation. Due to environmental policies coastal eutrophication has decreased but the proportion of marine dead zones near European shores has increased and the ecological status of many coastal areas are still unfavourable. In some coastal habitats the goal of conservation of at least 10 percent of coastal and marine habitats by 2020 has been reached (*IPBES, 2018*). Also the introduction of exotic species like the Pacific oyster has led to invasion of blue mussel beds. Moreover, coastal areas are at risk due to climate change induced sea level rise and increasing weather extremes. Consequently, the number and size of hard sea defences have increased, decreasing natural processes of dune succession and levelling of tidal movement, exhausting the natural sand supply along the coast.

Nature-based solutions are being increasingly used in maintaining or restoring some of the key ecosystem services provided by coastal areas. Nature-based solutions can contribute both to restoration of Natura 2000 sites and increasing ecosystem services. Nature-based solutions can increase coastal resilience by protecting communities against extreme events such as storms and stabilizing shorelines against water erosion. Furthermore, the use of multifunctional nature-based solutions in coastal areas can provide a range of other economic and cultural values.

Integrated natural resource management and integrated coastal zone management offer opportunities to combine efforts to meet different planning goals along the coast.

III.3.2 Coastal defence: the 'sand-motor' project

One of the large-scale projects of 'building with nature' is the Dutch 'sand motor project' . Every year, for many decades, the sea would erode the Dutch coast. The water authorities had to replenish the shortfall by depositing sand on the beaches and in the offshore area. This was vital to avoid flooding of the lower lying coastal zones and urbanized areas in the Netherlands. The sand replenishment operations had to be repeated every five years, and due to sea level rise there was an increased need to find alternative options to protect the coast in a more sustainable and natural way.

The solution was the creation of what is called the Sand Motor (also known as Sand Engine). This is a peninsula on the coast near The Hague, constructed with a large volume of sand.

Nature-Based Solutions

Nature-based solutions (NBS) are defined by the IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

However, more than one definition and interpretation of NBS exists and it also depends on the context in which it is used. In the context of climate change NBS means: an effective, long-term and cost-efficient approach to tackling climate change. These practices can protect natural resources while improving the state and quality of our ecosystems. NBS are an essential part of the overall global response to climate change and sustainable development.

In principle, NBS mimics natural processes and builds on fully operational water-land management concepts that aim to simultaneously realize goals, e.g. to improve water availability and quality and raise agricultural productivity, or coastal defence measures and restoration of coastal wetlands;

There is no straightforward distinction between NBS and other human induced management of ecosystem services.

Between March 2011 and November 2011, the water authorities and the provincial authority of Zuid-Holland created the hook-shaped peninsula. It extended 1km into the sea, and it is 2km wide where it joins the shore. Hopper dredgers picked up the sand ten kilometres off the coast and deposited it at the peninsula and two replenishment locations alongside the peninsula which are also part of the Sand Motor.

Figure III.6
An aerial view of the 'sand motor project', showing the artificial sand deposition along the Dutch coast near The Hague. © Rijkswaterstaat: dezandmotor.nl/fotos-en-videos

The sea will erode gradually the deposited sand of the peninsula and spread the sand along the coast. This stops further coastal erosion. The approach has been very successful, and the coastal defences are now at maximum strength.

The Sand Motor is open for recreational purposes. Visitors are able to ramble over the enormous sand shoal. Seals may also be present on the Sand Motor. Of course, nature – young dunes for example – needs time to develop. This project therefore provides opportunities for important Habitats such as 2130* grey dunes, 2110 embryonic shifting dunes, 2120 white dunes and 2190 humid dune slacks (see also *Houston, 2016*).

The Sand Motor is a great example of building with nature. By depositing a large amount of sand in a single operation, the repeated disruption of the vulnerable seabed is avoided. Nature takes the sand to the right place, and the expectation is that no further sand replenishment is required for the next 20 years.

The Sand Motor is the first experiment of its kind. In fact, it is 'working with water', instead of against it. The concept can be applied in other areas in the Netherlands and the rest of the world.

III.4 Climate and ecosystem services

The Natura 2000 network holds a large proportion of Europe's natural and semi-natural ecosystems that provide a wide variety of ecosystem services. Many of these Natura 2000 habitats do deliver several climate services: carbon storage, temperature and drought reduction, reducing risks of sea level rise and extreme weather events, (fires, floods), and water retention (*Bouwma et al., 2012*). At the same time, coastal habitats, freshwater habitats, bogs, mires, fens and alpine habitats are vulnerable to climate change.

