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PART 1/3

COMMISSION STAFF WORKING DOCUMENT

EU guidance on integrating ecosystems and their services into decision-making

EU GUIDANCE ON INTEGRATING ECOSYSTEMS AND THEIR SERVICES INTO DECISION-MAKING

By 2050, EU biodiversity and the ecosystem services it provides — its natural capital — are protected, valued and appropriately restored for biodiversity’s intrinsic value and for their essential contribution to human well-being and economic prosperity, and so that catastrophic changes caused by the loss of biodiversity are avoided.

EU 2050 biodiversity vision¹ endorsed by the EU Heads of States in 2010

Our quality of life and economic activities depend greatly on ecosystems and the benefits and services they provide. Through the flow of ecosystem services, nature can offer smart, cost-effective and integrated long-term solutions to numerous societal challenges, such as climate change, disaster-risk and pollution. Ecosystem services also contribute to human health and well-being.

However, ecosystem services and their dependency on biologically diverse, functional ecosystems, are often poorly understood. There is great potential for businesses and policy-makers to better integrate ecosystems and their services into their decisions. This can create social and economic co-benefits from the protection, restoration and sustainable management of ecosystems. These co-benefits might also be seen in sectors where nature protection is not usually among the primary considerations.

This guidance document aims to help decision-makers who are seeking to improve the impact, cost-effectiveness and sustainability of their policies, plans and investments. It does this by (i) highlighting the benefits that flow from nature to people and the need to protect and enhance the ecosystems that deliver these benefits, and (ii) providing an overview of the steps and available tools to assess and integrate these benefits into policy and planning decisions. The guidance is applicable to all ecosystems across EU landscapes and the marine environment (including artificial and semi-natural habitats that result from interactions with human activities, such as urban or agricultural ecosystems).

This guidance draws on key EU policy frameworks, and promotes the integration of ecosystems and their services into decision-making in sector policies and instruments having a connection or dependence with the environment. It is based on the EU biodiversity strategy to 2020², and also implements action 1b of the EU action plan for nature, people and the economy³.

The guidance is addressed to a range of EU, national and local decision-makers in different sectors. It is also addressed to planners and businesses who may have varying levels of experience in assessing and integrating ecosystem services in policy and planning. It therefore outlines basic concepts, principles and a generic, cross-cutting framework for approaching ecosystem services in the common stages of a decision-making process. Within each decision-making stage, readers can find an overview of (i) entry points and steps for integrating ecosystems and their services, (ii) reflections on aspects that need special attention, and (iii) references to tools and resources and to case studies that illustrate the use of these tools and resources.

1 [Options for an EU vision and target for biodiversity beyond 2010 \(COM/2010/4 final\)](#)

2 [Our life insurance, our natural capital: an EU Biodiversity Strategy to 2020 \(COM\(2011\) 244\)](#)

3 [An Action Plan for nature, people and the economy \(COM\(2017\) 198 final](#) and [SWD\(2017\) 139 final](#))

Due to its broad scope across a wide range of decision-making processes and target groups, the guidance provided in this document remains at a relatively general level. This is also a static document in a field of constantly developing research and practice. In the course of 2019 and 2020, this document will be followed up with online resources and tailored training to support specific groups of users in specific decision-making processes⁴.

A BRIEF OUTLINE OF THIS GUIDANCE DOCUMENT

PART 1: MAIN GUIDANCE DOCUMENT

- **Chapter 1** introduces the basic concepts and the rationale for ‘mainstreaming’ - in other words, taking into consideration the impacts of policy and planning decisions on ecosystems and their services.
- **Chapter 2** contains guiding principles for the successful integration of ecosystems and their services into decision-making.
- **Chapter 3** outlines the main entry points for integrating assessments of ecosystems and their services into a generic decision-making cycle. It also outlines a range of instruments available to support this integration (detailed further in Section A). It offers reflections on the different approaches to assessing ecosystems and their services.

PART 2: ECOSYSTEM SERVICES IN DIFFERENT POLICY AND PLANNING CONTEXTS

- **Chapter 4** elaborates on the integration of ecosystems and their services in the context of specific EU policy areas.
- **Chapter 5** highlights the ecosystem approach in land-based and marine spatial planning.
- **Chapter 6** offers insights for businesses willing to take into consideration their impacts and dependencies on natural capital.
- **References**
- **Glossary**

PART 3: FURTHER RESOURCES - ANNEXES

- **Section A** provides an overview of instruments and resources for the integration of ecosystem services into different stages of the decision-making cycle.
- **Section B** presents indicative tables of the ecosystem services provided by the main ecosystem types as per the EU MAES methodology (mapping and assessment of ecosystems and their services).
- **Section C** contains case studies illustrating practical integration in different contexts.
- **Section D** offers examples of the socioeconomic benefits that can result from protecting and restoring ecosystems and their services.

⁴ This will be announced via http://ec.europa.eu/environment/nature/ecosystems/index_en.htm.

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1. WHY INTEGRATE ECOSYSTEMS AND THEIR SERVICES INTO DECISION-MAKING?

1.1. Our society depends on ecosystem services

Our existence and socioeconomic model are strongly embedded in nature. Ecosystems create a flow of benefits to people called *ecosystem services*. Technical as this term may sound, it describes our critical dependence on nature for our basic needs, well-being and prosperity.

Natural processes in marine, freshwater and terrestrial ecosystems ensure a constant supply of oxygen, clean water, food, medicines and materials. These processes regulate the climate; break down and recycle organic waste; remove pollutants and sequester carbon from the atmosphere.

In cities, green areas of sufficient size and quality can reduce air pollution, noise and the impacts of extreme weather such as heat, drought and floods. These green spaces can also increase the attractiveness of residential areas. Access to nature encourages physical activity and a sense of well-being. It is linked to lower obesity rates, improved physical and mental health, and better concentration.

Natural habitats also maintain a rich genetic pool: they are a valuable resource for the bio-economy, green business, research and innovation. They are also our greatest resource for containing and adapting to global changes and risks, and they underpin society's potential for sustainable socioeconomic development.

Nature provides these and many more benefits without charge, yet they translate into very significant flows into society and the economy. For example, in Europe and central Asia the median value of natural ecosystems' contributions to the regulation of freshwater quality is estimated at EUR 1 685/ha/year. The value of their contributions to habitat maintenance is estimated at EUR 670/ha/year, and the value of their contributions to climate regulation is estimated at EUR 405/ha/year. Finally, the value of their contributions to air quality regulation is estimated at EUR 250/ha/year⁵. The benefits of land restoration (in increased employment, business spending, local investment in education and improved livelihoods) are on average 10 times higher than the costs, estimated across nine different biomes⁶. The figures above (as well as further examples in Section D) illustrate the socioeconomic advantages of maintaining and restoring ecosystems for the wide range of services they provide.

However, most of this value is not properly accounted for in market transactions or in policy, planning and investment decisions. This can result in missed opportunities for cost-effective nature-based solutions. It can also result in costs and risks to society and the economy due to the erosion of natural capital.

⁵ See IPBES (2018): [Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services](#).

⁶ See IPBES (2018). [Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services](#).

The conceptual framework of the EU initiative on the mapping and assessment of ecosystems and their services (MAES)⁷ (Figure 1, below) illustrates the links between natural ecosystems and socioeconomic systems through the flow of ecosystem services. Biodiversity plays a key role in the structure of ecosystems, and is essential to maintaining ecosystem processes and functions. These processes and functions in turn result in a flow of benefits to human socioeconomic systems. At the same time, ecological processes and functions are influenced by human drivers that may have a positive or negative impact on the delivery of services.

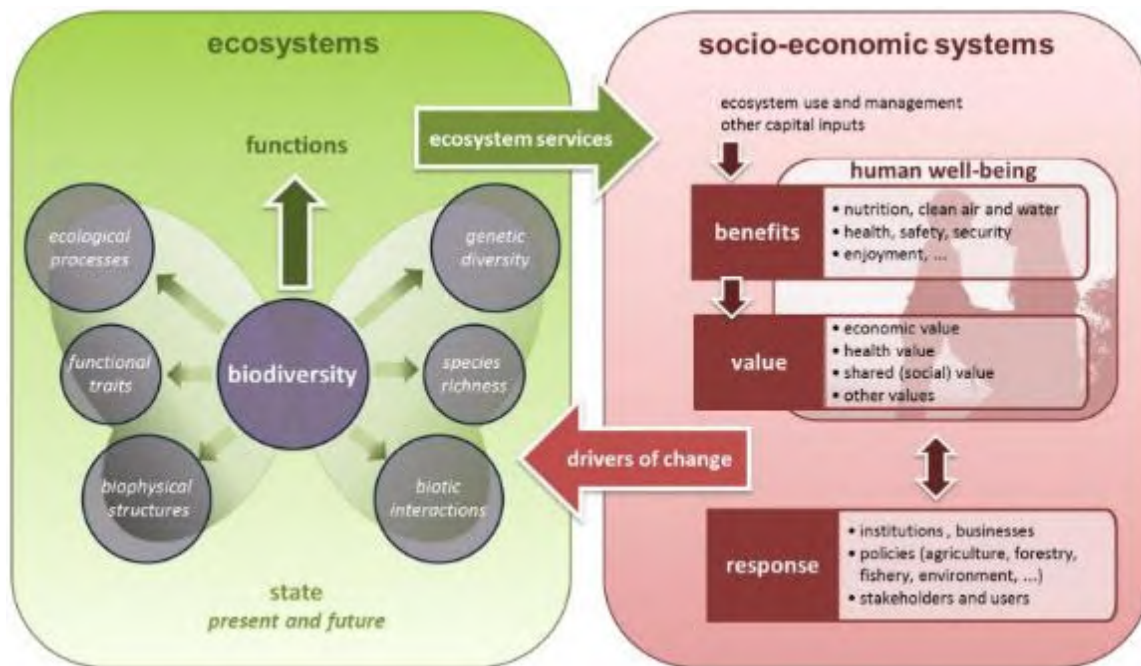


Figure 1. Conceptual framework for EU-wide ecosystem assessments (Source: MAES 2013)

Drawing on the Common International Classification of Ecosystem Services (CICES)⁸, MAES classifies ecosystem services into three main categories:

- **provisioning** (the production of tangible outputs such as crops, fish, wild plants and animals, timber, water or materials);
- **regulating and maintenance** (services that maintain the environment, such as the decomposition of organic waste, pollution removal, water-cycle regulation, pollination or soil formation); and
- **cultural** (the non-material benefits people obtain from ecosystems, such as symbolic, spiritual, or intellectual benefits, or recreation experiences from interaction with nature).

⁷ See [An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020 \(Discussion paper – Final, April 2013\)](#)

⁸ Common International Classification of Ecosystem Services ([CICES version 5.1](#) updated in 2018)

1.2. Ecosystem services can be a part of cost-effective solutions

The functions of biologically diverse, healthy ecosystems can translate into a wide range of services and benefits flowing to different stakeholders. Such bundles of benefits can offer integrated solutions to a number of challenges simultaneously, and in a cost-effective way.

This multifunctional character of natural ecosystems is at the core of **nature-based solutions** and **green infrastructure**.

Nature-based solutions are actions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions⁹. They protect, sustainably manage and restore natural or modified ecosystems in order to address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits¹⁰. Nature-based solutions can include, for example, nutrient pollution reduction by means of conservation and restoration of wetlands, or carbon sequestration and storage by peatlands or forests.

Nature-based solutions can contribute to [green infrastructure](#): a strategically planned network of natural and semi-natural areas, designed and managed to deliver a wide range of ecosystem services. The EU network of protected areas, [Natura 2000](#), is at the core of the EU's green infrastructure¹¹. Biodiversity is an essential component of green and blue infrastructure. The EU guidance on strategic EU-level green and blue infrastructure¹² defines criteria to prioritise investments in green infrastructure projects. That guidance document also provides an overview of opportunities for technical and financial support to deploy strategic green and blue infrastructure projects.

1.3. The flow of multiple ecosystem services depends on the condition of ecosystems

There is mounting evidence that the capacity of ecosystems to provide a wide range of ecosystem services depends on their structural and functional integrity, i.e. on ecosystem condition. Evidence also shows that biologically diverse, multifunctional ecosystems typically provide a wide range of ecosystem services simultaneously. Ecosystems that are degraded, heavily modified or intensively managed to maximise the delivery of a few priority services (or just one priority service) typically support lower biodiversity, and the ecological processes within these ecosystems may be impaired. As a result, their capacity to deliver multiple services can be severely reduced. The capacity to derive those maximised ecosystem services can also be impaired in the long run.

⁹ European Commission DG RTD. [Nature-Based Solutions: how we can use nature's own resources to tackle environmental challenges](#).

¹⁰ [UN definition of Nature-Based Solutions](#)

¹¹ http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

¹² Guidance on a strategic framework for further supporting the deployment of EU-level green and blue infrastructure (SWD (2019)193 final) and supporting methodological guidance document: [Strategic Green Infrastructure and Ecosystem Restoration: geospatial methods, data and tools](#).

Good ecosystem condition is particularly strongly linked to the delivery of **regulating services**. It is also linked to the delivery of provisioning and cultural ecosystem services **under moderate use intensity**¹³. For example, biologically diverse agricultural ecosystems in good condition can deliver the provisioning services of food and other agricultural materials in a sustainable manner. They can also deliver a range of regulating and maintaining services some of which are essential for agricultural production, such as pollination; soil formation; natural pest control; climate, nutrient and water-cycle regulation; and carbon storage in soil and biomass. Finally, they can deliver cultural services from traditional rural landscapes and habitats for biodiversity.

Conversely, severe ecosystem modification to maximise a single service (e.g. crops or timber provision in intensively managed monocultures) can impair these ecosystems' capacity to deliver a range of other services. This can have negative impacts on certain stakeholder groups in the area (e.g. through the loss of recreation opportunities). It can also have negative impacts in adjacent or further areas (e.g. through impaired water-regulation services) and on future generations (e.g. through weakening ecosystem resilience to climate change or reducing genetic diversity). In the examples above, intensive management practices can even gradually compromise the single objective that was originally prioritised. This can occur if ecosystem services that underpin productivity, such as soil fertility or pollination, are degraded. In such cases, maintaining the same level of production may require greater inputs of energy, water and chemicals. Conversely, measures to improve the condition of these ecosystems can help to restore their natural productivity over time, breaking the vicious circle and bringing additional co-benefits for the entire area.

1.4. Ecosystem resilience underpins societal resilience

In addition to securing a wider range of ecosystem services, biologically diverse ecosystems in good condition are also more resilient, i.e. they are better able to survive further pressures and recover from disturbances. This is important for securing essential services in the face of global environmental change. It is also critical for avoiding tipping points — where systems shift radically and potentially irreversibly into a different state — at the local, regional and possibly the global level.

This inter-dependency, and the way economies and societies are embedded in the biosphere, is illustrated in Figure 2, below (the example was created by the Stockholm Resilience Centre). As the figure shows, the sustainable development goals (SDGs) related to natural capital, including living ecosystems, are the basis for achieving all other social and economic goals.

¹³ [Millennium Ecosystem Assessment](#) (MA 2005)



Figure 2. How sustainable and healthy food connects all SDGs (Stockholm Resilience Centre 2016)¹⁴

However, nature is declining globally at rates unprecedented in human history — and the rate of species extinctions is accelerating, with likely grave impacts on people around the world. This is confirmed by the Global assessment of Biodiversity and Ecosystem Services (May 2019) by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)¹⁵. The IPBES Report presents an illustrative list of possible actions to support sustainability and pathways for achieving them across locations, systems and scales. The report notes that “land degradation has reduced the productivity of 23% of the global land surface, half a billion Euro worth in annual global crops are at risk from pollinator loss, and 100-300 million people are at increased risk of floods and hurricanes because of loss of coastal habitats and protection”. Furthermore, in 2015, 33% of global marine fish stocks were being harvested at unsustainable levels; 60% were fished at maximum sustainable yield (MSY), and 7% were harvested at levels lower than what can be sustainably fished¹⁶. There are significant regional differences: e.g. in the EU northern seas, overfishing has decreased to 41% of assessed stocks, and some stocks are recovering; while in the Mediterranean, only 9 % of fish stocks assessed are fished at levels below MSY.

According to the IPBES [Regional Assessment of Biodiversity and Ecosystem Services for Europe and Central Asia](#) (2018), the majority of regulating ecosystem services in Europe and central Asia deteriorated between 1960 and 2016. Ecosystems and biodiversity across the world are being degraded through intensive land-use practices, pollution, overexploitation, invasive alien species and climate change. Ecosystem services that are essential for human life — such as pollination, soil formation and water regulation — are under threat. Scientists warn that

14 Stockholm Resilience Centre, 2016. [How food connects all the SDGs](#)

15 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [Global assessment of biodiversity and ecosystem services \(2019\). Summary for policy makers.](#)

16 FAO (2018). [The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals.](#)

moving past planetary boundaries is putting humanity at the risk of large-scale abrupt or irreversible environmental change¹⁷. The World Forum on Natural Capital makes a parallel between financial and natural capital, noting that ‘if we keep drawing down stocks of natural capital without allowing or encouraging nature to recover, we run the risk of local, regional or even global ecosystem collapse [...] potentially leading to starvation, conflict over resource scarcity and displacement of populations’. The World Economic Forum's Global Risks Report 2019 warns that “of all risks, it is in relation to the environment that the world is most clearly sleepwalking into catastrophe.” It rates major biodiversity loss and ecosystem collapse amongst the 10 highest global risks both in terms of likelihood and risk of impact¹⁸.

It is therefore also important to ensure that ecosystems are resilient and can continue providing their services. This will avert risks for society and the economy.

1.5. The visibility of ecosystem services

Some ecosystem services are **visible** and **tangible**, and their benefits are widely recognised. Examples of these include crop production from agro-ecosystems, timber from forests, fisheries and aquaculture in marine and freshwater ecosystems, or recreation in coastal areas, forests or urban parks. Such benefits are usually **prioritised** in policy decisions. The economic value of these ecosystem services is at least partly reflected in markets and investment choices; yet, they are often overused. Provision of these ecosystem services is often **maximised** through management measures.

Other ecosystem services, in particular regulating ecosystem services, are **increasingly recognised but insufficiently ‘mainstreamed’** in decision-making. The potential of wetlands and floodplains to improve flood protection and groundwater recharge as part of sustainable green infrastructure solutions is much higher than is currently recognised. Sometimes, the long-term benefits of such services may be de-prioritised in favour of short-term needs and objectives. For example, carbon sequestration by healthy soils and peat ecosystems¹⁹ is a powerful mechanism to complement efforts to curb CO₂ emissions, yet soils and peat bogs continue to be degraded by human activities. Another example is access to nature, which is crucial for human wellbeing, mental health and the cognitive development of children²⁰. However, few cities have prioritised access to nature as a central objective of urban planning. The EU green infrastructure strategy²¹ promotes measures that increase the provision of ecosystem services. Similarly, the importance of pollination for the production of nutritious and varied food is well-known, but effective measures to address the key drivers of pollinator decline have not yet been systematically implemented. The EU pollinators initiative²² aims to improve understanding of these drivers and encourage coordinated and targeted action to address them.

Governments, land managers or communities can derive major benefits from recognising and improving the delivery of less visible, yet critically important, ecosystem services. Companies can improve their performance and strengthen their position by making the connection between

17 See Stockholm Resilience Centre: [the nine planetary boundaries](#).

18 [The Global Risks Report 2019](#). WEF.

