Support Policy Development for Integration of Ecosystem Service Assessments into WFD and FD Implementation

Resource document
September 2014

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DISCLAMER

The document was prepared by COWI A/S in cooperation with DHI and ARUP under the specific contract 070307/2012/637505/D1 at the instruction of, and for use by, the European Commission.

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Finally we would like to thank the interviewees from four RBDs that have contributed with their experience of the actual and potential use of ecosystem service assessments in river basin management planning.

LIST OF ABREVIATIONS AND ACRONYMS

APSFR	Area with Potential Significant Flood Risk
CAP	Common Agricultural Policy
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CEA	Cost-Effective Analysis
CICES	Common International Classification of Ecosystem Services
CIS	Common Implementation Strategy
DPSIR	Driving forces, Pressures, States, Impacts, Responses
DSS	Decision Support System
EPPS	Ecosystem Properties, Potentials and Services
ES	Ecosystem Service
ESA	Ecosystem Service Approach
ETC	European Topic Centre
FD	Floods Directive
FRMP	Flood Risk Management Plans
GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	Geographic Information System
ICES	International Council for the Exploration of the Sea
JRC	Joint Research Centre
MA	Millennium Ecosystem Assessment
MAES	Mapping and Assessment of Ecosystems and their Services
MCA	Multi-Criteria Analysis
MEA	Multilateral Environmental Agreement
MS	Member State
NPV	Net Present Value
NWRM	Natural Water Retention Measure
OECD	Organisation for Economic Co-operation and Development
PES	Payment for Ecosystem Services
PFRA	Preliminary Flood Risk Assessment
PoM	Programme of Measures
PPP	Polluter Pays Principle
RBD	River Basin District
RBM	River Basin Management
RBMP	River Basin Management Plan
SUD	Sustainable Urban Drainage
TEEB	The Economics of Ecosystems and Biodiversity report
UoM	Unit of Management
WFD	Water Framework Directive

EXECUTIVE SUMMARY

This resource document is the outcome of the study "Support Policy Development for Integration of an Ecosystems Service Assessment with the WFD and FD implementation" undertaken by COWI A/S in association with DHI and ARUP in the period from January 2013 to February 2014. It is targeted at those who work with water management in river basins either at local, regional or national levels throughout the European Union.

The study is a follow-up to the CIS-SPI 2011 workshop "Implementation of the WFD: When ecosystem services come into play" and the recommendation of "A Blueprint to Safeguard Europe's Water Resources Blueprint" on improving implementation of the Water Framework Directive (WFD).[1] The CIS-SPI 2011 workshop recognised the need to strengthen operational guidance on how ecosystem service assessments can be used to support the implementation of the WFD and the Floods Directive (FD).[2] The Blueprint identified deficiencies in the implementation of the WFD, which e.g. relate to the fact that not all benefits of the implementation of the Directive have been included in the decision-making process.

In light of this agenda, the objective of this study has been to review literature on ecosystem service assessments, consult stakeholders and provide inputs on how to use ecosystem service assessments to improve or support the implementation of the WFD and the FD.

Ecosystem services are usually defined as the benefits that humans derive from ecosystems. The link to society is established when ecosystem functions are translated into services. Such a holistic understanding of the environment can improve the integration of different aspects in the decision-making process. Especially the understanding of the benefits and the possibility of including the benefits will be improved due to the systematic approach to assessing ecosystem services.

Ecosystem services are typically classified into the following categories:

- Provisioning services (e.g. drinking water and food)
- Regulating services: (e.g. flood risk protection and pollution filtration)
- Cultural services (e.g. bathing, water sports and birding).

To these categories can be added abiotic services, such as hydropower and navigation. Abiotic services can be defined as the non-living chemical and physical components of the environment that affect living organisms and the functioning of ecosystems.

The study found that the main arguments for introducing an ecosystem service assessment approach to support the implementation of the WFD and FD are that it can:

- Support the assessment and communication of the benefits of the directives (WFD and FD). Systematic identification and assessment of the ecosystem services encourage open communication of the impacts of the implementation of the WFD and the FD.

[1] Directive 2000/60/EC of the European Parliament and of the Council.

[2] Directive 2007/60/EC of the European Parliament and of the Council.

- Support the selection of cost-effective measures by considering co-benefits generated by these measures. Better understanding of the changes caused by measures taken to improve the conditions of the waters will improve the quality of the cost-effectiveness analyses in that the approach considers co-benefits. By co-benefits are understood benefits that arise from changes in the water condition, but which are not the main purpose of a measure.
- Help avoid unintended impacts of measures on other benefits. A more consistent assessment of ecosystem services will enable decision-makers to consider all impacts caused by changes in the water condition in a systematic manner.
- Obtain more information on who may benefit or lose from measures or non-action. The assessment will include consultations with stakeholders.
- Enhance the coordination of the implementation of environmental directives by focusing on co-benefits. A consistent assessment will allow the river basin manager to identify the positive impacts of the implementation of the directives when choosing among a range of measures.
- Improve coordination and synergies of RBMPs and FRMPs with the ongoing mapping and assessment of ecosystems services, which are part of the EU Biodiversity Strategy to 2020. Ecosystem services are to be mapped in all Member States by 2020. The assessment of the ecosystem services will draw on that framework and allow for a more holistic approach to regulating the environment and visualising the interaction between themes, namely identification, quantification, valuation, link to planning and link to financing.

This document discusses how ecosystem service assessments can be integrated into water management to support WFD and FD implementation. In particular, it pays attention to two key questions:

- Where in the WFD and FD implementation process may ecosystem service assessments be applied?
- How may they be applied?

The two tables below explain the links between the WFD/FD requirements and ecosystem service assessments. Ecosystem service assessments are particularly relevant to the economic assessments, which are required by the directives, but the concept is also related to other requirements. Whereas the left column refers to the specific articles of the directives, the right column suggests how ecosystem service assessments can support the implementation of the requirements of the individual articles.

Table 0-1 Link between WFD requirements and ecosystem service assessments

WFD Articles	Link to ecosystem service assessments
Characterisation of the River Basin District (RBD) (Article 5) • review of impact of human activity (pressures) • economic analysis of water use. In relation to the characterisation, the following activities also link to ecosystem services: • registration of protected areas (Article 6) • information about abstraction of drinking water (Article 7).	In the analysis of the characteristics of the RBD (Article 5), knowledge about the status and functions of the ecosystem is imperative. Much human activity affecting the water bodies can be described as utilisation of ecosystem services and the same is the case for the water uses. It means that the existing assessments to a large extent already include the information about ecosystem services. Using ecosystem services as a "tool" to support the characterisation can help make the characterisation more complete, consistent and systematic and make it easier to communicate the benefits.
Setting objectives (Article 4) • Paragraphs 3, 4, 5, 6 and 7 on derogations, exemptions and designation of AWB/HMWB	When considering derogations and exemptions based on the disproportionate costs argument, in-depth assessment of the benefits of improving water status could improve the decision process. The ecosystem service consideration approach offers a tool for a more comprehensive benefit assessment.
Selecting cost-effective measures in the Programme of Measures (PoM) (Article 11)	Assessment of ecosystem services is highly relevant to the identification and assessment of the most cost-effective package of measures for the PoM (Article 11). Measures related to land use and agricultural practices could provide important ecosystem service co-benefits. The extent of such ecosystem service co-benefits depends on the particular measure.
Cost recovery and pricing (Article 9).	Ecosystem services link to Article 9 on cost recovery and water pricing; for example, the estimation of environmental and resource costs could be supported by the valuation of ecosystem services as a large proportion of these costs could be described as reduced provision of eco-system services.