The EU Biodiversity Strategy calls therefore for a strict protection of all the EU's remaining primary and old-growth forests. Also, the Commission will "put forward a proposal for legally binding EU nature restoration targets in 2021 to restore degraded ecosystems, in particular those with the most potential to capture and store carbon" (*European Commission, 2020*).

Adaptive management and no regret measures in Natura 2000 sites can be part of the solution, climate change needs to be an integral part of all (policy) sectors. In the Netherlands for instance, Natura 2000 legislation overrules climate policy. (National) legislation on Natura 2000 and climate could be integrated by introducing an overruling legal instrument on sustainability as has been introduced in New Zealand (*Kistenkas & Bouwma, 2018*).

Most Natura 2000 restoration measures have synergies with ecosystem services, but trade-offs may occur when one of the following aspects are not properly taken into account:

» Interactions between ecosystem services (including interactions with biodiversity): complex interactions between restoration measures and ecosystem services, e.g. water purification of target water areas may lead to pollution of other (downstream) waters.

» Forest management targeted to carbon conservation only, may lead to biodiversity loss, or vice versa. Climate smart forestry or a combined strategy, however, may protect carbon stocks and biodiversity better, compared to one management strategy (*Thomas et al., 2013, Nabuurs et al., 2017*). The central issue in this combined strategy is to prioritize biodiversity in a set of different ecosystems with different sets of (target) species. However, this works best for localised, small-range species, well-represented in habitats at the end of the abiotic gradients, such as high latitude and coastal areas.

» (Bundles) of ecosystem services: biodiversity targets and several services should be targeted together (*Bullock et al., 2011*). Different habitat types can deliver different bundles of ecosystem services and biodiversity. Whether synergies or trade-offs exists between restoration measures and ecosystem services depends on the specific bundle under consideration and on the scale level.

» Spatial scale: for some ecosystem services it is important that service provision is arranged at a global level, like carbon sequestration, some at a regional level, like flood prevention and some at a local level, like leisure and air quality (*Verhagen, 2019*). Restoration measures may lead to synergy with local ecosystem services, but trade-offs at other locations, e.g. when considering heterogeneity in Alpine landscapes (*Crouzat et al., 2015*) or in river catchments (*Verburg et al., 2012*). When considering buffer zones, creating buffer zones located outside protected areas may lead to synergies, e.g. with recreation, while creating buffer zones inside protected areas leads to trade-offs (e.g. *Palomo et al., 2013*). Landscape structure seems to have a positive effect on ecosystem services mainly at the local level (*Verhagen, 2019*). For site managers the landscape scale might be the appropriate level, and one might consider the use of 'landscape services' for that matter (*Van der Sluis et al., 2018*).

» Beside the aspect of spatial scale, time scales are also important to preserve the reliability of the provision of ecosystem services. Just as in targeting Natura 2000 goals, biodiversity is a crucial factor for both effectiveness and reliability of ecosystem service provision (*Vos et al., 2014*).

ESS restoration measures Natura 2000	carbon storage / capture	temp/ drought reduction	reducing risks sea level rise and extreme weather events (fire, floods, erosion)	water retention/ purification	recreation value
reduction of pressures					
improving hydrological conditions	+	no info	no info	-	-
reduction of acidification / eutrophication	+ and -	+	+	+	+
ensure good abiotic conditions	~~ reducing existing pressures				
manage extreme events	~~ reducing risks				
increase size	+ and -	+	+	+	+
create buffer zones	+	no info	+	+	+ and -

Table III.3
The impact habitat management and habitat restoration measures, and the various climate services that the Natura 2000 site can provide. + positive impact, - negative impact (*Bouwman et al., 2012*)

» The location where measures are taken: e.g. the bufferstrips on fields should be located where influx of pollution is likely, and measures that increase water retention are effective upstream to prevent floods downstream. For some ecosystem services it is crucial to take measures where the demand is, and that is often not in or near protected nature areas, but in agricultural (pollination, natural pest regulation, water purification) or urban areas (leisure, air quality) (*Verhagen, 2019*).

III.5 Ecosystem services and network coherence

Associated ecosystem services with landscape connectivity restoration measures
Based on measures for defragmentation and development of Green Infrastructure, the provision of ecosystem services may change. Selected ecosystem services for this assessment are related to Provisioning services, Regulating and Maintenance services, and Cultural services. Although this selection might be challenged to be subjective, the selected services are relevant in the wider European context and commonly used in other studies, and selected services may change as a result of landscape changes or measures for GI (*Bürgi et al. 2015*; *Vallés-Planells et al. 2014*). To estimate how the service provision changes as a result of measures to improve connectivity through GI, a semi-quantitative approach has been used (Table III.4) (*Van der Sluis & Bouwma, 2019*).