19 Deltares (2018) [MAES Soil ecosystems](#). A report for the European Commission.

20 IEEP (2016) [The Health and Social Benefits of Nature and Biodiversity Protection](#). A report for the European Commission.

21 [Communication from the Commission: Green Infrastructure \(COM\(2013\) 249 final\)](#)

22 [EU Pollinators Initiative \(COM/2018/395 final\)](#) and [SWD/2018/302 final/2\)](#)

the health of ecosystems and the bottom line of their business. Understanding and valuing the range of ‘less visible’ ecosystem services, and reflecting this understanding in well-informed management decisions and long-term objectives is crucial for human well-being. It is also crucial for public budgets and sustainable development.

1.6. Objectives of this guidance document

This guidance document aims to encourage and enable policy-makers, planners and developers to systematically recognise and take the range of ecosystems and their services into account. Our hope is that this will improve the impact and sustainability of their policies, planning and investment decisions. The concrete objectives of the guidance are set out below.

- **To raise awareness of nature’s** contributions to well-being and the economy, and its potential to provide solutions to many societal challenges. In so doing, to make the case for protecting and improving biodiversity for a range of stakeholders.
- **To encourage decision-makers to prioritise solutions provided by nature** by raising awareness of the synergies between improved ecosystem condition and the achievement of socioeconomic objectives.
- **To support decision-makers working with nature.** This can be achieved by explaining the different steps for integrating ecosystems and the services they deliver in policy and decision-making. Decision-makers are also supported by the available tools and approaches which are highlighted to assist them in making these decisions.
- **To promote long-term, holistic approaches,** accountability and stakeholder engagement in decisions that impact ecosystems and their services. Such approaches can encourage fairness in dealing with trade-offs and in addressing the costs and benefits borne by different stakeholders from decisions that affect ecosystems and their services. These approaches will also be essential for increasing ecosystem resilience and slowing down the degradation of ecosystem services under climate change.

The knowledge base on ecosystems and their services is rapidly developing at the global level, in the EU and in its Member States. There is also rapid development in the level of interest and experience in ‘mainstreaming’ ecosystems into decision-making. This guidance document draws on this knowledge base and highlights guiding principles, approaches, tools, and good practice. It cannot and does not aim to provide a model that can be followed in all situations, but rather to offer an overview of concepts and practical examples. The aim is to inspire decision-makers to use the existing knowledge and adapt it to their specific policy and planning context, and to engage in a constant learning process.

This guidance document will be followed up in 2019-2020 with online interactive guidance containing (i) new and updated tools, (ii) links to resources and best-practice examples in concrete decision-making processes, and (iii) targeted training.

2. GUIDING PRINCIPLES

There is a range of principles, safeguards and good-practice guidelines for improving the quality of ecosystem-related decision-making. At the international level, these include the Convention on Biological Diversity's (CBD) 12 principles of the ecosystem-based approach²³ and the CBD principles for building resilience and enhancing adaptive capacity through the ecosystem-based approach and ecosystem-based disaster-risk reduction²⁴.

At the EU level, the Treaty on the Functioning of the European Union (TFEU) stipulates that environmental protection requirements must be integrated into the design and implementation of the EU's policies and activities (the so-called environmental policy integration principle, TFEU, Article 11). It states that EU policy on the environment should be based on (i) the precautionary principle, (ii) the principle that environmental damage should, as a priority, be rectified at source, and (iii) the principle that the polluter should pay (TFEU Article 191). The environmental policy integration principle is strongly emphasised and partly implemented in a range of EU instruments and sectoral EU policies.

These principles are applied in EU environmental legislation including the EU Directives on Environmental Impact Assessment²⁵ and on Strategic Environmental Assessment²⁶; the Birds²⁷ and Habitats²⁸ Directives; the Water Framework Directive²⁹; and the Marine Strategy Framework Directive³⁰. This guidance document aims to support and complement these legal requirements without altering them in any way.

Furthermore, Action 7b of the EU biodiversity strategy to 2020 is to ensure no net loss (NNL) of ecosystems and their services. In support of this action, a working group set up by the Commission put forward a set of NNL operational principles in 2013³¹. These operational principles cover a range of topics, including operational governance, metrics, and the proper application of the mitigation hierarchy.

This chapter outlines and interprets guiding principles that can support the successful integration of ecosystems and their services into policies and planning decisions. It draws on the above sources. It also draws on discussions with national authorities and stakeholders that took place at Commission expert group meetings dealing with the implementation of the EU's biodiversity policy.

The implementation of these principles is also discussed in Chapter 3.

23 [Convention on Biological Diversity: 12 principles of the ecosystem-based approach](#)

24 [Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction](#)

25 [Directive 2014/52/EU](#) on the assessment of the effects of certain public and private projects on the environment.

26 [Directive 2001/42/EC](#) on the assessment of the effects of certain plans and programmes on the environment.

27 [Directive 2009/147/EC](#) of the European Parliament and of the Council on the conservation of wild birds

28 [Council Directive 92/43/EEC](#) on the conservation of natural habitats and of wild fauna and flora

29 [Directive 2000/60/EC](#) of the European Parliament and of the Council establishing a framework for Community action in the field of water policy

30 [Directive 2008/56/EC](#) of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

31 Final Report of the NNL WG (2013). [Development of operational principles of any proposed EU no net loss initiative.](#)

Box 1. Guiding principles for the integration of ecosystems and their services into decision-making

1. Prioritise measures that improve ecosystem condition while contributing to well-being and prosperity for net societal gain.
2. Address the inter-dependencies and trade-offs.
3. Address potential negative impacts according to the mitigation hierarchy.
4. Apply the precautionary principle.
5. Set long-term objectives and plans for essential ecosystem processes.
6. Ensure adaptive management.
7. Coordinate and integrate planning across governance sectors, levels and decision-making frameworks.
8. Ensure stakeholder engagement.

2.1. Prioritise measures that improve ecosystem condition while contributing to well-being and prosperity for net societal gain

There is usually a range of options available to address a specific societal challenge or achieve a socioeconomic objective.

Options and measures that improve ecosystem condition (e.g. through restoration activities, improved ecological connectivity or the reduction of pressures) should be duly considered and prioritised whenever feasible. Ecosystems in good condition are multifunctional, so measures that improve ecosystem condition can secure a wider range of benefits and bundles of ecosystem services for the sector's own benefit and the benefit of society more broadly. This can create synergies with broader objectives, and potentially mobilise co-investment from other sectors.

Crucially, this approach can enhance overall ecosystem resilience and help society to stay on the safe side of ecological tipping points. With political will and stakeholder support, systematically prioritising such approaches can (i) contribute to halting and reversing the loss of biodiversity and ecosystem services, (ii) deliver well-being and prosperity³², and (iii) drive a powerful positive agenda for sustainable development³³.

2.2. Address the inter-dependencies and trade-offs of biodiversity and ecosystem services

In a landscape subject to multiple pressures and competing land use, it may not always be feasible to choose the management option that yields the best results for nature and the entire range of services to different stakeholders. Measures to increase selected priority services (or bundles of these services) may result in new or increased pressures. They may also result in the alteration of ecosystem structure and functions, to the detriment of other ecosystem services. This can result in trade-offs (i) between benefits and costs borne by different stakeholders, (ii)

32 See [Reflection paper towards a sustainable Europe by 2030](#). European Commission, January 2019.

33 See JRC (2017) [Nature-based solutions for Europe's sustainable development](#)

between private and public benefits for the same area, (iii) between different areas, and (iv) between short-term and long-term benefits and costs for the same community or stakeholder. In such cases, it is important that the range of key provisioning, regulating and cultural ecosystem services is maintained, and that trade-offs are well understood by all parties and handled in a fair and equitable way. It is also important that ecosystems are managed within the safe limits of their resilience, with attention to the entire set of conditions that determine their structure, functioning and productivity³⁴.

2.3. Address the potential negative impacts on ecosystems and their services according to the mitigation hierarchy

Action 7 of the EU biodiversity strategy aims to ensure no net loss of biodiversity and ecosystem services³⁵. This can be achieved by adhering to a mitigation hierarchy to address potential adverse impacts on ecosystems and their services, in the following order of priority.

- **Avoidance:** measures to identify and completely avoid detrimental impacts from the outset, such as careful spatial placement of infrastructure.
- **Minimisation:** measures to reduce the duration, intensity and/or extent of detrimental impacts (including direct, indirect and cumulative impacts) that cannot be completely avoided.
- **Rehabilitation/restoration:** measures to rehabilitate degraded ecosystems or restore cleared ecosystems following impacts that could not be completely avoided and/or minimised.
- **Offsetting:** measures to compensate for residual, significant, adverse impacts that could not be avoided, minimised or restored. Measures to over-compensate for losses can also lead to net societal gains by their contribution to well-being and prosperity.

Actions within the mitigation hierarchy should be selected with careful thought, and in a transparent manner to permit scrutiny by environmental authorities and stakeholders³⁶.

2.4. Apply the precautionary principle

The [precautionary principle](#) set in ³⁷ enables decision-makers to adopt policy measures when scientific evidence about an environmental or human health hazard is uncertain and the stakes are high. The precautionary principle is also visible in the preamble to the CBD, which states that ‘where there is a threat of significant reduction or loss of biological diversity, lack of full

34 Cf. [12 CBD ecosystem approach principles](#) (Principle 5, Principle 6).

35 Note that any potential negative impacts on protected habitats and species in Natura 2000 sites are subject to the rules laid out in Article 6(3) and Article 6(4) of the Habitats Directive.

36 Further guidance on the application of the mitigation hierarchy include the operational principles developed by the working group on NNL and further studies and reports on approaches, metrics and good practice for achieving NNL of biodiversity and ecosystem services, is available on the [DG Environment webpage](#). Some tools that can assist with this are also listed in Chapter 3.

37 Official Journal C 326, 26/10/2012 P. 0001 - 0390

scientific certainty should not be used as a reason for postponing measures to avoid or minimise such a threat’.

The precautionary principle is especially relevant for mitigating potentially grave risks to ecosystems and the services they provide to different stakeholders including vulnerable groups. There are intricate links between environmental pressures, ecosystem structure, ecosystem functions, and the delivery of ecosystem services. Given these intricate links and in some cases, incomplete and uncertain scientific understanding, the precautionary principle can help to prevent the crossing of ecological thresholds, and ecosystem tipping points and, more generally irreversible loss of nature’s contributions to human wellbeing.

2.5. Set long-term objectives and plans for securing essential ecosystem processes

Ecosystem processes are characterised by varying — and sometimes very long — time scales and lag effects that last decades or even centuries. Not only does this inherently conflict with a human tendency to favour short-term gains and immediate benefits over future ones, it is also at odds with management systems, political and policy cycles, and business decisions that tend to operate at much shorter timescales. The complexity of ecosystems can make it difficult to detect and forecast long-term trends³⁸. Soil formation is a well-known example of a critically important long-term process (it takes centuries to produce a layer of just a few centimetres) which is particularly at risk from degradation through intensive management aimed at maximising short- and medium-term gains³⁹. It is important that management systems explicitly draw up and address long-term goals and plans for essential, life-supporting ecological processes.

2.6. Ensure adaptive management

Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices⁴⁰. It allows for actively adjusting objectives and implementation in response to (i) significant changes in context and (ii) developments in knowledge from monitoring the consequences of decisions. Adaptive management provides for continuous learning and adaptation, and it supports evidence-based decision-making. The CBD ecosystem-based approach promotes adaptive management to respond to uncertainties, support learning-by-doing, and ensure that management decisions are based on the best available science.

2.7. Coordinate and integrate planning across governance sectors, levels and decision-making frameworks

Ecosystem-services assessment and good ecosystem management depend on (i) coordination and collaboration across sectors and competent authorities (including sharing of relevant sector-specific information), (ii) ensuring that planning processes are undertaken at the appropriate spatial scales (closer to the ecosystems), and (iii) maintaining interlinkages between

38 [CBD guidelines on the ecosystem approach \(2004\)](#). Principle 8.

39 Commission report on the implementation of the soil thematic strategy and ongoing activities ([COM/2012/046 final](#)).

40 See Glossary of terms (based on the [ESMERALDA glossary for ecosystem-service mapping and assessment terminology](#)).

different governance levels. Integration depends on ensuring the consistency of baseline data used. Integration also depends on the consistency of policy objectives and decision-making processes and frameworks.

2.8. Enable stakeholder engagement

Public participation is at the core of integrating ecosystem services into decision-making. Managing ecosystems for the benefits they provide is a matter of societal choices, and it is crucial that stakeholders are engaged throughout the process. This engagement should start at the earliest stages of problem definition and objective setting, and continue through to the implementation of measures, monitoring and evaluation. Engagement of this sort can help to fill knowledge gaps by providing locally held information (e.g. through participatory mapping) on the supply and demand of ecosystem services, or local input to valuations. When analysing trade-offs, informed stakeholder discussions are an important basis for taking a decision. Support for implementation and trust will also depend on whether stakeholders consider that their interests have been addressed in a balanced and fair way. Enabling stakeholder engagement is a crucial and complex process requiring appropriate attention and expert advice, as well as time and resources. Chapter 3 provides further guidance on this.

3. PROCESSES AND INSTRUMENTS TO SUPPORT DECISION-MAKERS IN INTEGRATING ECOSYSTEMS AND THEIR SERVICES

Many socioeconomic activities have an impact on ecosystems and their services, or depend on ecosystem services to some degree. Integrating ecosystems and their services is thus relevant to a range of decisions at different levels, and in areas as varied as the programming of EU funds, spatial planning, the development of flood protection strategies, or the development of climate adaptation strategies.

Look out!	<p>The integration of ecosystems and their services into decision-making takes place within existing planning frameworks. It is not about creating parallel processes, but rather about complementing these frameworks.</p> <p><i>Ex-ante</i> environmental assessments such as strategic environmental assessment of policies, plans and programmes, or environmental impact assessments of projects) often provide the most suitable frameworks for integration as part of policy formulation, planning or the development of large projects. The Natural Capital Protocol (see Chapter 6) provides a standardised framework to guide the assessment and uptake of the value of ecosystems and their services when making business decisions.</p>
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This chapter provides an overview of decision-making steps and policy instruments for the integration of ecosystems and their services within the main stages of a generic decision-making process (formulation, decision-making, implementation, monitoring, evaluation and review). Figure 3 below presents the main integration steps and possible questions to guide decision-makers. Steps 3.1-3.3 take place in the policy/plan formulation stage and inform all decision-making stages. Step 3.4 supports the integration of ecosystems and their services into

the decision-making stage itself, while Step 3.5 supports implementation, monitoring and review. **Stakeholder consultation is an important element in all stages.**

For a well-planned and effective integration, ecosystems and their services should be put on the agenda from the onset, by clearly stating the intention to consider them in:

- the initial concept, roadmap or consultation strategy, so that stakeholders and administrations are aware that these aspects are to be given consideration;
- technical specifications for technical and scientific support to policy development, planning or project design, so that the necessary expert advice is mobilised and related tasks are planned;
- budgets and timetables, to ensure there is adequate time, financial and human resources for effective integration.

Because of the wide range of potentially relevant decision-making processes, the framework presented here is generic. The integration steps may need to be adapted to apply to specific processes in both higher-level (sectoral) policy-making and concrete decisions on the ground. The choice of tools will depend on many factors such as (i) the process and objectives, (ii) the environmental and socioeconomic context, and (iii) the availability of data or the capacity to carry out additional data collection, research or modelling.

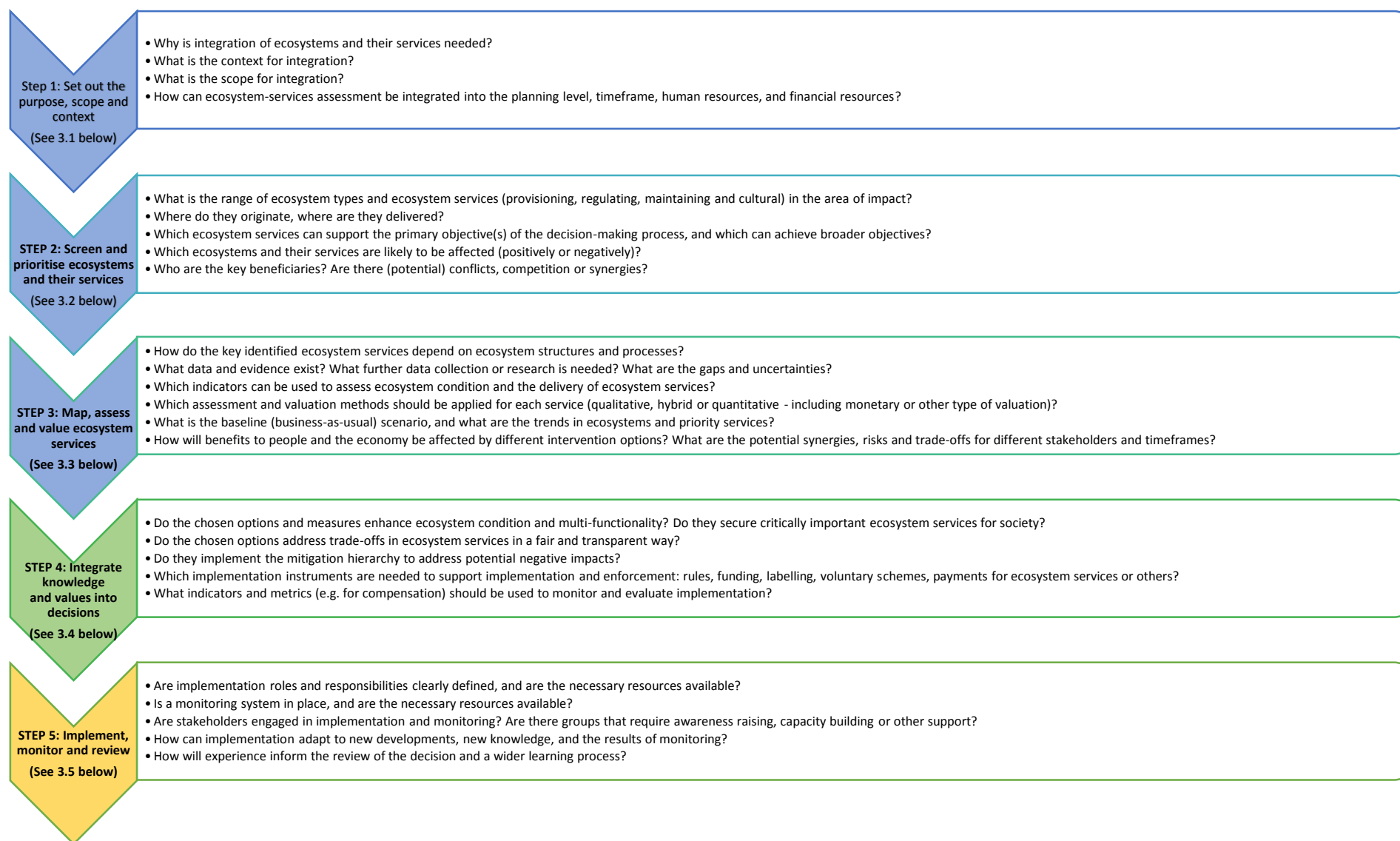
The framework outlined in Figure 3 corresponds well to the common assessment framework for integrated mapping and assessment of ecosystems and their services (MAES) developed in the second MAES report⁴¹ and subsequently refined in a number of practical steps⁴². Both frameworks can be used to integrate ecosystems and their services into decision-making. The MAES framework focuses more on spatially-explicit data of ecosystems and ecosystem services in decision-making, while the current guidance has a broader scope.