Source: COWI on the basis of Directive 2000/60/EC, Oct 2000

Table 0-2 Link between FD requirements and ecosystem service assessments

FD Articles	Link to ecosystem service assessments
Article 4: Member States shall undertake a preliminary flood risk assessment. The assessment shall include at least the following: mapping, description of historic floods and an assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity. Further, the Article reads "as far as possible issues such as the topography, the position of water courses and their general characteristics including floodplains as natural water retention areas."	The article requires River Basin Management planners to consider the likely impacts of climate change in assessing the potential adverse consequences of future floods. The ecosystem services could be used as a tool for this assessment. The understanding of the potential changes in the ecosystem services due to floods can be a valuable tool for assessing the risk. Information about topography, the position of water courses and their general characteristics, including floodplains acting as natural water retention areas, can help estimate changes to ecosystem services. When the baseline is known, it is possible to assess any marginal changes.
Article 7: "Flood risk management plans shall take into account relevant aspects such as	This article places an obligation on Member States to develop flood risk management plans (FRMP) that strike

FD Articles	Link to ecosystem service assessments
costs and benefits (…)" Annex A.I.5: "When available, for shared river basins or sub-basins, a methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects."	a reasonable balance between benefits and costs. Consequently, FRMPs need to build on sound information about the benefits and drawbacks of measures. The assessment of the ecosystem services can help visualise the balance between the costs and benefits.
Article 7: Member States shall establish flood risk management plans coordinated at the level of the river basin district, (or appropriate unit of management), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding. Further, the Article reads: "In the interests of solidarity, flood risk management plans (…) shall not include measures which, (…), significantly increase flood risks upstream or downstream of other countries (…)". The information used to put forward arguments for making that selection can be utilised to estimate ecosystem services.	The article recommends that FRMPs promote sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event. This will provide input for the assessment of changes in the ecosystem services. The need to consider the impact on the environment, cultural heritage and economic activity will be satisfied through the assessment of ecosystem services that not only reflect the water environment, but also surrounding ecosystem services.
Article 9: Member States shall take appropriate steps to coordinate the application of this Directive and that of the WFD focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of WFD.	Specifically, this entails that the development of the first flood risk management plans (and subsequent reviews) should be carried out in coordination with, and maybe integrated into, the reviews of the river basin management plans provided for in Article 13 of the WFD. The ecosystem services assessment can serve to ensure a common understanding when coordinated with the reviews of the river management plans of the WFD.

Source: COWI on the basis of Directive 2007/60/EC, January 2006.

Once the potential for ecosystem service assessments to contribute to the WFD and FD implementation has been established, the next step will be to determine how ecosystem service assessments are best used to support the WFD and FD implementation processes.

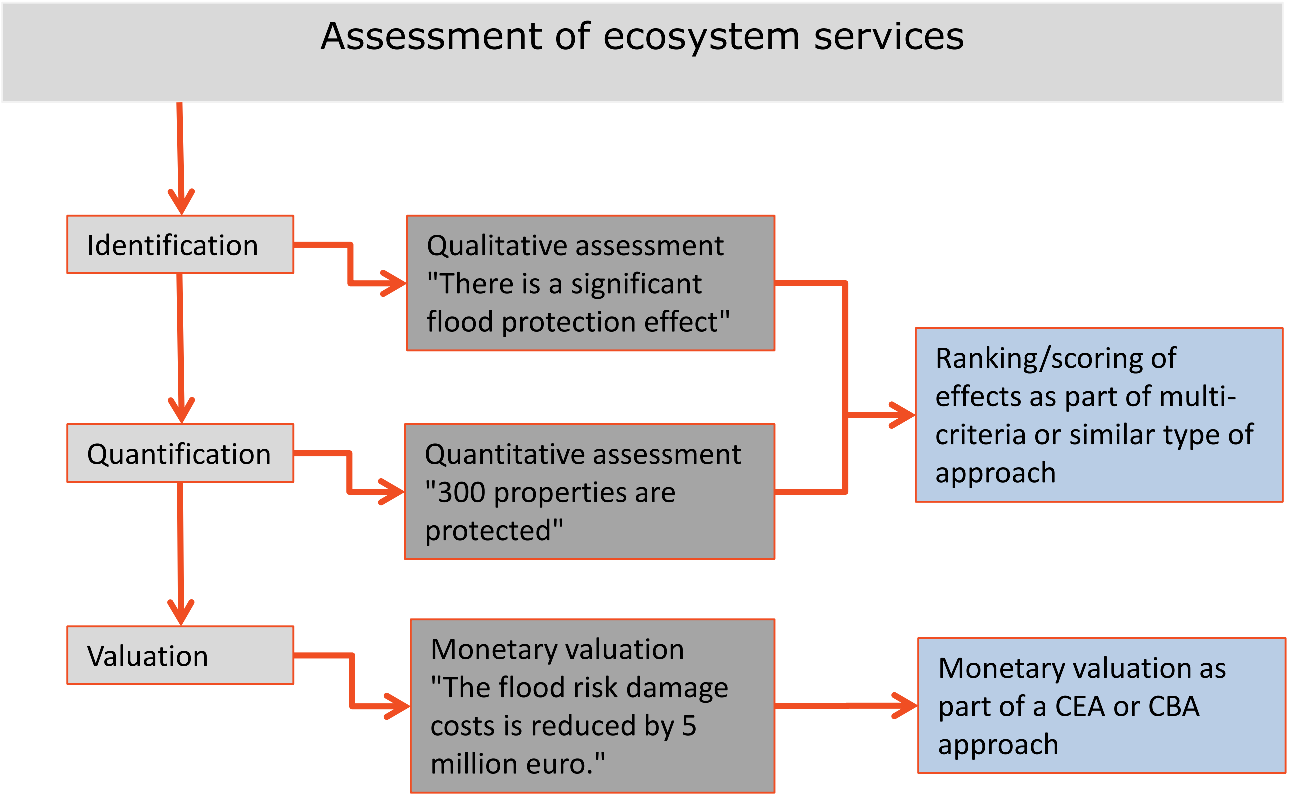
The literature review and stakeholder consultations revealed differing opinions on how to carry out ecosystem service assessments. The main issue is how far quantification and monetary valuation should and can be taken. In this regard, an important finding from the literature review and expert consultations is that it is not pertinent to establish a common approach on how to integrate ecosystem service considerations into the WFD and FD implementation. The main reason being knowledge gaps, but also the need to tailor ecosystem service assessments to individual Member State WFD and FD implementation practices. In addition, there is still a need to develop a common understanding and shared practices.