The results are related to the examples of habitat restoration and restoring connectivity as described in the chapter B.II Green Infrastructure.

Service Provision	Example study					
	Boreal Baltic Meadows (H1630)	Alpine Rivers (H3230)	Eurasian lynx	Stag beetle	Sturgeon	Large copper
Cultivated crops (CC)	○	○	-	○	○	○
Reared Animals (LSU)	++	+	-	○	○	○
Wild animals and their output (WI)	+	○	-	○	++	+
Materials from timber (MT)	○	○	++	-	○	○
Plant-based resources (PR)	++	○	+	○	○	++
Erosion protection (EP)	++	++	+	○	++	○
Climate regulation (CR)	+	○	++	++	○	++
Flood Protection (FP)	++	++	+	○	++	++
Pollination and seed dispersal	++	+	+	+	+	+
Maintenance of Nursery Populations and Habitats (NS)	++	++	++	++	++	++
Outdoor Recreation (RC)	+	++	++	+	++	++
Residential (RE)	+	○	○	○	○	○
Inspiration (IN)	++	++	++	++	++	+

Table III.4
Quantitative assessment of change in landscape service provision in study areas: + increase, ++ : strong increase, - decrease, -- strong decrease, ○ negligible. The cases are described in Chapter B.II and *Van der Sluis & Bouwma (2019)*

III.6 Key findings and recommendations

Co-benefits of measures to consolidate the Natura 2000 network are interwoven with all themes covered in this E-BIND handbook. Whether it is the use of remote sensing, (advantages of) habitat restoration or Green Infrastructure, it all is related to benefits of proper management of resources, proper management planning, 'keeping stock' of resources and development of species and habitats.

Ecosystem services are a fast developing field. However, the applicability of ecosystem services is not always straight-forward, and frequently it is rather theoretical in nature, of little use at site level.

However, ecosystem services can be important because they can be quantified and used for planning. A good selection of indicators can be a good proxy for ecosystem functioning. It is important though to make sure that a wider range of indicators is used, here

Figure III.7
Agricultural crops are important provisioning services.
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the hierarchical structure of CICES can be used to aggregate ecosystem services to a higher level for which suitable indicators may be available.

Ecosystem services also have shortcomings: economists tend to approach everything in monetary terms, and particular services are not easily assessed in this way (e.g. cultural heritage, landscape value), these might easily be missed in assessments. Moreover, in cultivated areas or well-studied regions one might easily quantify outputs of the system, whether it is crops, timber or water. However, it will become much more complex to attach such figures to e.g. natural maquis in Southern Europe, or to arctic tundra. Over time, more data will become available, and more tools will be developed to fill such gaps in knowledge.

With IPBES' 'nature's benefits to people' have been properly founded in international conservation planning, which are extremely important now for international discussions and negotiations e.g. at the CBD. Ecosystem services will therefore remain in site management and conservation planning. Ecosystem services are important for communication: with the 'public', site users, communication with politicians, or with decision makers. Ecosystem services and 'co-benefits of nature for society' can be used to justify the investment of capital and other resources. As such, it can support the site managers.

This chapter has provided a number of practical examples, such as co-benefits of habitat restoration, Table III.4 and Annex I.

III.7 Further sources of information

Eurosite has formed the 'Eurosite economics and Ecosystem Services Working Group'. They have produced a brochure with an introduction to ecosystem services for site managers, which can be found at the following site:
www.eurosite.org/wp-content/uploads/ESS-brochure-v06-WEB-1.pdf

MEDWET, the Mediterranean Wetlands Initiative has a Specialist Group on ecosystems services (**MedWet/STN/Ecosystem services-SG**). This specialist group has produced a short brochure on the services of Mediterranean wetlands which can be found at:
medwet.org/publications/the-ecosystem-services-of-mediterranean-wetlands-medwet-stn/

WEBINARS on Ecosystem Services can be found at:
Optimizing Restoration Activities for Ecosystem Services: The Restoration Opportunities Optimization Tool (ROOT) is at: vimeo.com/261376393

Ask **OPPLA** is a crowd-sourced enquiry service. It's designed to help you find the information you need about nature-based solutions. oppla.eu/ask-oppla

In the wealth of existing publications, a good basis for any work on ecosystem services form the reports from J. Maes, e.g. *Maes et al. (2013, 2014, 2018)* and *Burkhard & Maes, 2017*.