Chapters 4-6 highlight opportunities for the integration of ecosystems and their services in concrete policy, planning and business decisions.

41 Maes et al. (2014). [Mapping and Assessment of Ecosystems and their Services. Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020 \(page 22\).](#)

42 Benjamin Burkhard, Fernando Santos-Martin, Stoyan Nedkov, Joachim Maes (2018). [An operational framework for integrated Mapping and Assessment of Ecosystems and their Services \(MAES\).](#)

Figure 3. Main steps for the integration of ecosystems and their services into decision-making, and examples of questions to address in each step



3.1. STEP 1: Set Out The Purpose, Scope and Context of Integration

3.1.1. Setting out the purpose

The first stage of any decision-making process is to set out the issues/challenges that need to be addressed and the objectives of the intervention. The **objectives of integrating ecosystems and their services** should also be established at this stage. In general, forward-looking, sustainable policy and planning processes should seek to improve ecosystem condition. They should also seek to improve biologically diverse, multifunctional ecosystems for their intrinsic value, as well as for their benefits to people and the economy. Therefore, we can say that there are two objectives of policy integration, as set out below.

The first objective is to support the specific intervention objectives and address identified problems, (e.g. by providing **cost-effective nature-based solutions**). Whenever possible, this should seek to contribute simultaneously to (i) conservation, (ii) the preservation of natural capital and ecosystem services, and (iii) the achievement of wider socioeconomic or environmental policy objectives and long-term sustainable development. This should all be accomplished through the increased **delivery of multiple ecosystem services**. (For example, the creation and management of urban green areas of sufficient size and quality can help to address summer heat waves while also (i) supporting urban biodiversity, (ii) improving ecological connectivity, (iii) helping to reduce air pollution and noise, and (iv) delivering socioeconomic co-benefits in the form of health and recreation opportunities (See Trento Urban Plan case study, Box 3.11⁴³).

The second objective is to identify problems early in the process, and **prevent or mitigate potential damage** to ecosystems and their services as part of the policy or plan. This should ensure that risks and trade-offs are handled in a fair way.

Concrete examples of objectives for integrating ecosystem services into decisions can be to:

- make visible the benefits of nature and raise awareness of these benefits;
- secure the continued provision of critically important services;
- support choices between alternative programmes, policies, land-use options or interventions;
- help address potential risks and trade-offs in a fair way;
- increase the range of services delivered to different stakeholders to achieve net societal gain;
- improve connectivity between urban and peri-urban green areas;
- mobilise funding or design instruments, such as payments for ecosystem services (PES) schemes⁴⁴;
- Set up monitoring and review procedures.

43 This case study was developed as part of the EnRoute project. For all case studies, see the [EnRoute final report](#).

44 As encouraged, for example, under Action 11b of the EU Biodiversity Strategy to 2020.

3.1.2. Context mapping

The integration objectives should be formulated with reference to the **context within which the decision-making takes place**. This includes (i) legal and policy frameworks, (ii) interactions with existing policy objectives, development plans and strategies, (iii) the environmental and socioeconomic context, and (iv) key stakeholders and interests. Understanding the context helps to frame the issue and provide insights into relevant issues within and beyond the direct focus of the intervention. Understanding the context also helps to identify possible constraints, conflicting interests, or opportunities for synergies, and thus target knowledge creation on ecosystems and their services.

This process also helps to inform the stakeholder mapping process (see below) by identifying (i) stakeholders dependent on certain ecosystem services, and (ii) vulnerable groups. This helps to ensure that they are adequately engaged in the discussion of options, synergies and trade-offs.

3.1.3. Stakeholder assessment and engagement

Stakeholder mapping and analysis is an essential part of the policy formulation process. The purpose is to identify the key stakeholders that need to be engaged, either because (i) they can inform and/or influence the decision-making process and the implementation of the final decision, or because (ii) they could be positively or negatively affected by the decision. Stakeholder mapping and analysis may include stakeholders such as authorities in relevant policy sectors; land managers such as farmers; resource users such as those who fish and hunt; businesses; umbrella organisations; researchers and the general public.

In the context of sector-specific policy-making or decision-making, it is important to identify other sectors that might be affected by the planned changes and the risks or synergies they could create. The purpose of identifying these sectors is to engage with relevant authorities and stakeholders to develop mutually beneficial solutions and avoid or mitigate negative impacts.

It is also crucial to involve stakeholders from the earliest stages of the project, when the problem and objectives are being established, and when all options are open. This engagement must continue through all decision-making stages. Beyond the key stakeholders, less obvious stakeholders may also need to be identified through further research. There is a range of resources available to assist in the identification and engagement of stakeholders in ecosystem-based decisions^{45 46 47}.

The stakeholder assessment forms the basis for a plan to inform and engage relevant stakeholders in a discussion on problems, objectives, options, synergies and trade-offs in relation to ecosystems and their services. An engagement plan helps decision-makers to steer the participation process while allowing stakeholders to understand how and why they should participate. It can help to manage expectations of the outcome, increase stakeholder awareness

45 [ESMERALDA MAES Explorer](#) (see 'Questions and themes').

46 [Participatory and deliberative techniques to embed an ecosystems approach into decision making \(Defra Project\)](#).

47 [How to engage citizens through applying the ecosystem service approach?](#) (OPERAs Ecosystem Science for Policy and Practice).

and ownership, and create trust. It can also pave the way towards a more sustainable policy outcome. Stakeholder involvement also enriches the assessment with relevant information from different sectors and governance levels (e.g. ‘grey literature’, information on stakeholders’ values). Stakeholder debate on objectives, synergies and trade-offs can be a basis for balanced decisions. And stakeholder debate can also be an important corrective or consensus-building mechanism if there are data gaps, analytical uncertainties or conflicting objectives.

Step 1 should result in agreed objectives and an agreed scope for the assessment of ecosystems and their services as part of a wider decision-making process. It should also result in a stakeholder inventory, an indication of how key stakeholders are to be engaged in the next steps, and a work plan with milestones.

Box 2. Further resources to support this step:

The [MAES 1st report \(2013\)](#) (pp.13-14) proposed an initial set of 12 broad policy questions that could (i) help steer the mapping and assessment of ecosystems and their services at EU level, and (ii) provide a basis for the formulation of more detailed, sector-specific and level-specific questions (the list has been revised and elaborated in subsequent work, see below).

The [MAES explorer](#) online guidance tool created by the EU Horizon 2020 ESMERALDA project provides directions on the process of mapping and assessment of ecosystem services. These directions are structured around (i) sets of possible [questions that stakeholders may have](#) and (ii) a variety of themes (such as the [identification of relevant stakeholders, network creation and the involvement of stakeholders](#)).

The [EU guidance on integrating climate change into strategic environmental assessments](#) and the [EU guidance on integrating climate change into environmental impact assessments](#) outline a range of questions to help decision-makers frame impact assessments to integrate biodiversity and ecosystem services into their decisions.

The [Ecosystem Services Assessment Support Tool](#) developed by EU research projects (OpenNESS, OPERAs through OPPLA) breaks down the ecosystem service assessment process into a logical sequence of steps. Under “Getting Started”, it puts forward concrete methods for problem structuring and stakeholder identification.

The Science for Policy report on [Strategic Green Infrastructure and Ecosystem Restoration: geospatial methods, data and tools](#) provides methodological guidance for deploying a well-connected, multi-functional and cross-border green infrastructure (GI) and prioritising measures for ecosystem restoration. It draws on a range of European-wide datasets, geospatial methods, and tools. Concrete examples illustrate their use for mapping and assessing GI components and ecosystem services in rural and urban contexts.

3.2. STEP 2: Screen and Prioritise Ecosystems and Their Services

Step 2 includes (i) the identification of the full range of ecosystems and their services in the area of expected impact, and (ii) the process of arriving at a shorter list of priority ecosystem services after a more detailed assessment). Step 2 also provides a framework for ongoing stakeholder engagement, which can contribute relevant information from different sectors and governance levels while also raising awareness and increasing buy-in.

3.2.1. Identification of the range of ecosystems and their services in the area of impact

It is important to start this step with an overview of the range of ecosystem types in the area of impact. This will serve as a basis for identifying the range of ecosystem services flowing from these ecosystems. This basis will make it easier to select — in a participatory way and against established criteria — the most relevant ecosystem services for the decision-making process at hand. It will also make it easier to decide on what is required for further assessment.

Most of the information necessary for the screening and prioritisation of ecosystem services can be obtained through a combination of literature review, data analysis and stakeholder consultation. Where available, pre-existing mapping and assessments can inform the screening of ecosystems and their services and minimise complexity (especially where resources are limited). The [EU MAES and INCA data collections](#) can be useful in such cases.

Look out!	Assessments of ecosystems and their services may have been carried out as part of other decision-making processes in the concerned area where potential impacts on ecosystems and their services are likely to occur. Building on such assessments increases efficiency, and can result in a more consistent baseline assessment across sectors or policy objectives. It can also facilitate streamlining and consistency among different but related policy and planning processes within the area, and provide a common starting point for dialogue.
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Sometimes there are no pre-existing assessments or mapping information. In these cases, satellite images or existing land cover/land-use maps (such as Corine Land Cover and Copernicus Land Monitoring services⁴⁸ - Urban Atlas or high resolution layers provided by Land Copernicus or Bathymetry⁴⁹) and other information can provide a starting point to identify the range of ecosystem types in the area of impact.

48 [Copernicus land monitoring](#)

49 <http://www.emodnet-bathymetry.eu> see also <http://www.emodnet.eu/seabed-habitats>

Indicative lists of ecosystem services provided by different ecosystem types (e.g. based on MAES, see Box 3.2 below) can be used to develop a proxy. This proxy can be complemented by participatory mapping approaches⁵⁰, expert judgement and — if necessary — further data collection efforts.

Box 3. MAES indicative lists of ecosystem types and ecosystem services at european scale

The EU initiative on the mapping and assessment of ecosystems and their services (MAES) distinguishes the following ecosystem types at European scale.

- **Terrestrial:** (i) urban, (ii) agro-ecosystems (cropland and grassland), (iii) woodland and forest, and (iv) natural habitats (heathland and shrub, sparsely vegetated land and wetlands).
- **Freshwater:** rivers and lakes
- **Marine:** (i) inlets and transitional waters, (ii) coastal, (iii) shelf, and (iv) the open ocean (different pelagic photic zones or benthic habitats, including maërl, Sabellaria, Lanice or coral reefs in shallow and deep seas).

Drawing on the Common International Classification of Ecosystem Services (CICES)⁵¹, MAES classifies ecosystem services into provisioning, regulating/maintenance, and cultural services, as presented in Chapter 1. The indicative lists of the MAES ecosystem types and the services flowing from each of them are provided in Section B of this guidance document.

They are also provided on the Biodiversity Information System for Europe (BISE)⁵². The actual range and flow of ecosystem services in a certain area will depend on the interplay of factors related to the characteristics, use and condition of the ecosystems in this area. The lists can therefore be used only as a proxy, which must be complemented by other inputs, such as expert judgement, participatory mapping or further data collection.

This step should result in an overview (map) and a basic qualitative assessment of ecosystems in the area of impact. It should also result in lists of the range of ecosystem services provided by each of these ecosystems. Participatory mapping at this stage can help to identify ecosystem services and link them to the benefits flowing to different stakeholder groups.

3.2.2. Prioritising relevant ecosystem services

Ideally, all ecosystems and their services in an area of impact would be fully assessed. In reality, a full assessment of ecosystem services may be too time-consuming or expensive for individual projects, authorities or stakeholders. In addition, full assessments may not always be feasible —

50 Mapping ecosystem services: Burkhard B, Maes J (Eds.) (2017) Pensoft Publishers (Open Access content) <https://books.pensoft.net/product.php?p=13161&r=>.

51 Common International Classification of Ecosystem Services (CICES version 5.1 updated in 2018) <https://cices.eu/resources/>.

52 <https://biodiversity.europa.eu/>

or even necessary. To make the best use of limited time and resources, it is therefore important to prioritise an assessment of only the most relevant ecosystem services.

Look out!	The decision to focus on certain ecosystem services (and therefore not address others) will influence the outcomes of the assessment, the establishment of options, and the final decision. It is a decisive step and should be made in a participatory process, using clear and transparent criteria.
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The purpose and context of the assessment (Step 1) provide the basis for prioritising a smaller number of ecosystem services for further assessment and integration into the decision-making process. The prioritisation can be carried out on the basis of the lists developed in the screening process. Criteria for prioritisation must be agreed to ensure that the assessment captures critical ‘dependencies’ (areas where people or businesses rely heavily on ecosystem services), potential risks, and opportunities for co-benefits. Examples of questions to steer the selection process are listed in the bullet points below.

- Which ecosystem services can deliver cost-effective nature-based solutions to support the primary objective(s) of the decision-making process and help address the identified problems?
In the example of the Trento urban plan (see Box 3.11), nature-based recreation in peri-urban areas was linked to the city administration’s objective to ensure equitable access to green space.
- Which services are likely to be impacted by the policy/plan/project decision, either positively or negatively?
Identifying services potentially at risk at this preliminary stage may require input from experts. This input can help clarify links between the delivery of (the range of) ecosystem services on the one hand, and the extent and condition (structure, functions and pressures) of ecosystems, on the other.
- Which critically important degraded or vulnerable ecosystem services can be improved as part of the intervention?
What is considered to be a critically important service must be decided upon, depending on local needs (e.g. drinking water recharge or flood protection); rules (e.g. habitat protection); broader agendas (e.g. ecosystem-based climate mitigation); the socioeconomic context (e.g. a local source of incomes); societal values and choices (e.g. local identity linked to traditional landscapes); and the availability of feasible alternatives.

Other aspects to consider or highlight in prioritising ecosystem services for integration include:

- less visible but essential maintenance services that underpin other prioritised services;
- long-term trends that may affect the future demand for certain services, or their delivery;
- multifunctionality, in other words the capacity or potential of ecosystems in good condition to deliver bundles of ecosystem services, creating synergies with other policy areas and sectors;

- considerations about fairness and the needs of vulnerable social groups, which may be less vocal but highly dependent on certain ecosystem services.

The result of this process is a smaller set of agreed priority services for assessment in the area of potential impact. The format of the output could be a simple matrix (see Box 3.3 below) to list and score for relevance the range of provisioning, regulating (including maintaining/supporting) and cultural services. This matrix could also contain a list of the likely ways in which these services could impact the objectives of the concrete decision-making process, or be impacted by different intervention options.

Box 4. Some resources to inform screening and prioritisation of ecosystem services

- The [Common International Classification of Ecosystem Services \(CICES\)](#)⁵³ provides a standard typology of ecosystem services.
- MAES resources are available on the Biodiversity Information System for Europe (BISE) <https://biodiversity.europa.eu/maes> (including [country progress](#) and [topic](#) pages).
- The MAES indicative lists of ecosystem types and services (with indicators for condition assessment) are also provided in Section B to this document.
- In the absence of local ecosystem maps, land-use maps such as [Copernicus land monitoring](#) maps or Bathymetry⁵⁴ can be used in combination with ‘translation’ tools created by the European Environment Agency. These translation tools include [correspondence between Corine land cover classes and ecosystem types](#); a [crosswalk between European marine habitat typologies](#); and [linkages of habitats/species to ecosystems](#).
- [Mapping ecosystem services](#) (Burkhard B, Maes J (Eds.) (2017), Pensoft Publishers. Open Access) provides an extensive overview of mapping approaches and their application in different contexts.
- [The assessment report on biodiversity and ecosystem services for Europe and central Asia](#) (IPBES 2018) provides insights into the state and trends of ecosystems and their services in Europe.
- The [EnRoute Final Report](#) provides examples of application of the URBAN-MAES framework at EU scale and in 18 city-labs; each city-lab developed specific policy questions and selected a set of ES indicators to support decisions.

Further resources to support prioritising:

- The [fifth MAES report](#) (2018) provides an integrated analytical framework and indicators for mapping and assessing the condition of ecosystems in the EU. It also highlights, for each ecosystem type, links between ecosystem condition, the delivery of ecosystem services, and a range of policy objectives.
- The [VALUEs](#) step-by-step guidance to the valuation of ecosystem services in development provides a pathway and a simple matrix template for the screening and prioritisation of ecosystem services.
- The [ecosystem-services assessment-support tool](#) contains tools such as the [cascade model](#) which can be used to identify final ecosystem services and linkages to underlying structures and processes. It also contains methods such as the [simple matrix approach](#) and [quickscan](#).

53 Common International Classification of Ecosystem Services (CICES version 5.1 updated in 2018) <https://cices.eu/resources/>

54 <http://www.emodnet-bathymetry.eu/> see also <http://www.emodnet.eu/seabed-habitats>

Finally it contains advanced matrix approaches such as [greenframe](#).

3.3. STEP 3: Map, Assess and Value Ecosystems and Their Services

The mapping and assessment of ecosystems and their services aims to provide up-to-date and best possible information:

- on the ecosystems in the area of impact,
- on their condition (structure, functions and pressures) and trends,
- on the provision of services, and
- the social and economic importance (e.g. value) of services for various stakeholders and sectors.

The basic qualitative overview of ecosystems in the area of impact (type, area and management) and their services, developed in Step 2, provides a starting point to define the assessment. For the purposes of a concrete decision-making process, at least the ecosystems delivering priority services selected in Step 2 should be identified and subjected to more in-depth assessment. Further ecosystems may be prioritised for assessment if likely impacts on ecosystem condition need to be addressed and mitigated (e.g. areas of high conservation value), or ecosystem condition could be enhanced as part of the intervention, e.g. through restoration.

The MAES conceptual model is based on the premise that the delivery of critically important ecosystem services depends on the **ecosystem's area** and **ecosystem condition**. While this framework has been developed for EU level policy assessment, it is also applicable — and is being elaborated, complemented, adapted and applied to different levels and contexts.

The four MAES steps for the assessment of ecosystems and related services are:

3.3.1. Mapping of ecosystems:

Once a typology of the ecosystems has been defined, the next step is to map their spatial extent based on their biotic and abiotic characteristics. The map can be compiled and the underlying spatial data can be analysed using Geographical Information System (GIS) techniques, for instance to provide statistical information on the spatial extents and distribution of the different ecosystem types. For example, a map of ecosystem types on the European scale has been produced by combining maps of [CORINE land cover](#) with the [EUNIS habitats database](#). These types of maps are an important contribution to conservation objectives, such as assessing the degree to which different ecosystems are covered by protected area networks. The delineated ecosystem types can also be used as spatial units for the assessment of the selected ecosystem services.

Box 5. Further resources:

[Mapping ecosystem services](#) (Burkhard B, Maes J (Eds.) (2017) Pensoft Publishers. Open

Access) provides an extensive overview of mapping approaches and their application in different contexts.