As ecosystem service assessments are closely linked to the economic appraisals carried out as part of the development of the river basin management plans (RBMPs) and the flood risk management plans (FRMPs), the approach to ecosystem service assessments should be aligned with the approaches applied for economic appraisals.

In principle, ecosystem service assessments include three steps: identification, quantification and valuation. Depending on the availability of data, the three steps may be completed in parallel or in succession. Data availability and the documentation to inform the decision-making process will determine whether all steps are required. Figure 0-1 illustrates the three steps and how the results of the assessment in each step may be used in the further appraisal process.

The ecosystem service assessment starts by identifying the services available and how they are affected by changes to the water environment. Once identified, the services can be assessed either in physical terms or by also monetary values of the physically assessed changes as explained below. If the data only allow for an assessment of the impacts in physical terms, the use of a ranking or scoring system can help cross-comparisons and visualisation of trade-offs between different measures. If data and information allow for a valuation, the results can be used directly to meet the requirements for cost-effectiveness analyses and cost-benefit analyses.

Figure 0-1 Ecosystem service assessments – from identification to valuation

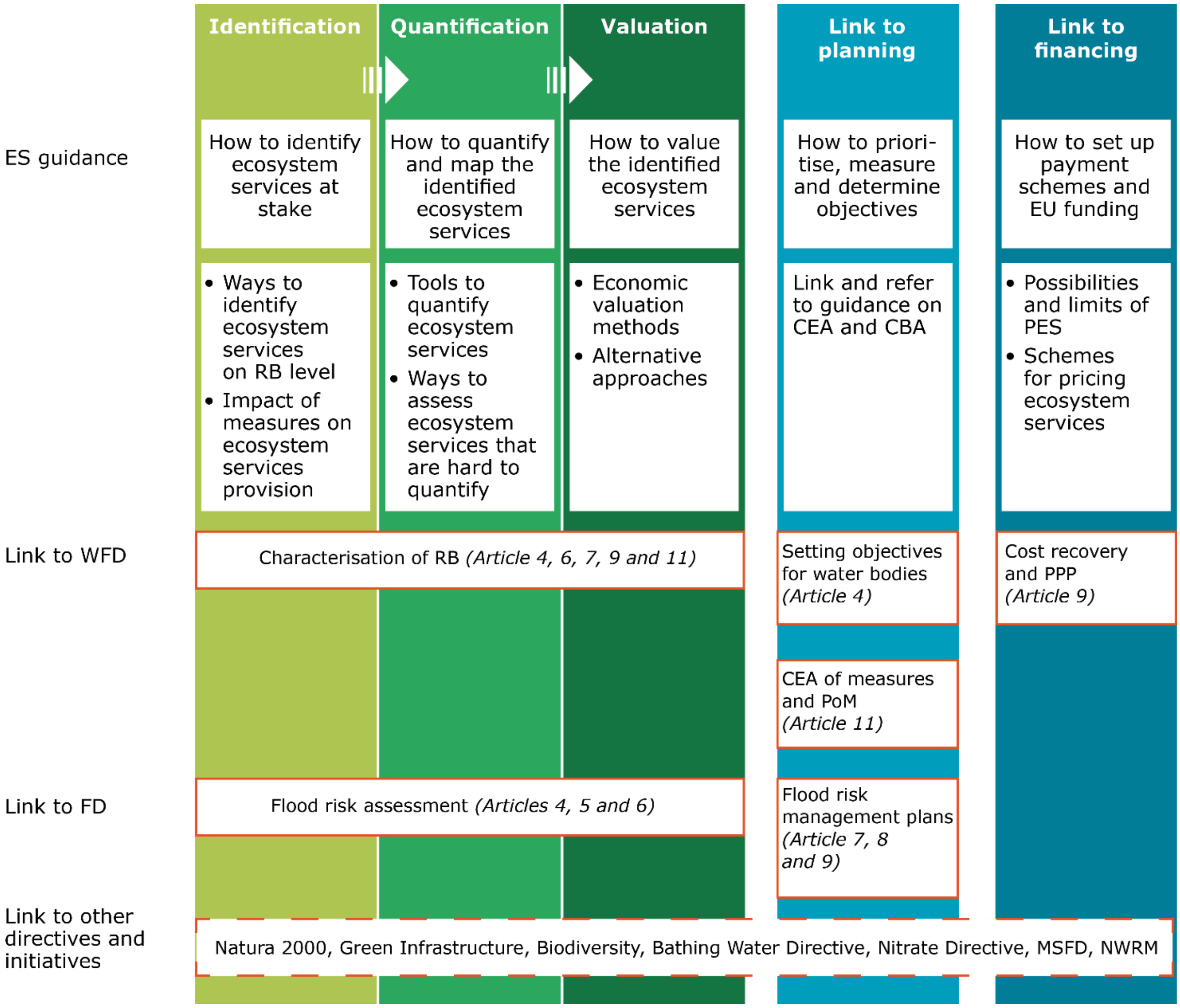


Source: COWI.

Instead of offering a ready-made recipe for assessing ecosystem services in the context of directive implementation, the present document discusses the concept of ecosystem service assessments and includes real examples of assessments of ecosystem services that have contributed to a better and more holistic planning and decision-making process in the context of the two Directives.

The figure below illustrates how the present resource document suggests working with ecosystem services assessments.

Figure 0-2 Structure of resource document and ecosystem service assessment



ES:	*ecosystem services*
CEA:	*cost-effective analysis*
CBA:	*cost-benefit analysis.*

Source: COWI.

The first three columns – **Identification**, **Quantification** and **Valuation** - describe how to assess ecosystem services in the context of the WFD and FD. Each description includes a checklist of the most relevant ecosystem services and examples of indicators and tools that can be used to quantify and value ecosystem services.

The subsequent columns - **Link to planning** and **Link to financing** - include examples of how to apply ecosystem services in the implementation process. **Link to planning** discusses alternative approaches to applying ecosystem service valuations in, for example, the selection of cost-effective measures for the RBMPs and the FRMPs. **Link to financing** specifically addresses how funding and pricing mechanisms in the context of ecosystem services can support the implementation of the directives.

In parallel with this study, several other ongoing EU initiatives generate results that are relevant to ecosystem service assessments. Most of them are under the overarching EU level initiative "Mapping and Assessment of Ecosystems and their Services" (MAES)[3], which supports the process of ecosystem service assessments in the Member States as part of the EU Strategy on Biodiversity by reviewing relevant data and tools. In addition, the initiatives on Green infrastructure and on Natural Water Retention Measures (NWRM) are closely linked to ecosystem service assessments. The knowledge that is accumulated in ongoing initiatives helps improve the understanding of the environment and especially how society is influenced by different measures aiming to regulate and protect the environment.