Best practices/websites:

country	measure	link
global	international platform on biodiversity and ecosystem services	www.ipbes.net
global	natural climate solutions	nature4climate.org
global	partnership on ecosystem services	es-partnership.org
the Netherlands	building with nature solutions	www.ecoshape.org/en
Portugal	LIFE project Pronatur	www.nortenatur.cimaa.pt
UK, the Netherlands, Belgium	INTERREG project building with nature	northsearegion.eu/building-with-nature
the Netherlands	maps of ecosystem service providing areas	www.atlasnatuurlijkkapitaal.nl
Europe	knowledge platform on ecosystem services and natural capital, developed by the EU project openness	oppla.eu/ask-oppla www.openness-project.eu
Europe	topic ecosystem services on BISE platform (biodiversity information system for Europe)	biodiversity.europa.eu/topics/ecosystem-services
the Netherlands	knowledge network for restoration and management of nature in the netherlands	www.natuurkennis.nl/english
UK	restoration of Fen habitats	www.greatfen.org.uk/restoration/habitats

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Annex 1: Overview of the expected effects of 38 floodplain interventions on the supply of 21 different ecosystem services

(derived from the paper from: *Schindler et al., 2016*)

Type of intervention	Intervention	Terrestrial plants and animals for food	Freshwater plants and animals for food	Water for human consumption	Water for agriculcural use	Water for industrial and energy use	Biotic materials	Biomass based energy	Bioremediation	Dilution and sequestration	Air flow regulation	Water flwo regulation	Mass flow regulation	Atmospheric regulation	Water quality regulation	Pedogenesis and soil quality regulation	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control (incl. invasive alien species)	Aestetic, heritage	Spiritual	Recreation and community activities	Information and knowledge
1	Surface water extraction	↘↗	↘	↘↗	↘↗	↘↗	↘	↘↗	↘	↘	0	↘↗	↘	↘	↘	↘	↘	↘↗	↘	↘	↘	↘↗
1	Groundwater extraction	↘↗	↘	↘↗	↘↗	↘↗	↘	↘↗	↘	↘	0	↘	0	↘	0	↘	↘	0	0	0	0	0
1	Mineral resource extraction	↘	↘↗	↘	↘↗	0	↘	↘	↘	↘	0	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘↗	↘↗
2	Settlement and traffic infrastructure	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	0	↘	↘	↘	↘	↘	↘	↘	↘	↘
2	Energy conversion	↘	↘	↘	↗	↗	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘↗	↘↗
2	Navigational infrastructure	↘	↘	↘	↘	↘	↘	0	↘	↘	0	↘	↘	0	↘	↘	↘	↘	↘	↘	↘↗	↘
3	Forestry intensive	↘	↘	↘	↘	↘	↘↗	↗	↘	↘	0	↘	↘	↘↗	↘	↘	↘	↘	↘	↘	↘	↘
3	Agriculture intensive	↗	↘	↘	↘	↘	↘↗	↗	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘
3	Fishery intensive	↘	↘↗	↘	0	0	↘	0	0	0	0	↘	↘	0	↘	0	↘	↘	↘	↘	↘	↘
4	Forestry extensive	0	0	0	0	0	↗	↗	0	0	0	0	0	0	0	0	↘	0	0	↘	↗	↘↗
4	Agriculture extensive	↗	0	↘	0	0	↗	0	0	0	0	0	0	0	0	0	↘↗	↘	↘↗	↘	↗	0
4	Fishery extensive	0	↗	0	0	0	0	0	0	0	0	0	0	0	0	0	↗	0	↗	↗	↗	↗
4	Hunting	↗	0	0	0	0	↗	0	0	0	0	0	0	0	0	0	↘	↘↗	0	↘	↘↗	0
5	Channel correction	↘↗	↘	↘	↘	↘	↘↗	↗	↘	↘	0	↘	↘	↘	↘	↘↗	↘	↘	↘	↘	↘↗	↘
5	Dike construction	↗	↘	↘	0	↗	↗	↗	↘	↘	0	↘↗	↘	↘	↘	↘	↘	↘	↘	↘	↗	↘↗
5	Band/bed stabilization	↗	↘	↘↗	↘↗	↘↗	↘↗	↗	↘	↘	0	↘	↘	↘	↘	↘↗	↘	↘	↘	↘	↘↗	↘
5	Sediment removal/dredging	0	↘	↘	↘	↘	0	0	0	↘↗	0	↘	↘	↘	↘↗	0	↘	0	0	↘	↘↗	0