3.3.2. Defining ecosystem condition:

Ecosystem condition refers to the physical, chemical and biological condition or quality of an ecosystem at a particular point in time. Ecosystem condition is used to assess trends and set targets related to the improvement of environment health. The concept of ecosystem condition is linked to well-being through ecosystem services. Ecosystems need to be in good condition to provide a set of essential services which, in turn, deliver benefits and increase well-being. Drivers of change can have a positive (e.g. conservation) or negative (pressures) impact on ecosystem condition.

For the purpose of the EU Mapping and assessment of ecosystems and their services (MAES), ecosystem condition embraces legal concepts such as conservation status under the Birds and Habitats Directives, ecological status under the Water Framework Directive and environmental status under the Marine Strategy Framework Directive, as well as other proxy descriptors related to state, pressures and biodiversity.

The MAES framework provides for the assessment of ecosystem condition per ecosystem type, using **indicators** for **environmental quality**, **biological quality** (structure and functions) and **pressures**. An assessment of the condition of the various ecosystem types requires information about drivers, mainly land/sea use and management and pressures such as land-take, fragmentation, invasive species, pollution and climate change as well as their impacts on the structure and function of each ecosystem type.

Pressures	Habitat conversion and degradation (land conversion)		
	Introductions of invasive alien species		
	Pollution and nutrient enrichment		
	Over-exploitation		
	Climate change		
	Other pressures		
Ecosystem Condition	Environmental quality (physical and chemical quality)		
	Ecosystem attributes (biological quality)	Structural ecosystem attributes	Structural ecosystem attributes (general)
			Structural ecosystem attributes based on species diversity and abundance
			Structural ecosystem attributes monitored under the EU nature directives
		Structural soil attributes	
		Functional ecosystem attributes	Functional ecosystem attributes (general)
Functional soil attributes			

Figure 4. MAES hierarchical classification of pressures and condition indicators

The [MAES 5th Report](#) (Maes et al., 2018) puts forward sets of EU level ecosystem condition indicators for each ecosystem type (Figure 4). It further provides examples to illustrate these complex relationships within different ecosystem types (see e.g. Figure 5 linking urban ecosystem condition with the provision of services, and ecosystem services with urban policy objectives). A full list of indicators for ecosystem services is available in the [MAES 2nd report](#) (2014).

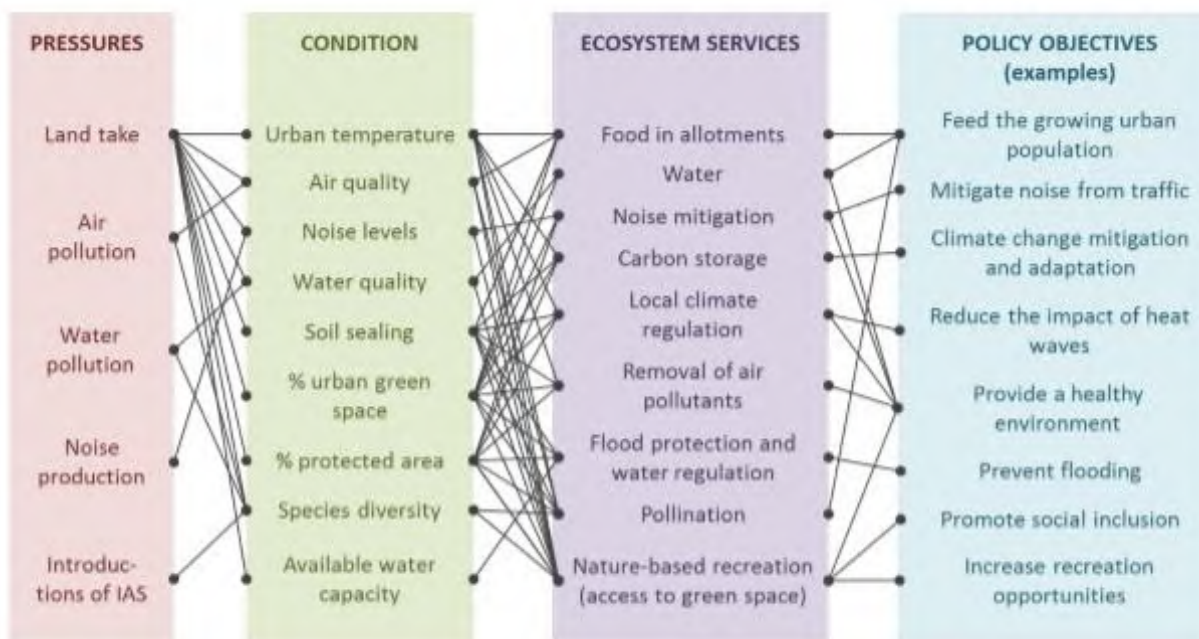


Figure 5. Synthesis of links between pressures, condition and ecosystem services in urban ecosystems (5th MAES Report, Maes et al. 2018).

The scope of an ecosystem services assessment depends on the policy or decision-making context. In general, all assessments start with the current (or baseline) condition of ecosystems and related services, and then aim to forecast changes under different policy options or decisions.

Assessing ecosystem condition **baseline** is necessary in order to evaluate the current condition and trends. A pristine ecosystem condition is rarely possible to define, especially for managed semi-natural ecosystems in the urban and rural context. For the purposes of policy-making, the current situation (or an agreed point in time or in a certain location) can be used to define the baseline situation, against which to assess and compare incremental changes to the conditions of ecosystems in result from different interventions, measures and management options, in order to detect further deterioration or improvements. The MAES framework for condition proposes that:

(1) the measurement of condition depends on the current pattern of land cover, land use and management which is reflected in using the MAES ecosystem typology resulting in specific indicators and assessments per ecosystem type.

(2) the measurement of condition in 2010 can be used as a reference condition so that ecosystem condition can be assessed relative to 2020.

Ideally, there will be existing assessments in the concerned area, e.g. from previous Environmental Impact Assessments of projects or Strategic Impact Assessments. They can be used to inform the decision-making process. If this is not the case, designing an assessment of ecosystem condition - and links to ecosystem services - should form an integral part of the policy formulation stage, including additional data collection, research and expert analysis as needed.

Box 6. Further resources:

- [MAES 5th report](#) (2018): integrated analytical framework and indicators for mapping and assessing the condition of ecosystems in the EU.
- [ESMERALDA MAES Explorer](#): online guidance tool on process and tools for mapping and assessment of ecosystems and their services, in support of MAES
- EnRoute Project [final report](#) and additional resources on the [EnRoute website](#)
- [Indicators for mapping ecosystem services](#) — a review (JRC 2012)
- Biodiversity Information System for Europe (BISE): <https://biodiversity.europa.eu/>

3.3.3. Quantification of ecosystem services

Prioritised ecosystem services may be subject to more detailed *quantitative assessments* and valuation using a range of biophysical, social and economic methods, including monetary valuation, at different spatial and temporal scales. Valuation is particularly useful in showing how the impacts of human activities on ecosystems and their services can affect human wellbeing and the economy.

Ecosystem services valuation needs to take account of the multiple types of values. Values have a strong socio-cultural context and are also linked to individual preferences. A range of values can be defined for the purposes of appraisal.

The Total Economic Values (TEV) Framework identifies:

- **Use values** including:
 - direct (actual or planned) use of an ecosystem service (traded or not),
 - indirect (typically less visible but crucial ecosystem services such as climate and water regulation, soil formation, pollination or nutrient cycling) and
 - option values (possible future use).
- **Non-use values** including:
 - bequest (the importance of securing a resource for future generations),

- altruistic (the importance of securing a resource for others), and
 - existence value.
- **Quasi-option value** arising from delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delaying.

TEEB identifies **ecological values** (e.g. resilience, biodiversity or functioning ecosystem), **socio-cultural values** (e.g. heritage, sense of place or spirituality) and **monetary values** (e.g. jobs, profits, costs or investments), while IPBES considers **intrinsic, instrumental and relational** value dimensions.

It is important to recognise the plural values of nature and ecosystem services, and incorporate all types of values into valuation and land and water management decisions — including the non-tangible ones⁵⁵.

Drawing on the different types of values, a range of methods and tools are available for the assessment of ecosystem services. These include:

- **biophysical methods**, such as matrix and spreadsheet approaches, Bayesian belief networks and modelling ecosystem services;
- **socio-cultural methods** for understanding preferences or social values for ecosystem services, such as participatory mapping, deliberative valuation methods, preference ranking methods, multi-criteria analysis methods, and photo-elicitation surveys;
- **monetary methods** for estimating economic values for services, such as stated preference methods using contingent valuation and choice modelling, revealed preference methods such as travel cost method or hedonic pricing methods.

Table 1 below provides an overview of valuation methods applied in an extensive review of 27 case studies by the [EU Horizon 2020 OpenNESS project](#)⁵⁶.

Method	Overview
<i>METHODS THAT ARE BROADLY BIOPHYSICAL:</i>	
Biophysical modelling	Biophysical models assess the biophysical factors (processes and functions) controlling ecosystem service supply. Many types of biophysical models can be relevant for ecosystem service assessment including: (i) ecological models, such as species distribution models (SDMs; e.g. Harrison et al., 2006); (ii) hydrological models, such as the Soil and Water Assessment Tool (SWAT; Francesconi et al., 2016); (iii) soil erosion models, such as the Revised Universal Soil Loss Equation (RUSLE; USDA, 2016); and (iv) state-and-transition

⁵⁵ [Ecosystem services assessment support tool](#).

⁵⁶ See project web page for the full references and resources on each method in the table. http://www.openness-project.eu/sites/default/files/OpenNESS_D3.3_D4.4_FINAL.pdf

	models (STMs) which simulate ecosystem dynamics after disturbances based on alternate state theory and can be useful for understanding the importance of ecological functions that underpin the provision of ecosystem services (see Bestelmeyer et al., 2010).
Ecosystem service modelling	Ecosystem service models assess the supply (and sometimes the demand) of multiple ecosystem services usually in a specialised Geographic Information System (GIS)-like software environment. They include models such as: (i) ESTIMAP , a set of spatially-explicit models each of which can be run separately for the assessment of different ecosystem services at the European or regional scale (Zulian et al., 2013; Zulian et al., 2017); (ii) QUICKScan tool, a spatial modelling environment to combine expert knowledge with spatial and statistical data designed to be used in a facilitated workshop to enable policy-makers, experts and stakeholders to jointly explore the impacts of different policy options on ecosystem services (Verweij et al., 2016); and (iii) InVEST, a set of models for mapping and valuing the ecological or economic value of multiple ecosystem services at a local to regional scale (Sharp et al., 2016).
Agent-based modelling (not applied in the OpenNESS case studies, but included here to enable more comprehensive guidance).	Agent based models simulate the human decision-making process involved in ecosystem service management or policy. They can represent multiple organisational levels of human interactions with each other and their environment (e.g. Guillem et al., 2015).
Integrated Assessment modelling	Integrated assessment models (IAMs) couple together models representing different sectors or ecosystem components to simulate land use change and/or the delivery of ecosystem services. IAMs differ from ecosystem service models as they include feedbacks between the components that are coupled. Examples that were used in OpenNESS include: (i) IMAGE-GLOBIO, a global model which simulates past, present and future impacts of human activities on biodiversity and ecosystem services (Alkemade et al., 2009); and (ii) the CLIMSAVE Integrated Assessment Platform (IAP; Harrison et al., 2015), which combines ten sectoral models to analyse the impacts of different climate and socioeconomic scenarios on ecosystem services, and possible adaptation options, at the European scale.
Simple matrix mapping	Simple matrix mapping links a spreadsheet of ecosystem service supply/demand indicators by land cover category to a GIS map, to generate maps of ecosystem service supply, demand and balance (supply minus demand). The indicators can be derived from scientific data or can be scores based on local or expert knowledge (e.g. Burkhard et al., 2012).
Advanced matrix mapping	Advanced matrix mapping approaches build on simple matrix mapping approaches through incorporating multiple sources of spatial datasets. An example of such an approach used in OpenNESS is GreenFrame which was developed to assess spatial variation in ecosystem service provision potential of green infrastructure in spatial planning (Kopperoinen et al., 2014). The method utilises an extensive set of spatial datasets grouped into themes combined with

	both scientific experts' and local actors' scorings.
<i>METHODS THAT ARE BROADLY SOCIO-CULTURAL:</i>	
Deliberative mapping	Deliberative or participatory mapping is a broad group of methods which aim to include stakeholder's local knowledge, values and preferences in creating maps of ecosystem services. Several deliberative or participatory mapping methods were applied or developed within OpenNESS including: (i) Participatory GIS (PGIS) or Public Participation GIS (PPGIS) which uses workshops, face-to-face interviews or web-based surveys to integrate perceptions, knowledge (local-based or technical) and values of different stakeholders and presents the outputs in the form of a map of ecosystem services (see Brown and Fagerholm, 2015); (ii) MapNat App, a Smartphone app for mapping mainly cultural, but also some provisional and regulating, services and disservices; and (iii) BGApp, a Smartphone app for scoring different green and blue 'elements' of the landscape based on their importance for an ecosystem service, or a bundle of services, and an area-weighted score is calculated for a proposed property development.
Participatory scenario development	Scenarios are defined within the OpenNESS project as 'plausible, simplified description(s) of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces'. Engaging with stakeholders helps to formulate scenarios which are consistent with the stakeholder perspectives (Priess and Hauck, 2015).
Narrative analysis	Narrative methods aim to capture the importance of ecosystem services to people through their own stories and direct actions (both verbally and visually) (see de Oliviera and Berkes, 2014).
Deliberative valuation	Deliberative valuation is not one particular valuation method, but it is a valuation paradigm providing a framework to combine various tools and techniques that bridge citizens and academia, as well as different disciplines within science. Such methods invite stakeholders and citizens (the general public) to form their preferences for ecosystem services together through an open dialogue with others (see Wilson and Howarth, 2002).
Preference assessment	Preference assessment is a direct and quantitative consultative method for analysing perceptions, knowledge and associated values of ecosystem service demand or use (or even social motivations for maintaining the service) without using economic metrics. Data is collected through surveys using a consultative approach with different variations, such as free-listing exercises, ecosystem service ranking, rating or ecosystem service selection (e.g. Martín-López et al., 2012).
Photo-series analysis	Photo-sharing websites such as Flickr, Panoramio and Instagram are used to provide revealed preferences for cultural ecosystem services, assuming that visitors are attracted by the location where they take photographs (e.g. Richards and Friess, 2015).
Photo-elicitation	This method aims to translate people's visual experiences and perceptions of landscapes in terms of ecosystem services. Respondents to questionnaires specify the principal ecosystem

	services provided by each landscape from a list of potential services provided by the area (e.g. López-Santiago et al., 2014).
ES card game	The ecosystem services card game is a method developed to capture the sociocultural values related to ecosystem services through combining photo-elicitation (see below) with a rating exercise.
<i>METHODS THAT ARE BROADLY MONETARY:</i>	
Cost-effectiveness analysis	Cost-effectiveness analysis is a decision-support tool for ranking alternative ways of meeting the same policy goal by their ratio of effectiveness to cost (see Boardman et al., 2006).
Benefit-cost analysis	Benefit-cost analysis is a decision-support tool for screening alternatives by their internal rate of return, or ranking alternatives by their discounted benefit/cost ratio or net present value (see Boardman et al., 2006).
Market price / exchange-based methods	Values are observed directly or derived from prices in markets. This is a large category of monetary methods which includes cost-based methods (below). Revealed preferences methods (below) are sometimes included in exchange-based methods, because market prices (house prices, costs of travel) are used to derive values of ecosystem services indirectly. Shadow pricing is also an implicit form of market price defined as the marginal price society 'puts' on the provision of non-marketed ecosystem services through setting environmental targets (e.g. Konrad et al., 2017).
Cost-based methods /Mitigation costs	Mitigation cost-based valuation methods are a group of 'exchange-based' techniques that use the cost of actual measures to maintain ecosystem service provision as a proxy for the value of actions undertaken in the mitigation hierarchy (BBOP, 2009), including actions to avoid, minimise, restore or replace ecosystems and their services that are potentially at risk in connection with a development. As a valuation technique, the costs of actions are taken as proxies for the value of the ecosystem services lost. This group of methods therefore includes: (i) restoration cost; (ii) replacement cost; and (iii) clean-up cost.
Revealed preference methods	Values of ecosystem services are revealed indirectly through purchases (e.g. house prices) or behaviour (travel costs). Examples used in OpenNESS include: (i) hedonic pricing, which is the study of multi-correlation between environmental characteristics of a good and its sales price; and (ii) travel cost methods (TCM), which are based on the observation that recreational services can only be realised through physical access to nature.
Stated preference methods	Stated preference valuation is a family of economic valuation techniques which use individual respondents' stated hypothetical choices to estimate change in the utility associated with a proposed increase in quality or quantity of an ecosystem service or bundle of services (Bateman et al., 2002). The methods include: (i) contingent valuation; (ii) choice experiments; and (iii) contingent ranking among others.
Time use studies	This method is an innovation of the conventional stated preference techniques taken from the contingent valuation approach. Surveys are used to estimate the value of ecosystem services by asking people

	how much time they would be willing to invest for a change in the quantity or quality of a given service (García-Llorente et al., 2016).
Resource rent ⁴	The resource rent method derives the value of the ecosystem service as a residual after the contributions of other forms of capital have been deducted from the operating surplus (e.g. Obst et al., 2016)
Simulated exchange ⁴	Based on a derived demand function it is possible to estimate a marginal exchange value by choosing a point along the demand function, either based on observed behaviour or through intersection with a modelled supply curve. This is an experimental method proposed for ecosystem accounting (see Campos and Caparros, 2011; Obst et al., 2016).
Production/cost function ⁴	These approaches relate the output of marketed goods to the inputs of ecosystem services through the use of econometric techniques (e.g. Bateman et al., 2010).
Value transfer	Benefits transfer (BT), or more generally — value transfer (VT) — refers to applying quantitative estimates of ecosystem service values from existing studies to another context (see Johnston et al., 2015).
<i>INTEGRATIVE METHODS:</i>	
Bayesian Belief Networks (BBN's)	BBNs are based on a graphical structure consisting of nodes representing, for instance, processes or factors, and links specifying how the nodes are related. BBNs can be constructed from a combination of historical data and expert knowledge, but BBNs representing ecosystem services are mainly derived from expert knowledge as historical data is sparse. Each link represents a dependence relation such that each node has a conditional probability distribution specifying the (causal) relationship between the values of nodes with incoming links to the node and the values of the node itself. This means that uncertainty is explicitly taken into account (see Smith et al., in press). BBNs can be linked to GIS to undertake spatial analysis.
Multi-criteria Decision Analysis (MCDA)	MCDA is an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter. Spatial MCDA are carried out in GIS in order to enable a visualisation of the multiple criteria (see e.g. Munda, 2004).

The selection of a particular method to apply in a specific case can depend on many factors, including the decision-making context, the ecosystem services at stake, the strengths and limitations of different methods, and pragmatic reasons such as available data, resources and expertise.

Decision-trees⁵⁷, such as those developed by the OpenNESS project⁵⁸, can serve as a useful pathway to selecting between and within the categories of [biophysical](#), [socio-cultural](#) and [monetary](#) valuation methods (the OpenNESS guide further includes factsheets on each method and a method selection tool that can be particularly useful for decision-makers to develop terms

57 Harrison et al (2017). Selecting methods for ecosystem service assessment: A decision tree approach. Ecosyst Serv. doi: <https://doi.org/10.1016/j.ecoser.2017.09.016>.