The key findings of this study are:

- Ecosystem service assessments need not be very quantitative and include monetary valuations to provide valuable input for the decision-making process. Qualitative assessments can provide valuable support to the implementation - and only when it matches the appraisal approach and data are available, more quantitative assessments can be made. In some cases, simply the identification of all relevant ecosystem services will improve the level of knowledge and allow for better decision-making.

- The approach to ecosystem service assessments should be tailored to the national context, and if operational guidance should be developed, it needs to be done at the national level. Alternatively, a generic guideline can be developed which does not include national considerations, but is merely a general explanation of how the ecosystem service assessment can be carried out. While it might be relevant for Member States to consider their appraisal processes in order to improve the implementation of the directives, such changes to the appraisal processes would probably have a scope, which is much broader than just including ecosystem service assessments.

- When assessing ecosystem services, existing information, approaches and methodologies should be used, to the extent possible. Many data have been collected and are being collected also as part of implementing other policies; for example, in relation to the biodiversity strategy where mapping and assessment of ecosystem services are ongoing. The utilisation of the existing data sources will save the resources necessary for performing the assessment while at the same time support the consistency in the regulation of the environment and ensure integrated coordination across policies.

[3] Mapping and Assessment of Ecosystems and their Services (MAES) Analytical Framework, EC, 2013: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.

- There is no single tool or model to support the assessment of all the relevant ecosystem services. The reason is, among other things, that many disciplines have to be activated. As the characteristics of the different ecosystem services differ, the tool and methods needed to identify, quantify and value them inherently also vary. Rather than being a tool, the approach to assessing the ecosystem services is a methodology that, if followed, will allow for an assessment of ecosystem services. Many disciplines come into play in order to make a comprehensive assessment of the ecosystem services in waters. The approach can be considered innovative, in that it draws on existing tools and methods from different disciplines and combines them systematically.

- As the concept of ecosystem services is relatively new, research and development are ongoing, which will result in better data and improved approaches. This calls for an exchange of lessons learnt on ecosystem service assessments throughout the EU. Coordination with other directives will be enhanced through the improved approaches thus enhancing communication and coordinated action. This will also be more in demand in the coming years when the knowledge base is expanded.

1. INTRODUCTION TO THE DOCUMENT

The Communication "A Blueprint to Safeguard Europe's Water Resources"[4] stresses the importance of addressing the challenges that threaten the European water ecosystems on which we depend. Ecosystems provide significant benefits to people in terms of health, wellbeing and economic prosperity. Currently, this is poorly accounted for in decision-making. There is a need to better demonstrate the link between the functions of ecosystems and the benefits derived by society.

Member States have been urged to improve the implementation of the Water Framework Directive (WFD) and other relevant EU legislation[5]. Overall, progress with respect to addressing diffuse pollution and hydro-morphological pressures seems to have been moderate. Measures to address these pressures often have important co-benefits such as flood protection, biodiversity improvements and recreational benefits. The concept of ecosystem services is one that can help capture such co-benefits in a systematic way.

The CIS-SPI conference in 2011 "Implementation of the WFD: When ecosystem services come into play" included discussions and examples of how to address ecosystem services in the context of the WFD implementation. The workshop discussions suggested that a next step would be to develop operational guidelines on how to introduce ecosystem service considerations[6].

Against this background, DG Environment has commissioned COWI, ARUP and DHI to review the literature and assess the current state of development. This resource document is therefore aimed at supporting the policy development in relation to how ecosystem services can be integrated into the further implementation of the WFD and the Floods Directive (FD). Furthermore, the resource document will contribute to the CIS Deliverables for Natural Water Retention Measures[7] and Better Calculations of Cost and Benefits that are proposed by the Blueprint, and supported by the new CIS work programme.

1.1. Purpose and context of the resource document

In the context of this study ecosystem services are defined as the benefits people obtain from ecosystems. Using the concept of ecosystem services and doing ecosystem service assessments are useful in supporting the identification of the benefits of the water policy directives and in particular the consideration of co-benefits of applying specific measures as part of the implementation of the WFD and the FD.

The review of existing literature and consultations with experts and stakeholders (see Annex report) have shown that the current knowledge of the practical assessment of ecosystem services has not reached a stage where detailed prescriptive guidance can be provided on how to incorporate ecosystem services into the implementation of the WFD and the FD.

There are different views among experts and stakeholders on the merits of quantification and monetary valuation of ecosystems services and there are different economic assessment

[4] http://ec.europa.eu/environment/water/blueprint/.
[5] COM(2012) 670.
[6] CIS-SPI (2011), Implementation of the Water Framework Directive: When ecosystem services come into play.
[7] NWRM CIS and pilot project, www.nwrm.eu.

practices across Member States. This renders it impossible to define a simple 'recipe type' of guidance.

Hence, this document presents alternative ways of assessing ecosystem services and the benefits of such assessments. It aims to provide River Basin Management (RBM) planners with suggestions for possible tools, data and existing knowledge that can help them assess ecosystem services.

The document links ecosystem assessments to the steps in the implementation process of the WFD and the FD. The aim is to incorporate ecosystem service assessments into this process to ensure that benefits are consistently taken into account in the implementation of the WFD and FD, contributing to the achievement of their objectives.

1.2. Target group of the resource document

The resource document is targeted at those who work with water management in river basins either at local, regional or national levels. Assessing ecosystems services requires different types of expertise depending on the ecosystem service in question. It is a balance to strike the right level of information as the non-expert might need more introductory information than the expert. In addition, the field of assessing ecosystem services is developing rapidly, and new findings and material are constantly published.

1.3. Guide to the reader

The document starts by presenting the nature of ecosystem services and discussing how they can be incorporated into the specific WFD and FD planning process.

Following the introduction, the document is structured around **five thematic chapters**. The first three chapters are naturally linked: They consider three steps in assessing ecosystem services (identification, quantification and valuation). The last two chapters explain how the assessment of ecosystem services can be included in the actual WFD/FD implementation drawing on the findings of the first three chapters. Although the document has an overarching structure, each chapter can be read independently. Each of the five chapters is concluded by a list of recommended literature, which provides additional information to the interested reader[8].

1.4. Additional information

The Annex Report provides the results of the literature review and discusses the different theoretical approaches to ecosystem services assessment. It also summarises the findings of an expert workshop and expert consultations.

[8] The report was prepared from January 2013 to September 2014 and the selection of relevant literature for the detailed review was completed by June 2013. Even though new literature has been included to the extent possible, some recent literature is only included in the main report and not in the detailed literature review.

2. ECOSYSTEM SERVICE ASSESSMENT IN CONTEXT OF THE WFD/FD

This chapter includes a brief introduction to the nature of ecosystem services and their relevance in the context of the WFD and the FD.