Table III.5

The judgements are based on expert opinion. "0": no effect; "↘": reducing effect; "↗": supporting effect; "↘↗": ambiguous effect, i.e. reducing or supporting depending on the environmental conditions. (*Schindler et al., 2014*)

Type of intervention	Intervention	Terrestrial plants and animals for food	Freshwater plants and animals for food	Water for human consumption	Water for agriculcural use	Water for industrial and energy use	Biotic materials	Biomass based energy	Bioremediation	Dilution and sequestration	Air flow regulation	Water flwo regulation	Mass flow regulation	Atmospheric regulation	Water quality regulation	Pedogenesis and soil quality regulation	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control (incl. invasive alien species)	Aestetic, heritage	Spiritual	Recreation and community activities	Information and knowledge
5	Detention basins	↘	↘	0	0	0	↘	↘	↘	↘	0	↘↗	↘	↗	↘	↘	↘	↘	↘↗	↘	↘↗	↘↗
5	Controlled retention areas	↘	↘	↘	↘	↘	↘	0	↘	↘	0	↗	0	0	↘	↘	↘	↘	↘	↘	↘	0
6	Dike relocation	↘↗	↗	↗	↗	↗	↘↗	↘	↗	↗	0	↗	↗	↗	↗	↗	↗	↘↗	↗	↗	↘↗	↗
6	Ecologically improved groynes	0	↗	0	0	0	0	0	0	0	0	0	0	0	0	0	↗	0	0	0	↘	0
6	Lowering floodplain/foreland	↘↗	↗	↗	↗	↗	↘↗	↘↗	↘↗	↗	0	↗	↗	↗	↗	↘↗	↘↗	↘↗	↘↗	↘↗	↘↗	↘↗
6	Sediment addition into riverbed	0	↗	↗	↗	↗	↗	↗	↗	↗	0	↗	↗	↗	↗	↗	↗	0	↗	↗	↘↗	↗
6	Removing obstacles	0	↗	0	0	0	↗	0	↗	0	0	↗	↗	0	↗	↗	↗	0	↗	↗	↘	0
7	Removal of bank fixations	↘	↗	↗	↗	↗	↘↗	↘	↗	↗	0	↗	↗	0	↗	↘↗	↗	↘↗	↗	↗	↘↗	↗
7	Removal of dams and weirs	0	↗	0	0	0	0	0	↗	0	0	0	↗	0	↗	0	↗	↘↗	↘↗	↗	↘↗	0
7	Lateral floodplain reconnection	0	↗	↗	↗	↗	↘↗	↘	↗	↗	0	↗	↗	↗	↗	↘↗	↗	↗	↗	↗	↘	↗
7	Channel, oxbow and pond creation	↘	↗	↗	↗	↗	↘↗	↘	↗	↗	0	↗	↗	↗	↗	↗	↗	↘	↗	↗	↗	↗
7	Construction of fish passages	0	↗	0	0	0	↗	0	0	0	0	0	0	0	0	0	↗	↘	0	0	↗	0
8	Creating natural habitat from forest	↗	↗	↗	↗	↗	↘↗	↘	↗	↘↗	0	↗	↗	0	↗	↗	↗	↗	↗	↗	↘↗	↗
8	Creating natural habitat from agro land	↘	↗	↗	↗	↗	↘↗	↘	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↘↗	↗
8	Creating nat. habitat from extraction sites	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↘↗	↗
8	Control of invasive alien species	↗	↗	↘	0	0	↘↗	↘↗	↗	↘↗	0	↗	↗	0	0	↗	↗	↗	↗	↗	↗	↗
8	Creation of gravel banks	0	↗	0	0	0	0	0	↗	0	0	0	↗	0	0	↗	↗	↗	0	↗	↗	↗
8	Elimination of top soil	↘	0	↘	0	0	↘	↘	↘	↘	0	↗	↗	↘	↗	↘↗	↗	↘↗	↘	0	0	↘↗
8	Land use extensification	↘	↘↗	↗	0	0	↘↗	↘	↗	↗	0	0	↘	↗	↗	↗	↗	↗	↗	0	↗	↗
9	Recreational infrastructure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	↘	↘	↘↗	↘	↗	↗
9	Recreational use of the floodplain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	↘	0	0	0	↗	0