58 http://www.openness-project.eu/sites/default/files/OpenNESS%20D3.3_D4.4_FINAL.pdf.

of reference for the assessment of ecosystem services — see box below for decision trees and further guidance to choose the most appropriate method)

Monetary valuation provides important opportunities to integrate information on ecosystem services into sectoral policies and project-level decision processes, as it enables the consideration of the impacts on biodiversity at the same level as other costs and benefits of policies. Thus, monetary valuation methods have an important role in informing decision-making and highlighting the value of ecosystems and their services.

At the same time, it is important to keep in mind some limitations and possible risks related to monetary valuation. Such methods can underestimate conservation as well as many socio-economic benefits provided by certain ecosystems, especially if only few, rather than the full range of ecosystem services, are taken into consideration in a cost-benefit analysis. Certain ecosystem services might be easier to assess in monetary terms, e.g. for disaster risk reduction and coastal protection infrastructure, but more difficult or contentious to monetise, e.g. when it comes to protecting human health or life. Furthermore, it needs to be acknowledged that valuation of ecosystem services can be linked with high uncertainty and different monetary valuation methods have been shown to arrive at very different values for the same service and context. It is therefore important to recognise situations when non-monetary values and perspectives may be more informative and appropriate. When it is not possible to monetarise the range of values, a *multi-criteria analysis*⁵⁹ would be more appropriate than a cost-benefit analysis.

Box 7. Key reference frameworks for the choice of methods:

- Overview of valuation methods, decision-trees to choose methods, method cards and further guidance are available in the EU FP7 OpenNESS Project Deliverable 3.3-4.4, Barton, D.N. and P.A. Harrison (Eds.). [Integrated valuation of ecosystem services. Guidelines and experiences](#). European Commission FP7, 2017.
- The **ESMERALDA MAES Methods Explorer** offers a database of almost 900 existing studies on mapping and assessing ecosystems and their services and highlights the methods, scale, ecosystem type, ecosystem service categories etc. [The Online Tool](#) provides a simple yet powerful interface for searching the database. The user can search for examples or methods by filtering the dataset by various attributes — such as ecosystem service, ecosystem type, policy question covered etc. Users can also find guidance to a [tiered](#)

⁵⁹ See e.g. Heli Saarikoski et al. OpenNESS Synthesis Paper on [Multi-criteria decision analysis \(MCDA\) in ecosystem service valuation](#).

[approach](#) to combine less sophisticated, expert- and land cover-based approaches, and the use of existing ES indicator data, with more complex and comprehensive ecosystem services modelling frameworks.

- The [VALUES database](#) provides access to a global inventory of methods and experiences for integrating ecosystems and their services into policy, planning, and practice. It includes a [Methods Navigator](#) through a broad range of methods with advice and practical information about how to choose the right ones in a specific situation. The database hosts additional tools for understanding context, as well as assessment methods from multiple disciplines.
- If the focus is on urban setting: the [EnRoute reports and city-labs case studies collection](#).
- If the focus is on marine ecosystems: [Valuing marine ecosystems: taking into account the value of ecosystem benefits in the Blue Economy. Future Sciences Brief \(April 2019\). European Marine Board](#).

The UK DEFRA has issued a series of guidance documents on valuing ecosystem services for different purposes, including:

- [An introductory guide to valuing ecosystem services for policy appraisal](#)
[Green Book supplementary guidance on environmental appraisal](#)
 - Environmental valuation [‘look-up’ tool](#)
- [Value transfer guidelines — non-technical summary](#)
- [Value transfer guidelines — full version](#)
- [Summary of value transfer steps](#)
- [Value transfer guidelines — Annex 1: Protocol for primary valuation studies](#)
- [Value transfer guidelines — Annex 2: Assessing the quality of primary valuation studies](#)
- [Value transfer guidelines: Annex 3: Glossary of econometric terminology](#)
- Non-monetary and participatory valuation: [general](#) and [supplementary](#) guidelines

3.3.4. Accounting for the contribution of ecosystem services to the economy

There is an increasing demand for quantifying the contribution of ecosystems to human well-being and the economy. Ecosystem services accounts provide relevant information on ecosystems delivering services and their use and benefits to society. They integrate and organize in a systematic way data derived from the biophysical, socio-cultural and monetary assessments (see 3.3 and 3.4) and reinforce the linkage between ecosystems and socio-economic systems. If developed in a consistent way and aligned with the System of National Accounts (SNA), ecosystem services accounts can be used to make direct comparisons with economic indicators.

SNA is an international standard for the systematic compilation and presentation of economic data. It provides information on how much economic sectors produce, households consume and save, on the level of investments and the amount of trading with the rest of the world. SNA represent the economy in a simplified way, by remaining integrated and internally consistent.

The contributions of natural capital are completely absent from standard SNA but the natural capital domain of information can be integrated in the SNA through satellite accounts. In satellite accounts, the SNA core statistical framework is applied to adapted outputs designed to meet specific/cross-cutting uses. The System of Environmental-Economic Accounting (SEEA) proposed and supported by the UN since 1993 provides methodological guidelines for setting up satellite accounts concerning natural capital. The [UN SEEA EEA \(Experimental Ecosystem Accounting\)](#)⁶⁰ include accounts of ecosystem extent, ecosystem condition, ecosystem services, thematic accounts as well as monetary accounts, which would help to integrate the results of ecosystem accounting with other economic indicators derived from SNA (Figure 6).

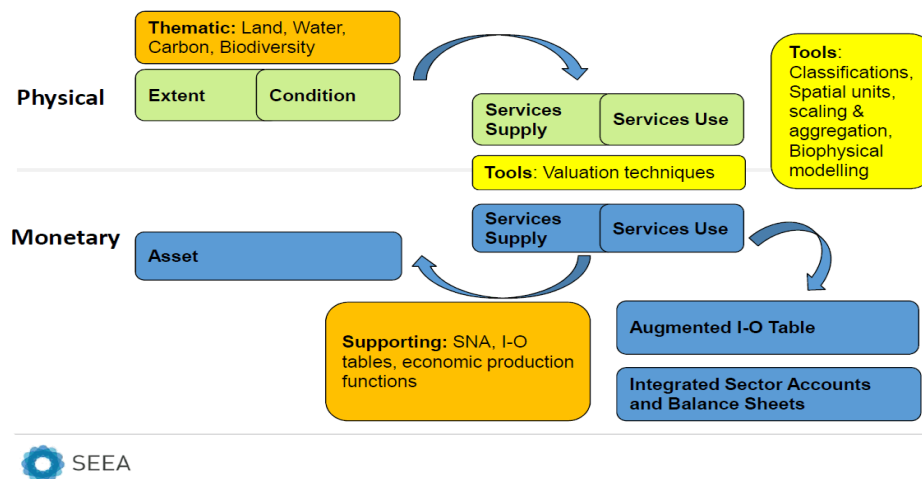


Figure 6. Components of the United Nations System of Environmental-Economic Accounting- Experimental Ecosystem Accounts (source: [KIP INCA Final report phase 1](#)⁶¹).

The accounting module “Services Supply and Services Use” in Figure 6 targets ecosystem services accounts in physical (green boxes) and monetary (blue boxes) terms. Supply and use in accounting terms refer to the amount of ecosystem service effectively used or **the actual flow** (of services from ecosystems to socio-economic systems). This flow is known as the accounting identity (i.e., supply equals use).

The EU Biodiversity Strategy to 2020 includes actions to develop natural capital accounting (NCA) in the EU, with a focus on ecosystems and their services. The EU [Knowledge and Innovation Project on an Integrated system for Natural Capital and ecosystem services](#)

60 https://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf.

61 http://ec.europa.eu/environment/nature/capital_accounting/pdf/KIP_INCA_final_report_phase-1.pdf.

[Accounting \(KIP INCA\)](#)⁶² aims to design and implement an integrated accounting system by testing and further developing the [technical recommendations provided by the UN SEEA EEA](#)⁶³. KIP INCA builds on the EU MAES initiative, and supports its second phase which will focus on the valuation of ecosystem services and their integration into accounting and reporting systems.

KIP INCA is developing the actual flow accounts for a range of ecosystem services⁶⁴ (see Box 3.7). The framework adopted in KIP INCA for ecosystem services accounts follows three steps:

- 1) Biophysical assessment;
- 2) Translation in monetary terms; and
- 3) Accounting (in both biophysical and monetary terms).

For some ecosystem services, it is possible to make a biophysical assessment based on official statistics. This is the case especially - but not only - for ecosystem services that contribute directly to generate products already reported in the SNA, such as timber and crop provision. In this way, ecosystem service accounts maintain the linkage with the official statistics also considered in the SNA. The advantage of this fast-track approach is the immediate application and simplicity. The disadvantage lies in the lack of underlying information to understand the changes over time (cause-effect)⁶⁵.

An alternative approach to the use of available official statistics for the biophysical assessment is the development of spatially explicit models. Spatial models are especially needed in the absence of official statistics (mainly for regulating and maintenance services). This modelling approach is more complex and requires ad hoc expertise. However, GIS-tools are available for practitioners. Several examples for modelled services are available for the EU⁶⁶.

The translation in monetary terms implies a direct connection between the biophysical assessment of the ecosystem service and the value it presents to the economy. In other words, a change in the biophysical model would also generate a change in the monetary value of the ecosystem service. Moreover, valuation techniques employed in natural capital accounts should comply with traditional economic accounts to allow for consistent integration and analysis with SNA economic accounts.

The accounting format used for ecosystem services represents supply and use tables. They are used to report annual flows of goods and services between different units in the system. In SNA, supply tables show the goods and services produced by each economic sector in the system, along with the supply of goods and services including imports. In ecosystem services satellite

62 http://ec.europa.eu/environment/nature/capital_accounting/index_en.htm

63 https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

64 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC107150/jrc107150_jrc107150_jrc_report_ecosystem_services_accounts_final_pubsy.pdf.

65 See also examples in the JRC Report [Ecosystem services accounting - Part II Pilot accounts for crop and timber provision, global climate regulation and flood control](#) (April 2019), with specific reference to timber provision and carbon sequestration.

66 See Vallecillo et al. (2019) <https://www.sciencedirect.com/science/article/pii/S030438001830320X>, and La Notte et al. (2017) <https://www.sciencedirect.com/science/article/pii/S2212041616304545>.

accounts, the supply table shows the flow of each service provided by different ecosystem types (e.g. cropland, woodland and forest, inland waters⁶⁷).

In the SNA, the use tables show the allocation of goods and services by economic sectors as intermediate consumption (i.e. used by other industries in the production of their output), and as final consumption (i.e. the purchases of each product by each category of final user such as households, government, or export). In ecosystem services satellite accounts, the use table shows the flow of each ecosystem service to the different user (economic sectors or households).

Since both supply and use tables report on actual flows, total values are the same: the former shows where it comes from (i.e. ecosystems), the latter shows where it goes (i.e. economic units). In KIP INCA, quantification of the actual flow of modelled ecosystem services is based on the mapping of different components determining the ecosystem service use (Figure 7):

- Ecosystem service potential: the service that can be provided by different ecosystem types, depending on their properties and condition (providers of the supply table).
- Ecosystem service demand: the need for a specific ecosystem service by economic sectors and households to generate a benefit (users of the use table).

The calculation of the actual flow of ecosystem services results from the interaction between ecosystem service potential and demand and fits the accounting identity condition.

Under the MAES initiative, ecosystem services have been mainly assessed in relation to the ecosystem potential, which is necessary but not sufficient to determine the actual flow. A step forward to assess the actual flow is to identify the demand, its location and its spatial relationship with areas providing the targeted ecosystem service.

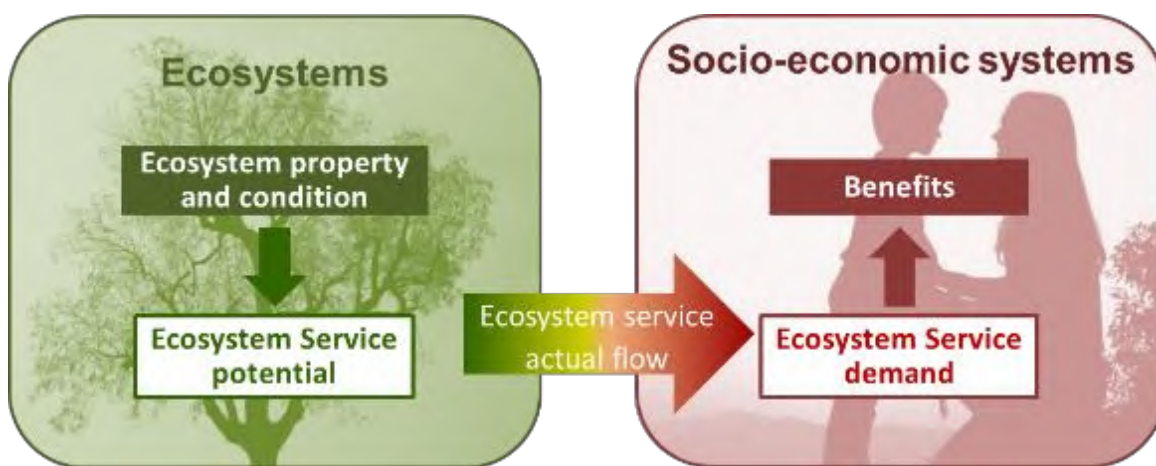


Figure 7. Mapping components of ecosystem services (adapted from “[Ecosystem services accounting: Part I](#)”)

67 KIP INCA uses the MAES ecosystem classification to build the supply table.

What ecosystems can provide may be different from what is demanded by users. This mismatch can create:

(i) overuse of a service, generating ecosystems degradation. This occurs when the service demand is above the ecosystem's capacity to generate the service

(ii) unmet demand, when not all the demand for the service is satisfied by ecosystems.

The measurement and valuation of this mismatch should be reported as complementary information in the accounts and can support respectively (i) sustainability assessment and (ii) restoration priorities to enhance the contribution of ecosystems to human well-being⁶⁸.

Box 8. Examples of natural Capital Accounting at the EU Level

Progress made during the first three years of KIP INCA provides results of ecosystem services accounts at the EU level for six ecosystem services (Vallecillo et al. 2018, Vallecillo et al. 2019):

Assessed until 2019	Input data	Valuation method
PROVISIONING		
Crop provision	Reported data	Market values
Timber provision	Reported data	Market values
REGULATING AND MAINTENANCE		
Crop pollination	Spatial model	Market values
Global climate regulation	Reported data	Market values
Flood control	Spatial model	Avoided damage cost
CULTURAL		
Nature-based recreation	Spatial model	Zonal travel cost

The adopted approach is consistent with the SEEA EEA. The workflow includes:

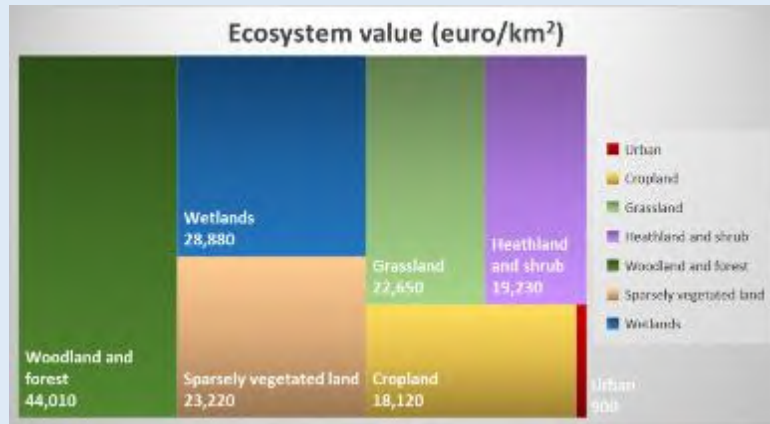
- Biophysical assessment (based on reported data or spatially explicit models);
- Translation in monetary terms (using different valuation techniques);

68 The issues of degradation and unmet demand in ecosystem services accounting are specifically addressed in La Notte et al. (2019) <https://www.sciencedirect.com/science/article/pii/S2212041617307246>.

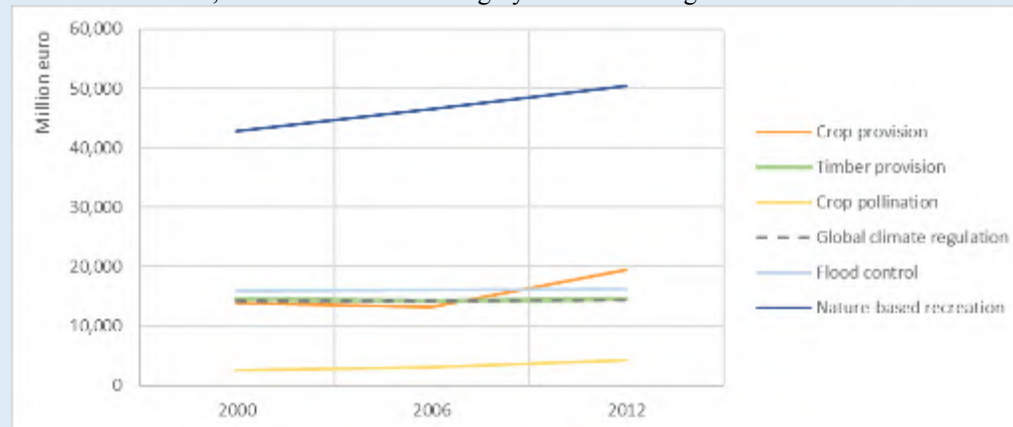
- Supply and use tables (in biophysical and monetary terms);

The accounts are performed for different years in order to assess temporal changes, which is among the main goals of accounting. The period assessed aims to cover 2000, 2006 and 2012 (only two years are considered when data are unavailable for all three).

The accounting of the six ecosystem services assessed so far shows Woodland and forest as the ecosystem types providing the highest monetary value per unit area, followed by Wetlands and Sparsely vegetated land.



This work is the starting point to further develop an integrated ecosystem services accounts. Future accounts will cover water purification, soil erosion control and habitat maintenance, **which may result in important changes in these values and the relative importance attributed to each ecosystem type**. The analysis of temporal changes in ecosystem services through accounting demonstrates an overall increase in the value of all six ecosystem services assessed. However, this EU level trend is highly variable among the different EU countries.



One of the advantages of using spatially explicit models is the provision of information on key drivers of change in the amount of the service used: what ecosystems can provide (potential) or the need for the service (demand).

While the increased value of flood control and crop pollination is mainly due to an increase of the **demand** for the service, for nature-based recreation, the increase is due to both: enhancement of natural areas for nature-based recreation and an increase of the demand.

The increase of demand for all ecosystem services assessed so far warns about the increasing need of consideration of the role of natural capital in guaranteeing the provision of these services. In this sense, ecosystem services accounts prove a useful tool to track changes over time, highlight undesirable changes in natural capital and call attention to areas where the enhancement of ecosystem services would result in direct contribution to human well-being.

Further references

[Vallecillo, S et al. \(2018\) Ecosystem services accounting: Part I - Outdoor recreation and crop pollination](#)⁶⁹.

[Vallecillo, S et al. \(2019\) Pilot accounts for crop and timber provision, global climate regulation and flood control](#)⁷⁰.