2.1. What are ecosystem services?

Ecosystem services are usually defined as benefits people obtain from ecosystems. Water ecosystems provide for example water for drinking, or they provide nutrition in the form of fish and shellfish. They also provide functions that clean the air, provide nutrients to grow our food and which breakdown pollutants. Ecosystem services are typically classified into the following categories[9]:

- Provisioning (e.g. drinking water and fish)
- Regulatory/maintenance: (e.g. flood risk protection and pollution filtration)
- Cultural (e.g. bathing, water sports and birding).

Table 2-1 below provides an overview of some of the key concepts related to ecosystem services.

[9] See Chapter 3.2 on classification for more details on alternative classification systems.

Table 2-1 Glossary of key concepts related to ecosystem service assessment

Key concept	Description
Ecosystem	A community of living organisms (plants, animals and microbes) in conjunction with the non-living components of their environment interacting as a system.
Ecosystem functions	Subset of the interactions between biophysical structures, biodiversity and ecosystem processes that underpin the capacity of an ecosystem to provide ecosystem services.
Ecosystem service	Benefit derived from ecosystem functions (typically classified in provisioning, regulatory and cultural).
Ecosystem service classification	There are a number of alternative classifications: • The Economics of Ecosystems and Biodiversity (TEEB)[10] • Millennium Assessment (MA)[11] • Common International Classification of Ecosystem Services (CICES).[12] All classifications include lists of all relevant types of ecosystem services. The classifications are relatively similar. They include three or four types of provisioning, regulatory and cultural (TEEB and MA have a fourth category of supporting services). It is important to pay attention to the classification mainly to ensure complete mapping of all ecosystems services and comparability, avoid overlap and redundancy. Concerning the use of ecosystem service considerations in relation to the WFD and FD, the choice of classification is less crucial (see Chapter 3.2 for further details on the classifications) since all the classification systems include the ecosystem services relevant in the context of the WFD/FD. This document uses the CICES classification.
Ecosystem Approach (based on the definition by Convention on Biological Diversity (CBD)	The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of scientific methodologies focused on levels of biological organisation that encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems. The Ecosystem Approach can be understood in terms of its 12 Principles and five points of operational guidance (one the 12 principles related to ecosystem services)[13].
Ecosystem services assessment	Assessment of ecosystem services in a process or project. An assessment includes identification and to various degrees quantification and valuation of ecosystem services. A broad range of services should be considered throughout the assessment although the full assessment may focus on those deemed important (where there is a large positive or negative impact) through screening. This does not necessarily represent all aspects of the much broader ecosystem approach.

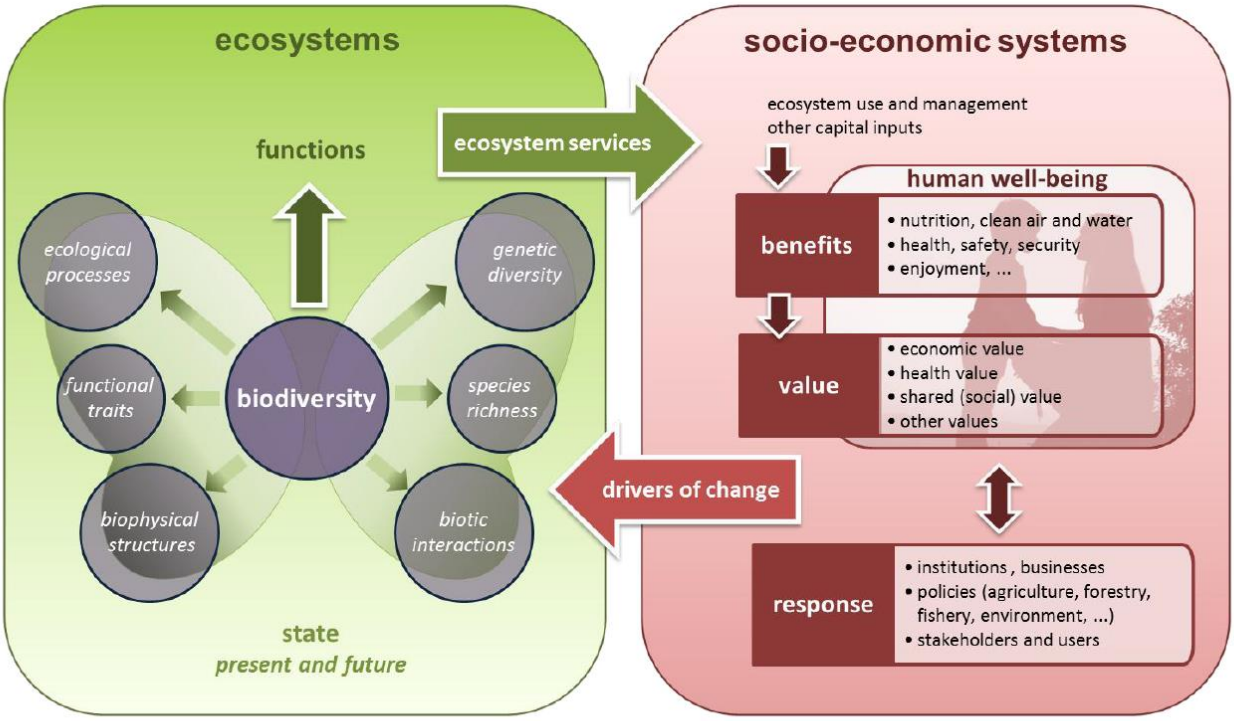
Source: COWI.

[10] TEEB 2010: The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation.
[11] http://www.unep.org/maweb/en/index.aspx.
[12] Cices.eu and http://cices.eu/wp-content/uploads/2012/07/CICES-V43_Revised-Final_Report_29012013.pdf.
[13] See: http://www.cbd.int/decision/cop/default.shtml?id=7748).

An overall understanding of the interaction between ecosystem services and the socio-economic systems is given by the Analytical Framework for Mapping and Assessment of Ecosystems and their Services (MAES)[14] which is a conceptual framework that links socio-economic systems with ecosystems via the flow of ecosystem services, and through the drivers of change that affect ecosystems.

The MAES analytical framework is illustrated in Figure 2-1 overleaf.

Figure 2-1 MAES framework for ecosystem services



Source: European Commission, 2013.

The analytical framework is presented in the following way:

> *"Ecosystem services are derived from ecosystem functions and represent the realized flow of services for which there is demand. For the purpose of this framework, ecosystem services also encompass the goods derived from ecosystems. People benefit from ecosystem (goods and services). These benefits are, among others, nutrition, access to clean air and water, health, safety, and enjoyment and they affect (increase) human wellbeing which is the key target of managing the socio-economic systems".*[15]

[14] Cf. European Commission: Mapping and Assessment of Ecosystems and their Services. Brussels, 2013: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.
[15] Ibid. p. 16.

When applying this framework to the management of the water environment, the starting point is that aquatic ecosystems provide services that benefit society. The way society uses and manages the ecosystems influences the ecosystem functions and, in turn, the provision of ecosystem services. It means that there are different types of trade-offs in using and managing ecosystems.

Utilising one ecosystem service, such as the provision of water for drinking by abstracting water may affect the flow in rivers and streams, which, in turn, may have a negative impact on other services such as fishery. Agriculture uses a terrestrial ecosystem to produce food but agricultural practices such as intensive farming using fertilisers and pesticides affect the aquatic ecosystem and reduce the services that the aquatic ecosystem can produce.

The objectives of the WFD are to obtain good ecological status (GES) and good chemical status (GCS) in all water bodies and good quantitative status for groundwater, as well as preventing any deterioration in the status of water bodies with the ultimate aim of ensuring sustainable water use. In the remaining part of the document, these objectives will be referred to simply as objectives.

The FD aims to prevent damage to humans as well as to man-made and natural assets with the overall objective of assessing and managing flood risks. Measures to mitigate or prevent flooding events can have significant impacts on the ecosystems and will have either negative or positive side effects on the WFD objectives.

In fact, the WFD and FD have a lot in common. They both aim at ensuring sustainable management of the benefits to society from water and the water environment. The WFD aims at sustaining the aquatic environment to safeguard the quality and quantity of water in the river basins while at the same time ensuring positive benefits to society from the functioning of the aquatic ecosystems. The purpose of the FD is to help us manage the risks associated with the benefits we reap from living and working near aquatic ecosystems.

This leads to the objective of this document – to assess how the concept of ecosystem services can be integrated into the implementation of the WFD and the FD to the benefit of both.

2.2. Integrating ecosystem service assessments into the WFD and the FD

2.2.1. Benefit of integration

The inclusion of the ecosystems service assessments in the implementation of the WFD and FD can raise awareness among managers, stakeholders and decision-makers, which can help streamline discussions about prioritisation of measures and management practices applied in a river basin.

By incorporating ecosystem service assessments into the WFD and the FD, it is possible to capture and describe the benefits and possible co-benefits of achieving the objectives of the directives. That is, it is possible to capture and describe not only the overall benefits of achieving the objectives of the directives but also - and equally important - the potential co-benefits of measures to improve the status of water bodies to aquatic and terrestrial ecosystems.

Hence, the main arguments for introducing ecosystem service assessments are that they could support:

- the assessment and communication of the benefits of WFD and FD due to the systematic assessment of all the benefits allowing visualisation of the trade-offs between the ecosystem services (mainly presented in Chapter 3.5 as part of the ecosystem service assessment)
- the selection of cost-effective measures by considering co-benefits delivered by measures. With the assessment of all benefits, the co-benefits of each option can be identified and compared (mainly presented in Chapter 6 on planning)
- avoiding unintended impacts of measures on other benefits. The assessment of the ecosystem services help obtain an overview of all effects of certain measure; intended or un-intended (mainly presented in Chapter 6 on planning)
- better understanding of those who may benefit or those who may benefit or not from measures or non-action. As part of the assessment, the users are identified such that a value can be attached to the service. This exercise gives information about who is gaining and who is losing from a specific option (addressed in the Chapter 3.5)
- the coordination between directives through the focus on co-benefits. The knowledge of the ecosystem services provide the possibility of visualising the effects on other directives than the one in question (Chapter 6 on planning)
- the coordination of… with the mapping and assessment of ecosystems services that are being done as part of the EU Biodiversity Strategy to 2020. The assessment of the services can be used for more purposes and there is no limitation to the context in which they can be utilised (Chapters 3 and 4)

The specific objectives of the WFD – such as "good status" and "no deterioration" – do not explicitly describe the benefits to the EU citizens. The objectives aim at improving the overall conservation status but if these objectives could be translated into ecosystem service benefits, to which the population can more directly relate, stakeholder involvement could be significantly improved throughout the implementation process. Please be aware that there are two distinctive issues at stake here - one regarding the perception of the public and how this affect public participation, and another regarding the engagement of stakeholders (e.g. farmers) for measures. A systematic assessment of ecosystem services could support the appraisal of measures making sure that co-benefits are taken into account. This aspect is very important in relation to the coordination between the WFD and the FD and also equally important to the wider coordination across water and nature policies.

2.2.2. Approach to integration

Through review of literature and stakeholder consultation, it has emerged that there are divergent opinions on how ecosystem service assessments could be done. The main issue is how far quantification and monetary valuation should be taken. In this regard an important finding of the literature review and expert consultations that it is not pertinent to propose a unified approach to how to integrate ecosystem service considerations into the WFD and FD implementation. The main reason being knowledge gaps but also the need to tailor ecosystem service assessments to individual Member State implementation practices.

As ecosystem service assessments link closely with the economic appraisals being done to develop the river basin management plans (RBMPs) and the flood risk management plans

(FRMPs), the approach to ecosystem service assessments should be aligned with the approaches applied to perform the economic appraisals.

A key question is: How to identify all relevant ecosystem services and, especially, what level of quantification and valuation should be applied to the ecosystem service assessments?[16] While the term valuation hints at monetary valuation, it is not necessary to apply quantified assessments in order to consider the effects on ecosystem services. The current application of economic assessments in the implementation of the WFD varies across Member States. The approach to the assessment of the ecosystem services should be aligned with the way the economic assessment is carried out or is planned to be carried out in the future.

Therefore, this document does not prescribe a specific approach for applying ecosystem service assessments in the implementation of the WFD and the FD. The discussions of tools, data and examples are valid to different ecosystem service integration approaches.