Box 9. CASE STUDY: Valuation for natural capital accounting in the Limburg province, the Netherlands

Perhaps one of the most advanced (and cited) applications of NCA to date has been implemented in the Dutch province of Limburg, as part of a research project between Statistics Netherlands and Wageningen University. It forms the basis for the ongoing development of broader ecosystem accounts for the whole of the Netherlands. The project team constructed the following accounts for the Limburg province:

- ecosystem extent account,
- (conceptual) condition account,
- physical supply (and use) ecosystem service accounts,
- monetary supply and use ecosystem service accounts.

Apart from the ecosystem monetary asset account, the study demonstrates a nearly complete account structure of the System of Environmental-Economic Accounting (Experimental Ecosystem Accounting), SEEA EEA. The project **focused on eight ecosystem services**: crop and fodder production, drinking water provision, hunting, carbon sequestration, air filtration, recreational cycling and nature tourism. The team accounted for 31 ecosystem units. The initial ecosystem extent accounts drew on a detailed spatially explicit database of the ecosystems within the province, as part of a wider national ecosystem mapping. A range of data sources were collated into a common statistical framework.

The project provided monetary values in terms of supply and use accounts for all of the selected services except recreational cycling. It applied the following valuation techniques⁷¹:

- **Resource rent method** for valuing crop and fodder production and nature tourism
- **Replacement cost method** for valuing groundwater extraction for drinking water
- **Avoided damage cost method** for valuing C-sequestration and air quality regulation
- **Access price method** (a form of resource rent method) for valuing hunting

The exchange value concept was used which helps to ensure compatibility with national statistics and indicators (and therefore relevance to macro-economic indicators). In addition, it allows the summing up of different values of ecosystem services for given ecosystem type. This gives a better understanding of how the values are distributed across the Province, and can be useful for example for identifying areas with significant natural capital contribution to economic activities.

The valuation thus revealed that the southern part of the province provides significantly higher average values to economic activities than the northern part (see figure to the right). Construction of the accounts over a period of years will add the dynamic perspective to the picture –how the distribution of values change over time. This can indicate change of state in natural capital and/or in the importance of natural capital for economic activities.

The use of exchange values also enables the construction of ecosystem services supply and use accounting tables that link ecosystems to human activity. In the example of Limburg, such tables were developed providing estimates of the monetary value of ecosystem services delivered to the economy.

⁶⁹ <http://publications.jrc.ec.europa.eu/repository/handle/JRC110321>.

⁷⁰ <https://ec.europa.eu/jrc/en/publication/ecosystem-services-accounting-part-ii-pilot-accounts-crop-and-timber-provision-global-climate>

⁷¹ The biophysical models of ecosystem services are reported in Part I, and the monetary valuation methods in Part II of the report 'Ecosystem accounting Limburg province, the Netherlands: <https://www.wavespartnership.org/en/knowledge-center/ecosystem-accounting-limburg-province-netherlands-part-2-monetary-supply-and-use>:

The [2019 Report on NCA overview and progress in the EU](#) presents an update of progress on natural capital accounting in the EU, and more specifically, ecosystem accounting, and showcases NCA work in EU Member States and at the EU-level, illustrating its use for various types of decision-making.

In addition to the EU or national level, instruments are also available to carry out accounting for ecosystem services and natural capital at the level of businesses and other private sector organisations that depend and/or have an impact on natural resources and ecosystems. Information and references to accounting initiatives and methods in the private sector are provided in Chapter 6.

Look out!	Carrying out an ecosystem service assessment is not the same as ecosystem policy integration.
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It is important to understand the difference between mapping and assessment and policy integration. Ecosystem service mapping and assessment serves to **inform** policy integration. Policy integration is the **uptake** of this information at relevant stages of decision-making. Even the most comprehensive ecosystem service assessment does not automatically guarantee policy integration in practice. For successful policy integration, interplay of the different instruments for assessment and integration — supported by awareness raising and stakeholder engagement — is required.

3.3.5. Models and scenarios, and ex-ante (impact) assessment of options

The assessment of ecosystems and their services provides the basis for modelling and assessment of scenarios in order to explore the likely outcomes for ecosystems and their services under alternative policy or intervention options. This includes outcomes for the sector in question and for other relevant sectors, and can support the identification and analysis of potential synergies and trade-offs (for stakeholders and wider policy goals).

In line with the guiding principles, dedicated efforts should be made **to develop options and scenarios that maintain or improve ecosystems’ condition and their ability to deliver a range of ecosystem services**. Policy options and related scenarios entailing likely damage to biodiversity, ecosystems and/or related services should reveal likely trade-offs and also indicate possible measures to avoid or mitigate such negative impacts as much as possible. As a last resort, policy options and related scenarios building on compensation or offsetting schemes could be developed (See section 3.3 below).

Look out!	While policy options may concern short- or medium-term interventions, their likely impacts need to be assessed within medium and long-term scenarios in order to take account of time lags and long-term trends in ecosystems and their services.
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Dealing with information gaps and uncertainty

Mapping and assessing ecosystems and their services is a complex subject and should include strategies to deal with uncertainty in a transparent manner. Proxy indicators, expert judgment or using information from another similar location can be used when no information on a given ecosystem service is available. Proxy indicators and benefits (or value) transfer are pragmatic ways of dealing with information gaps and resource (time and money) constraints. For example, land cover or land use can be used to reflect or predict status or changes in ecosystem services (proxy), or there might be sufficient commonalities between different locations to allow insights from one area to be transferred to another (benefit transfer). The suitability of proxies or benefit transfer needs to be carefully considered and supported by expert judgment. The key considerations for the use of benefit transfer are 1) the ecosystem service or related goods valued are very similar at the site where the estimates were made and the site where they are applied to, 2) affected stakeholders have very similar characteristics, 3) original estimates are considered reliable, and 4) there is no reason to expect that the socio-economic value(s) associated with a benefit have changed since the estimate (value of carbon markets etc.).

Box 10. Integrated assessment and modelling tools:

- Integrated Valuation of [Ecosystem Services and Trade-offs](#) 3.4.2 — InVEST (Sharp et al., 2018) provides an effective tool for exploring the likely outcomes of alternative management and climate scenarios and for evaluating trade-offs among sectors and services. A range of decision-makers from government agencies through conservation organisations to corporations and utilities can use the tool.
- [Multiscale Integrated Models of Ecosystem Services](#) — MIMES (Boumans et al., 2015)
- [ESTIMAP](#) (Ecosystem Service Mapping Tool) is a GIS model-based approach to spatially quantify ES, developed to support ES policies at a European scale. It is a set of separate process-based models that assess the supply, demand and flow of different ecosystem services, for use within a GIS. Although developed at the European scale, the models can be downscaled to the local level (Zulian et al 2017), the nature-based recreation, pollination and air quality models are being used by several of the OpenNESS case studies and EnRoute CityLabs.
- [ARIES](#) (Modelling Artificial Intelligence for Ecosystem Services) (Villa et al. 2014)
- [OPAL](#): Offset Portfolio Analyser and Locator
- [Co\\$ting Nature v.3](#) (Mulligan, 2015)
- [WaterWorld](#) v.2 (Mulligan, 2015).

3.4. STEP 4 : Integrate Knowledge and Values into Decisions

The decision-making stage is the key point of uptake of information on ecosystems and their services. The information can be used to identify the most suitable policy options, instruments and incentives for implementation in order to achieve the intervention's objectives. It is guided by decision-support frameworks and procedures for assessing impacts and possible risks (e.g. ex-ante and ex-post assessments). The EU EIA and SEA Directives, the Habitats Directive or the Water Framework Directive provide key opportunities for integrating ecosystems and their services during the planning and authorisation of programmes, plans and projects. However, consideration of ecosystems and their services often needs to take place also in decision-making processes that are not subject to the ex-ante assessments.

3.4.1. Choosing desirable scenarios, intervention options and instruments

The information from the mapping and assessment of ecosystems and their services, and the scenarios developed during policy formulation, should inform the assessment of alternative policy options and their likely outcomes — for the policy or planning sector in question and for other relevant sectors. This should lead to a choice of intervention options and instruments.

3.4.2. Steering decisions towards maximising synergies and minimising trade-offs:

As in the guiding principles, policy and planning instruments should, on top of their objective, aim to maintain or enhance ecosystem resilience, while looking to maximise the delivery of multiple ecosystem services and avoid or minimise trade-offs among different services due to damage to the ecosystems in question, and considering restoration where possible.

Look out!	Prioritise scenarios or policy options that enhance biodiversity and ecosystem condition and support societal and economic benefits through the delivery of multiple ecosystem services. Such scenarios can yield long-term sustainable development benefits and avoid potentially substantial costs from the loss of ecosystem services (including the cost of compensating, if at all feasible, by means of natural and technological solutions).
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Ecosystem service synergies arise when multiple services are enhanced simultaneously, e.g. as a consequence of targeted measures to improve ecosystem conditions. Ecosystem service trade-offs occur when the provision of one ecosystem service is reduced as a consequence of increased use of another ecosystem service. They arise from management and behavioural choices that change the type, magnitude, and relative mix of ecosystem services provided by an ecosystem. As noted in Chapter 2, trade-offs can occur between benefits and costs borne by different stakeholders, between private and public benefits for the same area, between different areas but also between short-term and long-term benefits and costs for the same community or stakeholder.

In terms of **trade-offs**, an exchange of biodiversity losses for gains in (single) ecosystem services may not only conflict with international and EU nature conservation objectives but also lead to potential loss of ecosystem services to a wider range of beneficiaries. In the case of such

trade-offs, the option(s) that maintain or improve ecosystem condition and enable the delivery of ecosystem service related benefits to a wide group of beneficiaries (i.e. not only one sector) should be prioritised.

For example, single cropping systems are known to contribute to the loss of biodiversity and degradation of soil and water resources whereas multiple cropping systems can help to integrate ecosystem services into agricultural practices and support the delivery of multiple services (e.g. soil fertility) (See Case Example 1 in Section C).

The OPERAs project has researched trade-offs and synergies in ecosystem services in a variety of socio-ecological systems, and developed methods that can assist in navigating them⁷².

Scenarios entailing likely damage to biodiversity, ecosystems and/or related services would need to be balanced by significant gains in the absence of reasonable alternatives. In such cases, *the mitigation hierarchy* would form the basis for decision.

3.4.3. Applying the mitigation hierarchy to impacts on ecosystems and their services

Decisions on policies, plans and projects should aim to avoid or mitigate as much as possible negative impacts on biodiversity and ecosystems and, where this is not possible, restore ecosystems and offset unavoidable losses as a last resort. This includes ecosystems and their services in the wider landscape, i.e. also beyond protected habitats and species (see principle 3)⁷³.

Look out!	The mitigation hierarchy needs to be applied with careful consideration before moving to the next stage in the hierarchy, often iteratively, and always with adequate scrutiny by environmental authorities, and in a transparent manner for stakeholders.
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A wide variety of mitigation measures can be identified and carried out during the formulation stage, in order to **avoid** or at least **minimise** impacts on biodiversity and ecosystem services, such as:

- **Spatial** i.e. locating the development in an area that ideally avoids significant impacts or at least reduces them
- **Temporal**, i.e. carrying out activities at times that avoid or minimise impacts
- **Technical**, e.g. those that may reduce pollution, noise or other forms of disturbance
- **Management mitigation measures**, e.g. activities that prevent access of certain animal populations to an area of impact.

Relevant and feasible mitigation measures should be identified and incorporated into the proposed options, taken into account in the planning processes and incorporated into decisions, e.g. into development permits. In order to ensure implementation, mitigation measures should be

⁷² OPERAs: ‘How do you take into account trade-offs between ecosystem services in land management and decision-making?’ www.operas-project.eu.

⁷³ Without prejudice to protected habitats and species for which the provisions of Article 6(3) and Article 6(4) of the EU Habitats Directive apply. Updated Methodological guidance on the application of Articles 6(3) and 6(4) is to be published in 2019.

clearly defined with SMART biodiversity and ecosystem service objectives, based on sound scientific principles and evidence based best practice. They should take into account uncertainty, by incorporating additional contingency measures, have strict timetables, sufficient long-term arrangements and adequately monitored and publicly reported results.

It is important to give priority to **avoiding and minimising impacts** for a number of reasons. Natural ecosystems are often the result of millions of years of evolution and complex interactions, and it may not be possible to fully restore all but the simplest of ecosystems. Some impacts are irreversible, or their restoration may require hundreds of years. Offsetting will often be carried out at a different location to the impact site, and therefore unavoidable spatial or socio-economic impacts may occur — e.g. the loss of important recreational benefits for stakeholders in a certain area. In addition, measuring offsetting is linked to uncertainties and it may be difficult to ensure that it is effective or maintained in the long-run.

Nevertheless, **offsetting** is sometimes a necessary last resort and in some cases, it has been demonstrated to achieve No Net Loss or even net gains of biodiversity⁷⁴. Where offsets are required, the appropriate default position in terms of biodiversity is that impacts on one species or habitat are offset by equivalent gains in the same species or habitat — i.e. by ‘like-for-like’ (also sometimes known as in-kind offsets). Assessing biodiversity losses and gains to determine net outcomes requires adequate data management tools⁷⁵. Risks should be comprehensively and transparently spelled out and considered. Careful design and regulation supported by adequate oversight, monitoring and where necessary, enforcement, can reduce or eliminate some of these risks. The key design elements for biodiversity offsetting include consideration of the following:

- Whether compensation is required (issues of scope, conditions and threshold)
- What type of compensation is allowed (‘like for like’, potential for ‘trading up’, additionality)
- How much compensation is required (metrics to be used, multipliers for uncertainty)
- Where compensation should be delivered (location, compensation ‘service area’)
- When compensation should be delivered (temporal requirements, e.g. before, during or after the impact occurs).

In offsetting for ecosystem services, a range of further factors need to be considered, e.g. the location of the beneficiaries of the services in relation to the offset location; fairness and intergenerational justice, as well as long-term costs if technical alternatives are used to compensate the loss of services provided by nature for free.

74 An overview of offsetting principles, methods, research, planning practice and case studies in a range of EU Member States is provided in W. Wende et al. Biodiversity Offsets: European perspectives on No Net Loss of biodiversity and ecosystem services. Springer (2018).

75 See also [OPERAs: ‘What should the EU consider to move towards No Net Loss?’](http://www.operas-project.eu) www.operas-project.eu.

Box 11. Example of a national framework: NNL legislation in Germany

Germany's Impact Mitigation Regulations (IMR) provide a good example of a relatively strict and mandatory policy framework for restoring ecosystems, their services and also for biodiversity offsetting (Albrecht et al. 2014). These regulations were adopted in 1976 as part of the Federal Nature Conservation Act. They address the mitigation, compensation and offset of impacts from developments and projects. Precautionary in nature, they are not only related to biodiversity but also constitute an instrument of landscape conservation. The IMR have to be applied at the level of individual projects, such as the development of new residential areas or the construction of roads or railways. The main objectives of the IMR, when applied properly are to avoid significant negative effects and to ensure compensation for impacts on natural assets such as habitats, soil, water, climate and air quality as well as the aesthetic quality of the landscape. At a minimum, the existing ecological situation is to be preserved ('no net loss' principle).

Operational principles, guidance, metrics and extensive case studies on the application of the mitigation hierarchy to biodiversity and ecosystem services have been developed in the scope of Action 7b (Achieving No Net Loss of ecosystems and their services) of the EU Biodiversity strategy to 2020. Further guidance, tools, studies and reports and further resources are referenced in Section A.

3.4.4. Informing and engaging stakeholders and raising awareness

As explained in Principle 2.2, interventions and management decisions to achieve a socio-economic objective, or to maximise a selected ecosystem service, may result in pressures or alteration of ecosystem structure and functions to the detriment of other ecosystem services. The resulting trade-offs — between benefits for the same or different stakeholders, between different areas or between short-term and long-term benefits — need to be well understood by all parties and handled in a fair and equitable way.

It is critically important that stakeholders are able to fully understand information on the likely outcomes for ecosystems and their services under different scenarios, and to get engaged in a discussion on these outcomes including potential trade-offs. Engagement with relevant sector administrations, supported by capacity building and the provision of maps, data and other information in appropriate and accessible form, is required to ensure this. Similarly, awareness-raising activities are needed to ensure that the stakeholders participating in the process are appropriately informed, remain motivated and are able to provide feedback and reach consensus based on the best available evidence and information.

3.4.5. Choosing the right implementation instruments

Implementation instruments form the basis for management action on the ground. Choosing the right implementation instruments is crucial for the success of the intervention. Instruments for implementing ecosystem services into practice in the context of (sectoral) policies and

decisions vary widely across the EU. They include legislative instruments, a range of spatially explicit instruments (designation and management of protected areas such as Natura 2000 sites, national to local zoning and land-use plans, green infrastructure plans etc.), and market-based policy instruments.

Legislative instruments include EU and national regulations and decisions, including any dedicated provisions for ecosystem conditions and/or services. Furthermore, a range of sector-specific instruments are in place to allocate financing from public budgets towards policy implementation. An increasing number of market-based instruments such as payments for ecosystem services, certification and procurements schemes, offsetting schemes etc. can be used to support integration.

Box 12: Key market-based and voluntary instruments for ecosystem services integration

Payments for ecosystem services (PES): PES schemes provide incentives to landowners to manage their land and/or resources in a way that preserves or enhances ecosystems' ability to provide different ecosystem services. PES schemes can be established at different levels of governance, from national to local, and used to target a range of different ecosystems and related sectoral activities. In Europe to date, PES schemes are most commonly associated with agriculture and/or water management with some schemes also targeting forests, peatlands, grasslands and floodplains⁷⁶. Results-based payments schemes established under the EAFRD pioneer the PES-type approach at the EU level.

Offsetting schemes: Offsetting schemes are aimed at compensating for adverse biodiversity or ecosystem impacts arising from project development across different economic sectors. They are to be used only after appropriate prevention and mitigation measures have been taken to avoid such impacts, following the mitigation hierarchy (see principle 2.3 and sub-chapter 3.4.3). At the EU level, Article 6.4 of the Habitats Directive establishes a requirement for developers to compensate for (i.e. offset) unavoidable impacts on the Natura 2000 network. In addition, a number of countries, including France, Germany, Sweden and the UK, have taken up broader national or regional offsetting initiatives. Most offsetting schemes to date focus on the impacts on species and habitats however they can, in principle, be designed to also compensate for the loss or degradation of ecosystem services to stakeholders.

Green public procurement (GPP): GPP is a process whereby public authorities seek to procure goods and services with a reduced environmental impact. Criteria for GPP can include elements that encourage integration of ecosystem services into different sectors by opting for providers of goods and services that use nature-based solutions as part of their business model. This could, for example, include using producers that have signed up to voluntary guidelines for sustainable agriculture, including maintenance of natural pollinator populations.

Certification schemes: Certification schemes can be used as a means to incentivise sectoral actors (e.g. business) whose products and/or production methods proactively enhance

⁷⁶ Illes et al. 2017: https://ieep.eu/uploads/articles/attachments/dcc74b53-6750-4ccd-99b9-dc9e9d659dd4/IFMs_for_biodiversity_EUROPE_Illes_et_al_2017.pdf?v=63664510044.

conservation objectives (e.g. maintenance or restoration of ecosystem services). Commonly such schemes take the form of eco-labels, which identify overall environmental preference of a product (i.e. good or service) based on a life cycle consideration. They are awarded by an impartial third party to products that meet established environmental criteria. To date, a number of certification schemes take biodiversity issues into consideration (e.g. [EU FLEGT licence for sustainably harvested timber](#)), however schemes explicitly focused on ecosystem services are still rare.

Voluntary codes of conduct: Voluntary codes of conduct are non-binding practices that businesses, producers of land-owners and –managers in different sectors adopt to carry their operations in a way that benefits both themselves and wider public good (e.g. environmental objectives). Such codes of conduct can be taken up by actors of any sector (water, forestry, agriculture, tourism etc.) with an aim to acknowledge the importance of ecosystem services to their own viability and societies’ wellbeing. As such, codes of conduct help to ensure long-term basis of an economic activity while also possibly providing an attractive competitive advantage in the eyes of consumers. Examples of existing voluntary initiatives target both national actors (e.g. [FAO code of Conduct for Sustainable Fisheries](#)) or individual businesses (e.g. biodiversity and ecosystem standards by [Shell](#)).

Box 13. Practical examples of private sector standards:

The UK Peatland Code

The development of voluntary standards for the private sector can facilitate creating markets for peatland climate benefits, making peatland restoration attractive for business sector sponsors. The UK Peatland Code demonstrates how such a framework can be developed and taken up in practice through targeted science-policy research and pilot projects. The Peatland Code is a voluntary standard which provides restoration projects with best practice guidance and standard quantification methods to prove their climate benefits. It was developed from 2011 to 2015 within a range of pilot research projects on Payments for Ecosystem Services funded by the Department for Environment, Food and Rural Affairs (Defra) of the United Kingdom. The standard is issued by the IUCN UK National Committee and is managed by an Executive Board, facilitated by the IUCN UK Peatland Programme and supported by a Technical Advisory Board. *For further information, see Section C — Case Study 7.*

Private investment environmental and social standards by the IFC

The International Finance Corporation (IFC) Environment and Social Performance Standards define IFC clients’ responsibilities for managing their environmental and social risks. The IFC’s Sustainability Framework, which includes the Performance Standards, applies to all investment and advisory clients whose projects go through IFC’s initial credit review process. IFC recently looked at the performance of 656 companies in their portfolio and found that companies with good E&S performance tend to outperform clients with worse environmental and social performance on return on equity and return on assets. IFC Environment and Social Performance standard PS6 recognises that protecting and conserving biodiversity, maintaining ecosystem

services, and managing living natural resources adequately are fundamental to sustainable development. The IFC Good Practice Handbook for the agro-commodity supply chain guides companies on conducting sustainable business in, for example, the palm oil, soy, cacao or coffee primary supply chains.

The Corporate Ecosystem Services Review promoted by the World Resources Institute and the World Business Council for Sustainable Development builds on IFC E&S Performance Standard 6 and consists of a structured methodology that helps managers proactively develop strategies to manage business risks and opportunities arising from their company’s dependence and impact on ecosystems. It is a tool for strategy development, not just for environmental assessment. Examples that show how the standard has been applied can be found in the work of the World Business Council for Sustainable Development, such as the Cement Sustainability Initiative.

For further information, see Section C — Case Study 12.

Instruments and tools need to be applied in combination in order to achieve successful integration. There are hierarchical interlinkages and interdependencies between different instruments, reflecting the characteristics of decision-making at the different levels of governance.

Look out!	Different instruments are interlinked, playing dedicated roles in the integration process at different levels of EU governance.
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The application of all instruments needs to be supported by cross-cutting actions for awareness raising, capacity building and stakeholder consultation. For example, information instruments require inputs from a range of stakeholders, ranging from local actors (e.g. monitoring) to regional and national institutions (e.g. data collation and analysis).

Section A provides references and further resources on instruments and tools for implementation.

3.5. STEP 5 : Implement, Monitor and Review

3.5.1. Applying an adaptive management approach

The key steps for the integration of ecosystems and their services are taken in the formulation and decision-making stages. However, it is also important to engage in **adaptive management** during implementation to ensure that new developments and evidence from monitoring the consequences of decisions are taken into consideration. This will ensure continuous learning and adjustments to improve implementation (see also Chapter 2 on guiding principles). Building mechanisms for adaptive management into policies, plans or other decision-making frameworks is especially important when dealing with uncertainties, increasing pressures from global change and ongoing knowledge creation on ecosystems and their services.

3.5.2. Ensuring implementation capacity

Capacity-building and awareness-raising activities are crucial as part of continuous efforts to engage with stakeholders and promote effective implementation. This includes activities such as training to improve the capacity of national and regional decision-makers to integrate ecosystems and their services into their processes. It also includes systematically informing different (sectoral) stakeholders of the benefits of maintaining or restoring ecosystems and their services through policy implementation. For this task, it is considered best practice, as part of the implementation process, to create a dedicated communication plan on the benefits provided by ecosystem services. Finally, successful implementation of policy instruments must be supported by **appropriate financial and staffing resources**.

3.5.3. Monitoring and evaluation based on suitable indicators

As explained in Chapter 3.2, the framework for the assessment of ecosystems and their services, and any other monitoring indicators developed during the formulation and decision-making stages, are important tools for monitoring how decisions affect ecosystems and their services. The framework and monitoring indicators also help decision-makers to take corrective or adaptive action if necessary.

The selected indicators for biophysical status of ecosystems and their services, and the socioeconomic value of these services, help to target monitoring and evaluation efforts. They also link the results to assessments, evaluations, and reviews of the approach or of the objectives.

As in the earlier stages of the policy and/or decision-making cycle, it is important to make available to stakeholders and the broader public the results of monitoring and evaluations of how a policy affects ecosystems and their services. This is especially important for creating support for policy implementation. It is also important for making any required changes to the policy regime to improve its effects on ecosystems and their ecosystem services.

3.5.4. Ensuring resources for implementation at different stages of the cycle

Existing EU and national assessments of biodiversity-policy implementation point to a lack of resources (e.g. financing, human resources or expertise) as one of the key barriers to effective implementation⁷⁷. It will therefore be crucial to assess the resource needs and ensure there are sufficient resources to support the integration of ecosystems and their services throughout the policy cycle, including for implementation and monitoring. This means, for example, having processes in place that allow the funding allocations (e.g. funding from the EU budget) to be absorbed by stakeholders as planned.

⁷⁷ http://ec.europa.eu/environment/nature/legislation/fitness_check/index_en.htm

Box 14. Practical examples at the regional and local levels

The Interreg Europe BID-REX project

EU funding can support capacity building and the establishment of science-policy structures for the integration of ecosystem services into regional development policies. The **Interreg Europe project ‘From biodiversity data to decisions: enhancing natural value through improved regional development policies’ (BID-REX)** seeks to protect and enhance natural capital by improving regional development policies. It brings together public authorities and research institutions in seven European regions in six Member States. By promoting the increased use of biodiversity information to prioritise biodiversity measures in decision-making, BID-REX aims to increase the impact of European Regional Development Fund funding across Europe. Each of the seven project regions has created a policy instrument that it will seek to improve.

For more information, see Section C — case study 11.

Climate bonds to support the establishment of green spaces in Paris

In 2015, the city of Paris issued its first climate bond to mobilise finance from the private sector to help fund its sustainability programme. This programme included the creation of a EUR 60 million territorial adaptation plan with tree-planting programmes and projects to create new green areas, green roofs, green facades and green walls. The goal was to prepare the city for future climate change and resource scarcity through (i) protection from extreme climate events; (ii) ensuring the supply of water, food and energy; (iii) more sustainable city planning; and (iv) fostering new lifestyles and solidarity. The success of the bond sale has been underpinned by a clear financial framework, the well-structured use of funds, frequent reporting, and collaboration between internal and external participants with clear responsibilities all coordinated by the financial office. A new Paris sustainability bond is planned for 2019 and a resilience bond is projected for 2020.

For further information, see Section C — case study 13.

Funding is used to develop, implement and monitor the policies and decisions of relevance to ecosystem services. It is crucial to assess the availability, uptake and effectiveness of this funding. And this assessment should form a crucial part of the monitoring and evaluation stage. Depending on the results, the evaluation may provide recommendations for improving the uptake of funding (e.g. capacity building) or increasing its availability. The dedicated [framework for tracking expenditures on biodiversity across EU funds](#) forms the basis for monitoring biodiversity expenditure at the national and regional level.

Box 15. National-level methodologies and approaches

The **Biodiversity Finance Initiative [BIOFIN](http://www.biodiversityfinance.net)**⁷⁸ has developed a methodology to measure biodiversity expenditure, assess financial needs, and identify the most suitable finance solutions. This methodology is based on several assessment steps that culminate in the creation of a national biodiversity finance plan. The finance solutions produced by this methodology contribute to a country's national biodiversity targets by identifying revenue, realigning expenditure, avoiding unnecessary future biodiversity expenditure, and delivering financial resources more effectively and efficiently. The BIOFIN knowledge platform offers a series of webinars on the BIOFIN methodology and on finance solutions.

The **OECD [Paris Collaborative on Green Budgeting](http://www.oecd.org/environment/green-budgeting/)**⁷⁹ works with governments, institutions and experts to embed environmental goals within national budgeting frameworks. It aims to design innovative tools to align national expenditure and revenue processes with climate and environmental goals.

3.5.5. Ensuring that the institutional setting caters for integration (including stakeholder engagement)

Integration of ecosystems and their services requires three different types of information flows:

- knowledge from the expert and scientific community (e.g. on the status and trends in biodiversity, ecosystem condition and the delivery of ecosystem services);
- knowledge and views from the wider community of stakeholders and interest groups (e.g. local knowledge to assess the relative importance of ecosystem services); and
- sharing of this information between relevant decision-makers and across policy sectors.

Institutional structures should be in place or created to allow information on ecosystems and their services to be taken up throughout the different stages of the decision-making process. Such structures include science-policy working groups, expert committees, advisory bodies and wider stakeholder consultation settings (e.g. statutory hearing processes, stakeholder interviews and online consultations or other consultation fora). Public hearing processes are a common practice in legislative decision-making across the EU (for example, they are integral to EU legislative procedures). Sometimes these public hearing processes involve the expert community although this is not necessary. In addition, structured meetings between representatives of different policy sectors play a crucial role in decision making, identifying synergies and trade-offs.

These processes can also be targeted to engage certain stakeholder groups (such as businesses or landowners). In addition, engagement of the general public can be promoted through local action groups or community/stakeholder councils.

78 Biodiversity Financing Initiative (BIOFIN): <http://www.biodiversityfinance.net/about-biofin/biofin-approach>.

79 <http://www.oecd.org/environment/green-budgeting/>.

Finally, inter-ministerial committees and working groups supported by an internal consultation process are commonly used to promote information flow between policy domains at EU, national and regional level.

The instruments and processes outlined above can be established on a temporary basis (e.g. to support policy formulation and decision-making) or on a more permanent basis (e.g. to support implementation and evaluation on an ongoing basis). In general, more permanent instruments and processes (e.g. community/stakeholder council, local action groups, etc.) benefit from an institutional memory and thus gain the most from awareness raising efforts.

An overview of different institutional and stakeholder engagement instruments is provided in Section A to this document.

The case studies outlined below (Box 3.15 and Box 3.16) illustrate how the integration steps are used to inform and shape policy and planning decisions.

Box 16. Case study: Ecosystem service mapping and assessment to support the urban plan of Trento, Italy

Trento is an Alpine city of 120 000 inhabitants in north-eastern Italy. In 2017, the municipal administration started drafting a new urban plan for the city and engaged in a science-policy process to assess and integrate ecosystem services into its decision-making process.

Step 1: Set out the purpose, scope and context of the assessment

The overall purpose of the assessment was to enhance the provision of ecosystem services and related benefits through the actions and instruments of the Trento urban plan. The city raised specific policy questions about the potential uses of ecosystem-service knowledge to support the planning process. These questions were:

- how can knowledge of ecosystem services improve the identification of the structural ‘elements’ of the urban plan?
- how can an assessment of ecosystem services support the comparison of specific planning options?

Step 2: Screen and prioritise ecosystems and their services for assessment

An initial screening led to the identification of six relevant urban biodiversity benefits and ecosystem services:

- habitat provision for focal species;
- hydrogeological risk mitigation (rock falls, landslides, floods);
- air purification and noise reduction;
- food production;

- microclimate regulation;
- nature-based recreation.

Two ecosystem services were selected for more detailed quantitative assessment. These services, and the reasons they were selected, are listed below.

- **Microclimate regulation:** this ecosystem service was selected for more detailed assessment due to growing concerns over intense summer heat waves in the city. The most urbanised and sealed part of the city is particularly exposed to this problem, causing peaks in energy demand, and posing serious threats to the health and well-being of the general public.
- **Nature-based recreation:** this ecosystem service was selected for more detailed assessment due to one of the main objectives of the city administration: to enhance public green areas, particularly in deprived neighbourhoods, to provide equal opportunities to the general public for recreation and relaxation.

Step 3: Map, assess and value ecosystems and their services

Most of the selected ecosystem services were assessed using spatial proxies or simple modelling. Microclimate regulation and nature-based recreation were subject to detailed assessments. The mapping and assessment of microclimate regulation used a method to analyse shading and evapotranspiration effects, by considering soil cover, canopy coverage, and the size of green areas (Zardo et al., 2017). For the mapping and assessment of potential opportunities for nature-based recreation, existing recreation modelling was adapted to the Trento context (types of recreational activities and related natural settings). The approach combined indicators for the availability and accessibility of nature-based recreational areas (Cortinovis et al., 2018). (*see also Box 3.16 below for further detail on how the ESTIMAP tool was used in this case*).

The recently completed urban ecosystem-services assessment addressed the first policy question through the identification of ‘ecosystem-service hotspots’. A more detailed ecosystem-services assessment is underway to address the second policy question. This more detailed ecosystem services assessment is also considering demand for ecosystem services, leading to (i) the identification of disadvantaged neighbourhoods, and (ii) suggestions for how to meet current and future demand. One example of how the approach was used was in a comparison of different greening interventions in brownfield sites (Geneletti et al., 2016). Scenarios were assessed by quantifying the expected benefits from the interventions on different groups of the surrounding population. These scenarios were based on demographic characteristics that determined, for example, recreation needs or vulnerability to heat waves. Similar scenario analyses will be conducted in the remaining part of the planning process to support land-use decisions.

Step 4: Integrate knowledge and values into decisions

The analysis of the delivery of ecosystem services by green and blue infrastructure led to the identification of ‘**ecosystem-service hotspots**’ (areas that are instrumental to ensuring a high level of ecosystem services). These hotspots will become part of the structural ‘elements’ of the urban plan and will be protected from urbanisation (urban plans already protect from urbanisation the more traditional ‘elements’ such as protected areas, areas subject to hydrological risk, etc.). In doing this, the urban plan’s design integrates urban green and blue infrastructure as

important parts of the urban system. The Trento authorities are considering different actions to improve the current network of green and blue spaces based on the hotspots, thus increasing both connectivity and the provision of ecosystem services.

The results of the ongoing and more detailed ecosystem service assessment will form the basis for a decision on the **specific requirements for future urban transformations**. Such requirements will be place-specific and will have two aims: to safeguard the current provision of key ecosystem services, and to enhance their provision in areas of the city where they are most needed. These goals will be pursued by designing **performance-based indicators** and **compensation schemes**.

The process: Researchers from the University of Trento were engaged from the start to carry out an urban ecosystem-services assessment and propose measures in the planning process. They drew on experience from work on the MAES urban pilot (a study in the city of Trento) and the ESMERALDA project on ecosystem-services mapping and assessment. The city planning department helped draft the policy questions for the assessment and selection of ecosystem services, and provided feedback on the results. The assessment outcomes and emerging issues in the drafting of the new urban plan are periodically discussed in a wider science-policy working group. This working group includes academics, local practitioners from various disciplines, NGOs, and representatives of the general public. A consultation process (online questionnaires and follow-up discussions) involved 17 experts in the assessment of nature-based recreation, including officers from several municipal and provincial departments, researchers from various institutions, and local practitioners.

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Box 17. CASE STUDY: Ecosystems-Services Assessment in the River Basin Management Plan for the Scotland River Basin District,

The river basin management plan (RBMP) of the Scotland river basin district is the primary tool for achieving good ecological status under the EU Water Framework Directive (WFD). The draft of the first RBMP (2009-2015) was subject to a strategic environmental assessment (SEA), which addressed the potential impacts of the measures proposed in the RBMP on a range of parameters related to ecosystem services (although the term ‘ecosystem services’ was not used).

The drafting of the RBMP was carried out in five steps, described below.

Step 1: Set out the purpose, scope and context of the assessment

The preparatory work for the first RBMP included an economic analysis of water use in the river basin district to inform the development of measures necessary for Scotland’s waters.

Step 2: Screen and prioritise ecosystems and their services for assessment

The preparatory work for the first RBMP included an assessment of a limited set of ecosystem services: clean drinking water, irrigation, industrial water use, aquaculture, salmon angling.

Step 3: Map, assess and value ecosystems and their services

Valuation methods used in the economic assessment of the above uses included netback analysis, avoided cost, willingness to pay, stated preference and travel cost. Some of these valuation methods also made use of the benefits-transfer method. The SEA considered a baseline scenario without RBMP, a scenario that implemented the proposals in the draft RBMP, and a continued improvement scenario (implementation of RBMP measures plus additional measures). The assessment incorporated stakeholders’ input through a consultation on the RBMP and on the SEA itself.

Step 4: Integrate knowledge and values into decisions

The first RBMP integrated ecosystem services as being among the ‘multiple benefits’ provided by aquatic ecosystems in good condition, which support the well-being of people and the economy. The analysis of the value of water for different uses, and of the impacts of economic activities on water was used to inform the programmes of measures. These programmes of measures included a range of legislative instruments, education initiatives, regulatory checks, codes of practice and economic instruments to reduce pressures on the water environment and deliver multiple benefits. The assessment determined that the measures had many positive impacts on biodiversity; water quality; recreation; amenity value; mitigation of — and adaptation to — floods and drought; and climate-change adaptation. The assessment also proposed methods to mitigate adverse impacts on these parameters.

Step 5: Implement, monitor and review

The measures in the RBMPs are further elaborated at the sub-basin level in area management plans developed and implemented by multi-stakeholder area advisory groups. In some cases, local catchment managers develop and implement the RBMP at local level. For example, projects in the Forth sub-basin have embraced the concept of multiple benefits from improving

the ecological condition of waterbodies.

Monitoring and review: the Scottish Environmental Protection Agency ensures implementation of the RBMP and monitors the progress of this implementation. The condition of waterbodies is reviewed annually, reported every 6 years, and used to inform future planning cycles. The second RBMP (covering the period 2015-2027) refers to the ‘wider range of benefits’ that can be delivered if the condition of waterbodies is improved. A statutory consultation was conducted on the current condition of Scottish waterbodies and the challenges these waterbodies faced in the future. The consultation document also referred to the ‘range of benefits that the water environment provides to us’. The Scottish Environmental Protection Agency also created a data application with an interactive tool containing maps of ecosystem services by individual waterbodies.

More information: SEPA, 2009. Scottish RBMP and supporting documents.

<https://www.sepa.org.uk/environment/water/river-basin-management-planning/publications/>.