2.2.3. Level of quantification in the assessment of ecosystem services

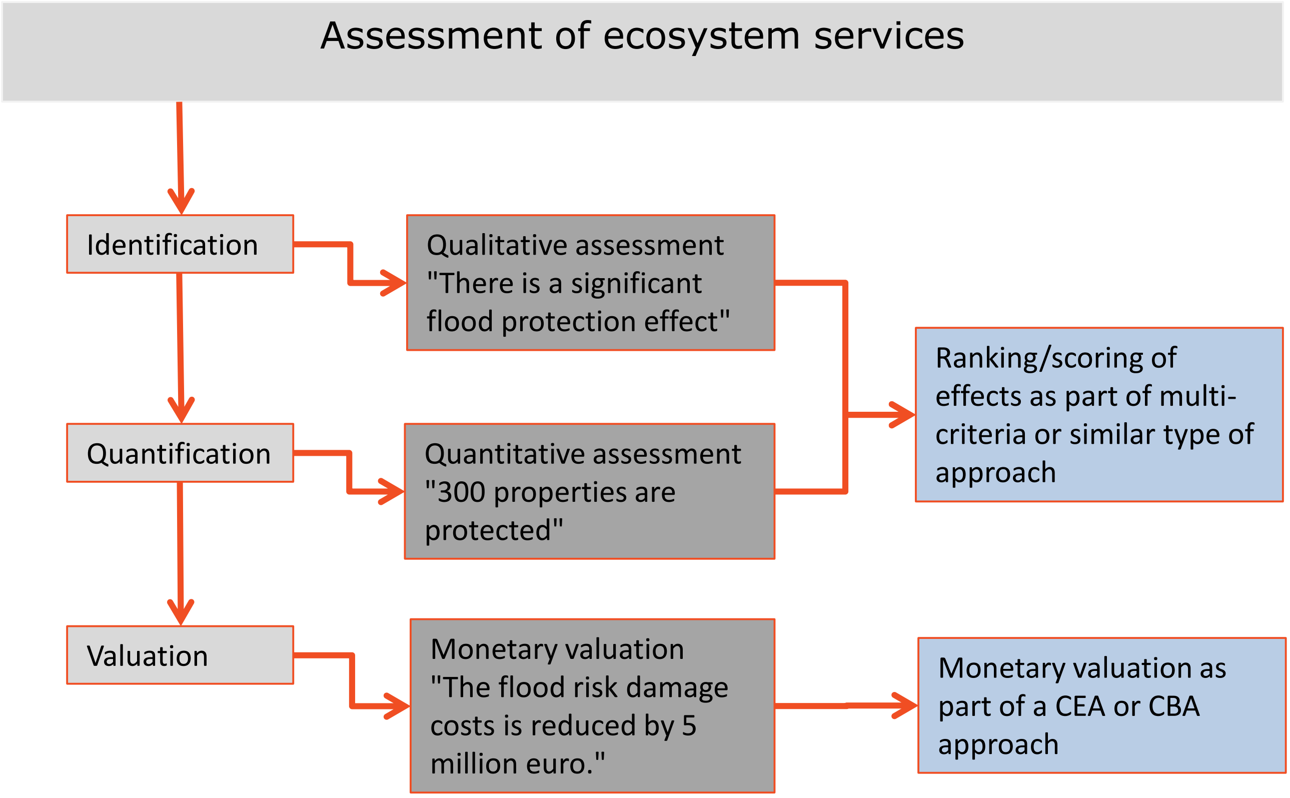
As mentioned above, one of the key elements in defining how to apply ecosystem services in the implementation of the directives regards the level of quantification. Figure 2-2 presents alternative ways of making assessments. The identification can lead to qualitative assessments of relevant ecosystem services. Such qualitative assessments can form a basis for decision making – typically in what could be described as a multi-criteria framework. Likewise, quantification of the ecosystem services could be used in a multi-criteria decision making framework.

It should be noted that a multi-criteria decision framework could include what has been labelled an extended cost-benefit analysis[17]. This is a framework where monetised valuations from the cost-benefit (or cost-effectiveness) assessment are combined with qualitative or quantitative assessments.

[16] The question of how ecosystem services can be integrated was the subject of discussions at a workshop attended by Member State experts; see Appendix B for a summary of the discussions. The options have been defined by the consultant drawing on the findings of the literature review and the discussions in the expert and stakeholder workshop.

[17] See CIS Working Group Floods *Resource document on flood risk management, economics and decision making support* 2012: http://ec.europa.eu/environment/water/flood_risk/pdf/WGF_Resource_doc.pdf.

Figure 2-2 Ecosystem service assessments – from identification to valuation



Source: COWI.

Hence, when reading the chapters on ecosystem service assessment (identification, quantification and valuation), it should be kept in mind that ecosystem service assessments could lead to results at different levels of quantification and that, in many situations, monetary valuations are neither feasible nor necessary.

The next chapter describes in more detail how the consideration of ecosystem services can support the implementation of the two directives.

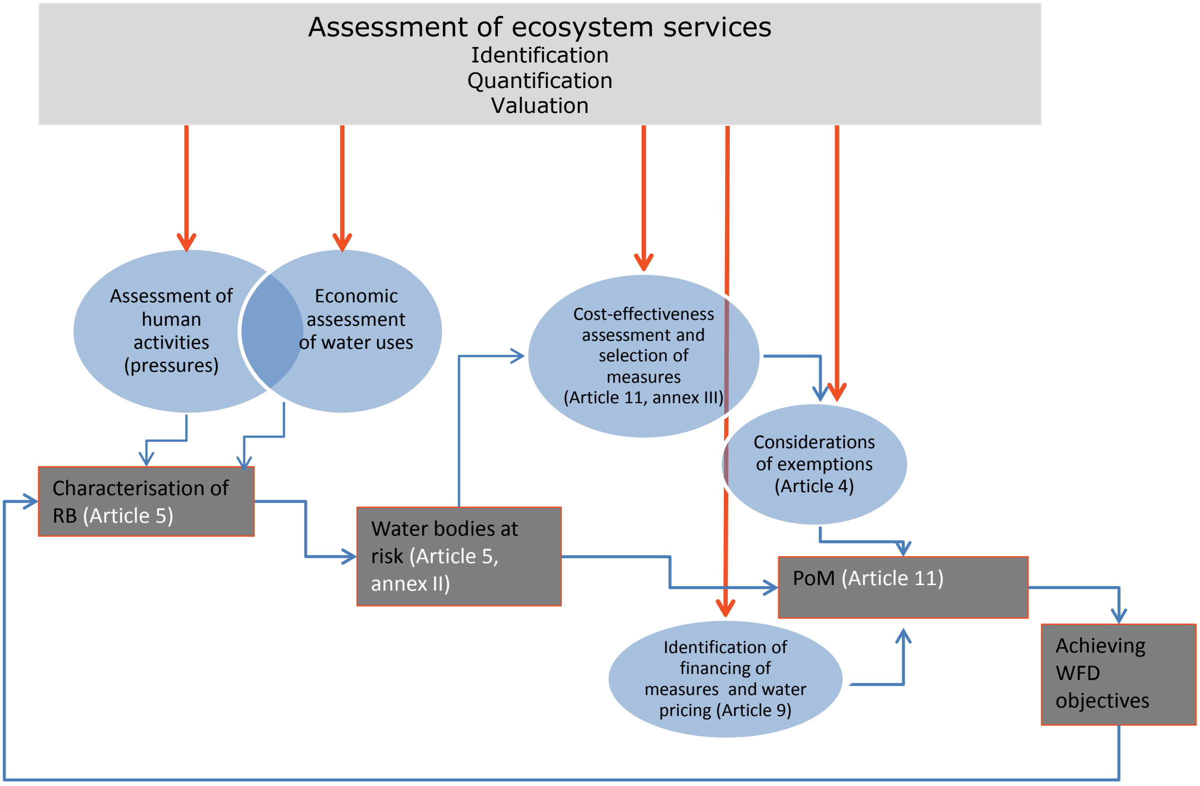
2.3. Important elements of the WFD with regards to ecosystem services

The assessment of ecosystem services is relevant throughout the WFD process. This includes: For instance:

- aims setting objectives (Articles 1 & 4);
- characterisation of the RBD (Article 5);
- register of protected areas (Article 6);
- identification of water use for abstraction of drinking water (Article 7);
- monitoring of status of surface water and groundwater (Article 8)cost recovery and pricing (Article 9);
- selecting cost-effective measures in the PoM (Article 11);
  public information and consultation (Article 14).