Box 18. The ESTIMAP ecosystem services mapping tool

ESTIMAP is a suite of GIS models to spatially quantify ecosystem services to support policies at a European scale. It is continuously updated with new models and for different types of applications. Nature based recreation, Pollination, Coastal Protection and Flood Control are “Advanced multiple layer LookUp Tables” (Advanced LUT). Air quality regulation is based on land use regressions (LUR). Advanced LUT assign ecosystem services scores to land features according to their capacity to provide the service. The values of ecosystem services scores for each input are generated from either literature review or experts input. The final value is based on cross tabulation and spatial composition derived from the overlay of different thematic input maps (Zulian et al. 2017).

ES model	Applications
Nature-based recreation	<p>EU- scale Assessment of ES sustainability in the Mediterranean Sea (Liquete et al. 2016) Trends in ecosystems and ecosystem services in the European Union (2000 – 2010) (Maes J., Fabrega N., Zulian G. et al. 2015) Ecosystem services accounting (Vallecillo et al. 2019) EU-wide assessment of urban ecosystem services (Maes et al 2019)</p> <p>Local scale Assessment of urban nature-based recreation (Baró et al. 2016; Cortinovis et al. 2018) Analysis of nature based recreation in rural-mixt landscapes and protected areas (Zulian et al. 2017)</p> <p>Key publications: Paracchini et al. 2014; Zulian et al. 2017</p>
Pollination	<p>EU- scale Trends in ecosystems and ecosystem services in the European Union (2000 – 2010) (Maes J., Fabrega N., Zulian G. et al. 2015) Ecosystem services accounting (Vallecillo et al. 2018) EU-wide assessment of urban ecosystem services (Maes et al 2019)</p> <p>Local scale Assessment of urban pollination to support beekeeping zoning (Stange et al. 2017; https://oppla.eu/casestudy/19231) Mapping Urban Pollination in Helsinki-Vanta and Espoo (FI) (https://oppla.eu/casestudy/19226)</p> <p>Key publications: Zulian et al. 2013</p>
Coastal Protection	<p>EU-scale Assessment of ES sustainability in the Mediterranean Sea (Liquete et al. 2016)</p> <p>Key publications: (Liquete et al. 2013)</p>
Flood control	<p>EU-scale Ecosystem services accounting (Vallecillo et al. 2019) EU-wide assessment of urban ecosystem services (Maes et al 2019)</p> <p>Key publications: Vallecillo et al. 2019</p>
Air quality regulation	<p>EU-scale Trends in ecosystems and ecosystem services in the European Union (2000 – 2010) (Maes J., Fabrega N., Zulian G. et al. 2015)</p> <p>Local scale Assessment of air quality regulation in urban areas (Baró et al. 2016)</p>

EXAMPLES OF THE USE OF ESTIMAP

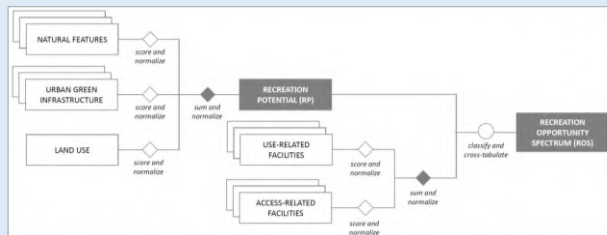
RECREATION OPPORTUNITIES IN URBAN AREAS: TRENTO (CORTINOVIS ET AL. 2018)

This example elaborates on the Trento case study provided in Section C and box 3.14 above. Trento offers its citizens a diversified portfolio of opportunities for day-to-day nature-based recreation. Citizens benefit from the proximity to different typologies of green infrastructure where they conduct a wide range of recreational activities. In addition to typical “urban” activities commonly carried out in urban parks (e.g., playing with children, walking, and meeting with friends), popular day-to-day recreational activities in Trento include hiking, mountain-biking, skyrunning, and climbing in nearby forests and mountain areas.

Policy question: How and where can the municipality promote nature-based recreation through a multifunctional urban green infrastructure?

Model configuration

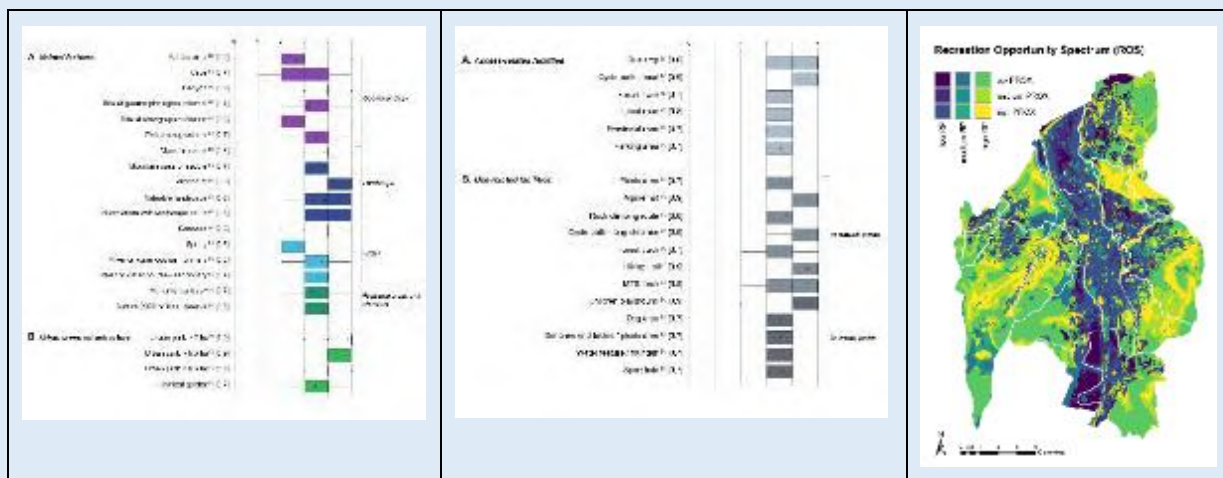
Example of model configuration adapted to map urban recreation in Trento.



The model was adapted to the local setting engaging 19 local stakeholders. Experts were invited, in collaboration with the municipal department responsible for green infrastructure planning, to interactive workshops and focus groups to discuss the types of recreation activities and the relative

importance of the different elements included to map areas suitable to support recreation activities. A survey was prepared to collect the scores.

Examples of resulting maps



<i>Example of scores implemented to map the suitability of Natural features</i>	<i>Example of scores implemented to map the use related facilities</i>	<i>Recreation Opportunity Spectrum Map</i>
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The table below provides a district-level comparison among values of total and per-capita area of urban parks and total and per-capita area in the highest class of the recreation opportunity spectrum (ROS): close to nature-based recreation opportunities and close to facilities (modified from Cortinovis et al. 2018).

District	District Area [ha]	Urban Parks [m ²]	Areas in the Highest Class of ROS [m ²]	Population	Per-Capita Area of Urban Parks [m ² /person]	Per-Capita Area in the Highest Class of ROS [m ² /person]
Vigolo	306.64	986	196,252	334	3	587.6
Villamontagna	302.68	2111	1,558,512	1263	1.7	1234
Villazzano	734.28	63,251	1,622,761	5042	12.5	321.8
<i>Total (city)</i>	<i>15,784.34</i>	<i>936,191</i>	<i>20,949,729</i>	<i>116,994</i>	<i>8</i>	<i>179.1</i>

The ESTIMAP recreation model combined with a simple accessibility model proved to be a relatively simple and effective method to identify unsatisfied demand for nature-based recreation: a key information for urban planning, especially when an equal distribution of ecosystem services is among the goals of planning actions.

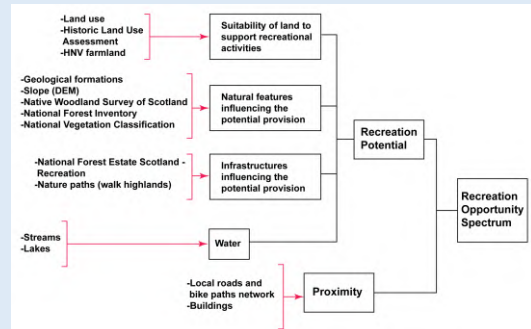
RECREATION OPPORTUNITIES IN A PROTECTED AREA (DICK ET AL 2019, SUBMITTED)

The Cairngorms National Park (CNP), was established in September 2003 in accordance with the National Parks (Scotland) Act 2000. The four aims set out in the National Parks (Scotland) Act 2000 are: (i) to conserve and enhance the natural and cultural heritage of the area; (ii) to promote sustainable use of the natural resources of the area (iii) to promote understanding and enjoyment (including enjoyment in the form of recreation) of the special qualities of the area by the public; and (iv) to promote sustainable economic and social development of the area's communities. These multiple aims are managed by the Cairngorms National Park Authority (CNPA). The CNP encompasses 6% of the land mass of Scotland (4528 sq kilometres) and is home to a population of some 18,000 people which has been growing steadily since 2001. In addition, about 1.7 million people visit the National Park each year.

Policy question: Where are located key areas for nature based recreation activities and what type of users are they suitable for? Can we avoid or manage negative impacts on wild life conservation?

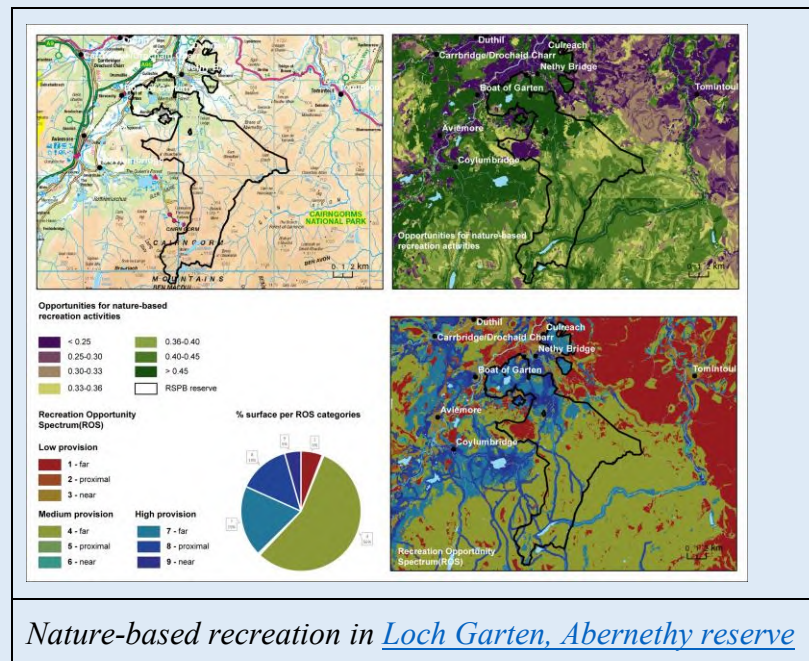
Model configuration

Example of model configuration adapted to map recreation in CNP.



The model was adapted to the local setting engaging 33 local stakeholders. Experts were invited to interactive workshops and focus groups to discuss the model configuration and the relative importance of the different elements included to map areas suitable to support recreation activities. Particular attention was paid to the distinction between *hard* (e.g. trekking, canyoning) and *soft* (e.g. wildlife viewing or easy walking) recreation activities.

Examples of resulting maps



Nature-based recreation in [Loch Garten, Abernethy reserve](#)

Results were considered relevant from local stakeholders to inform decision makers on human

preferences in terms of cultural ecosystem services and wildlife in a protected area. The information provided by the spatial modelling has already been used to manage human-nature interaction in the siting of car parking facilities encouraging people to walk in areas that minimised their impact on wildlife.

POLLINATION IN URBAN SETTING OSLO (STANGE ET AL. 2017)

Oslo, Norway's capital city is the municipality with the country's highest biodiversity, with the largest number of recorded observations of the country's rare and red-listed species and numerous habitat types with high levels of local biodiversity. Oslo also features a growing community of urban beekeepers—experiencing a rapid rise in the number of beehive locations since 2012, following the founding of a local chapter of the Norwegian beekeepers association. Norwegian legislation stipulates that government bodies such as the Oslo municipality must act to safeguard against loss of both species and habitat types, with particular emphasis on rare and threatened species. As a precautionary measure to guard against negative effects that high honeybee densities could have on nationally and internationally important biodiversity, Oslo Urban Environmental Agency has proposed establishing eight “precautionary zones” within the municipality, within which placement of honeybee hives could be more strictly regulated.

Policy question: Where are areas of potential competition between honeybees and wild pollinators?

Model configuration



The model was adapted to the local setting engaging local experts and collecting field data on flower visiting insects.

High-resolution maps were used to increase accuracy and spatial precision; disturbance from high traffic roads was included. The final aim was to develop an appropriately parsimonious model to describe local variation of resources that determine urban and peri-urban pollinator abundance.

Figure 1: Pan trap used to collect insects. Results were used to set model parameters.

Examples of resulting maps

<p><i>Figure 2: Map of pollinator habitat quality scores and locations of pan traps used for model validation</i></p>	<p><i>Figure 3: Map of relative honeybee foraging densities and locations of beehives.</i></p>	<p><i>Figure 4: Map of relative competition potential</i></p>

Implications for managing urban biodiversity

Bees' integral role in plant reproduction means that the ESTIMAP model can represent spatial distribution of Oslo's broader urban biodiversity. Bees' ability to capitalize on small patches offer opportunities for small actions to yield large benefits. Citizen engagement in increasing floral resources can contribute to more sustainable urbanization

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GLOSSARY OF TERMS

Analytical framework: An analytical framework consists of a conceptual framework complemented with the main definitions and classifications needed for its operational use (based on OECD, 2016)

Assessment: The analysis and review of information derived from research for the purpose of helping someone in a position of responsibility to evaluate possible actions or think about a problem. Assessment means assembling, summarising, organising, interpreting, and possibly reconciling pieces of existing knowledge and communicating them so that they are relevant and helpful to an intelligent but inexpert decision-maker. Assessments are inherently transdisciplinary processes where scientists and stakeholders work together to match data to the elements of a shared a conceptual framework (based on Parson, 1995).

Assets: Economic resources (TEEB, 2010). Ecosystems with their respective extent and condition can be considered as *ecosystem assets* (based on SEEA-EEA, 2012).

Benefits: Positive change in wellbeing from the fulfilment of individual or societal needs and wants (based on TEEB, 2010).

Biodiversity: The variability among living organisms from all sources, including inter alia terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species, and of ecosystems (based on CBD, 1992).

Capacity (for an ecosystem service): The ability of a given ecosystem to generate a specific ecosystem service in a sustainable way (based on SEEA-EEA, 2012).

Conceptual framework: A model describing the relevant elements of a physical or social system and the main connections between them for the purposes of understanding and communication

Conservation status (of a natural habitat): The sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species (EEC, 1992).

Conservation status (of a species): The sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations (EEC, 1992).

Drivers of change: Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver of change unequivocally influences ecosystem processes and can therefore be identified and measured to differing degrees of accuracy; an indirect driver of change operates by altering the level or rate of change of one or more direct drivers (MA, 2005).

Ecological status (of freshwater ecosystems): a legally defined expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters (EC, 2000).

Ecological value: Non-monetary assessment of ecosystem integrity, health, or resilience, all of which are important indicators to determine critical thresholds and minimum requirements for ecosystem service provision (TEEB, 2010).

Economic valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) in monetary terms (TEEB, 2010).

Ecosystem: 1 (*in a general context*): A dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit. Humans may be an integral part of an ecosystem, although 'socio-ecological system' is sometimes used to denote situations in which people play a significant role, or where the character of the ecosystem is heavily influenced by human action (based on CBD, 1992 and MA, 2005). 2 (*in the MAES context*): An ecosystem type.

Ecosystem accounting: Ecosystem accounting is a coherent and integrated approach to the measurement of ecosystem assets and the flows of services from them into economic and other human activity (SEEA-EEA, 2012)

Ecosystem assessment: A social process through which the findings of science concerning the causes of ecosystem change, their consequences for human well-being, and management and policy options are brought to bear on the needs of decision-makers (UK NEA, 2011).

Ecosystem condition: The physical, chemical and biological condition or quality of an ecosystem at a particular point in time (definition used in MAES). The Millennium Ecosystem Assessment has defined ecosystem condition as the capacity of an ecosystem to deliver ecosystem services, relative to its potential capacity (MA 2005). The SEEA-EEA defines ecosystem condition as the overall quality of an ecosystem asset in terms of its characteristics.

Ecosystem degradation: A persistent decline in the condition of an ecosystem.

Ecosystem extent: The spatial area covered by an ecosystem or ecosystem type (based on SEEA-EEA, 2012).

Ecosystem process: Any change or reaction, which occurs within or among ecosystems, physical, chemical or biological. Ecosystem processes include decomposition, production, nutrient cycling, and fluxes of nutrients and energy (MA, 2005).

Ecosystem service: The contributions of ecosystems to benefits obtained in economic, social, cultural and other human activity (based on TEEB, 2010 & SEEA-EEA, 2012). The concepts of 'ecosystem goods and services', 'final ecosystem services', and 'nature's contributions to people' are considered to be synonymous with ecosystem services in the MAES context.

Ecosystem status: Ecosystem condition defined among several well-defined categories with a legal status. It is usually measured against time and compared to an agreed target in EU environmental directives (e.g. Habitats Directive, Water Framework Directive, Marine Strategy Framework Directive), e.g. "conservation status".

Ecosystem type: A specific category of an ecosystem typology.

Ecosystem typology: A classification of ecosystem units according to their relevant ecosystem characteristics, usually linked to specific objectives and spatial scales.

Environmental status (of marine ecosystems): the overall state of the environment in marine waters, taking into account the structure, function and processes of the constituent marine ecosystems together with natural, physiographic, geographic, biological, geological and climatic factors, as well as physical, acoustic and chemical conditions, including those resulting from human activities inside or outside the area concerned (EC, 2008).

Flow (of an ecosystem service): The amount of an ecosystem service that is actually mobilized in a specific area and time (based on Openness, 2014).

Habitat: 1. (*in a general context*): The physical location or type of environment in which an organism or biological population lives or occurs, defined by the sum of the abiotic and biotic factors of the environment, whether natural or modified, which are essential to the life and reproduction of the species (based on EEC, 1992). 2 (*in a MAES context*): A synonym of 'ecosystem type'.

Human well-being: A state that is intrinsically (and not just instrumentally) valuable or good for a person or a societal group, comprising access to basic materials for a good life, health, security, good physical and mental state, and good social relations (based on MA, 2005).

Indicator: An indicator is a number or qualitative descriptor generated with a well-defined method which reflects a phenomenon of interest (the indicandum). Indicators are frequently used by policy-makers to set environmental goals and evaluate their fulfilment (based on Heink & Kowarik, 2010).

Mapping: The process of creating a cartographic representation (map) of objects in geographic space. In the MAES context mapping means a spatially detailed assessment of the elements of the MAES framework, which aims inter alia at creating cartographic representations of the studied elements (based on OpenNESS, 2014).

Pressure: Human induced process that alters the condition of ecosystems.

Socio-economic system: Our society (which includes institutions that manage ecosystems, users that use their services and stakeholders that influence ecosystems).

Value: The contribution of an action or object to user-specified goals, objectives, or conditions (MA, 2005).

See also [ESMERALDA Glossary of ecosystem services mapping and assessment terminology](#)