An illustration of the links to the WFD process is provided in Figure 2-3, focusing on the key WFD requirements.

Figure 2-3 Assessment of ecosystem services and key WFD requirements



Source: COWI.

In addition to the application to the specific decision processes, the assessment of ecosystem services may support the communication of the WFD benefits and, very importantly, stakeholder engagement throughout the whole implementation process. Hence, ecosystem service assessment also relates to Articles 1 and 4 - the aims and objectives of the WFD – by translating them into human benefits that can be communicated to demonstrate the value of water management under the WFD.

In the characterisation/monitoring of the River Basin District (Articles 5, 6, 7, 8), ecosystem services could be included in:

- the assessment of the impacts/pressures of human activities (intensive agriculture, navigation and hydropower are examples of management practices or utilisation of ecosystem services that put pressure on the aquatic ecosystem)
- the economic assessment of water uses (e.g. the ecosystem service of provision of raw water for abstraction for drinking water is a water use and it can also be a pressure on the water ecosystem).

If the classifications of ecosystems services are applied as checklists, it would increase the likelihood that all relevant water uses and pressures are addressed and assessed and an appropriate management balance (sustainable water use - the objective of the WFD identified in the preamble) - is achieved.

Once the most relevant ecosystem services are identified as part of the characterisation, the improved characterisation could support the assessment of possible derogations under Article 4 through a more comprehensive consideration of all benefits of improving the water status, which may also help secure additional funding (see Chapters 6 and 7).

One of the most important area where ecosystem service assessments can be applied is in the identification, assessment and selection of cost-effective measures for the Programme of Measures (Article 11). Measures related to land use and agricultural practices could have important ecosystem service co-benefits or costs. Thus, by considering ecosystem services, the basis for selection of the most cost-effective measures could be improved. A comprehensive assessment of all relevant ecosystem services is likely to have the consequence that measures that deliver multiple environmental benefits will improve their ranking in the cost-effectiveness assessment. Such measures typically provide additional benefits such as increased flood protection, increased biodiversity preservation - and some also recreational opportunities. The inclusion of such multi-benefit considerations is one of the main advantages of a systematic use of ecosystem service assessments.

Finally, ecosystem service assessments link to Article 9 on cost recovery and water pricing, and they also link more broadly to the issue of financing measures.

The key links between ecosystem service assessments and the WFD are summarised in Table 2-2.

Table 2-2 Link between WFD requirements and ecosystem service assessments

WFD Articles	Link to ecosystem service assessments
Characterisation of the River Basin District (RBD) (Article 5) • review of impact of human activity (pressures) • economic analysis of water use. In relation to the characterisation, the following activities also link to ecosystem services: • registration of protected areas (Article 6) • information about abstraction of drinking water (Article 7).	In the analysis of the characteristics of the RBD (Article 5), knowledge about the status and functions of the ecosystem is imperative. Much human activity affecting the water bodies can be described as utilisation of ecosystem services and the same is the case for the water uses. It means that the existing assessments to a large extent already include information about ecosystem services. Using ecosystem services as a "tool" to support the characterisation will help make the characterisation more complete and make it easier to communicate the benefits.
Setting objectives (Article 4) • Paragraphs 3, 4, 5, 6 and 7 on derogations, exemptions and designation of AWB/HMWB	When considering derogations and exemptions based on the disproportionate costs argument, in-depth accounts of the benefits could improve the decision process. Ecosystem service assessments provide a tool for a more comprehensive benefit assessment.

WFD Articles	Link to ecosystem service assessments
Selecting cost-effective measures in PoM (Article 11)	Assessment of ecosystem services is highly relevant to the identification and assessment of the most cost-effective package of measures to be selected for the PoM (Article 11). Measures related to land use and agricultural practices could provide important ecosystem service co-benefits. The extent of such ecosystem service co-benefits depends on the specifics of each particular measure.
Cost recovery and pricing (Article 9).	Ecosystem services assessment links to Article 9 on cost recovery and water pricing; for example, the estimation of environmental and resource costs could be supported by the valuation of ecosystem services as much of these costs could be described as reduced provision of eco-system services.

Source: COWI on the basis of Directive 2000/60/EC, October 2000.

2.4. Important elements of the FD with regards to ecosystem services

The FD encompasses a number of explicit references to the consideration of economics in flood risk management where the link to ecosystem services can be established (Table 2-3). While there are no explicit references to the incorporation of ecosystem services into this process, there are a number of implicit references, which relate either to synergies with the WFD or to utilising natural processes for flood risk management. This also includes references to climate change mitigation and adaptation.

Considerations of the ecosystem services are most relevant in flood risk assessment (Article 4) and in the development of Flood Risks Management Plans (FRMPs) required by Article 7.

Table 2-3 Link between FD requirements and ecosystem service assessments

FD Articles	Link to ecosystem service assessments
Article 4: Member States shall undertake a preliminary flood risk assessment. The assessment shall include at least the following: mapping, description of historic floods and an assessment of the potential adverse consequences of future floods for human health, the environment, cultural heritage and economic activity. Further, the Article reads "as far as possible issues such as the topography, the position of water courses and their general characteristics including floodplains as natural water retention areas."	The article requires River Basin Management planners to consider the likely impacts of climate change in assessing the potential adverse consequences of future floods. The ecosystem services could be used as a tool for this assessment. The understanding of the potential changes in the ecosystem services due to floods can be a valuable tool for assessing the risk. Information about topography, the position of water courses and their general characteristics, including floodplains acting as natural water retention areas, can help estimate changes to ecosystem services. When the baseline is known, it is possible to assess any marginal changes.
Article 7: "Flood risk management plans shall take into account relevant aspects such as costs and benefits (…)"	This article places an obligation on Member States to develop flood risk management plans (FRMP) that strike a reasonable balance between benefits and costs. Consequently, FRMPs need to build on sound information about the benefits and drawbacks of measures. The assessment of the ecosystem services can help visualise the balance between the costs and benefits.
Annex A.I.5: "When available, for shared river basins or sub-basins, a methodology, defined by the Member States concerned, of cost-benefit analysis used to assess measures with transnational effects."	

FD Articles	Link to ecosystem service assessments
Article 7: Member States shall establish flood risk management plans coordinated at the level of the river basin district, (or appropriate unit of management), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding. Further, the Article reads: "In the interests of solidarity, flood risk management plans (…) shall not include measures which, (…), significantly increase flood risks upstream or downstream of other countries (…)". The information used to put forward arguments for making that selection can be utilised to estimate ecosystem services.	The article recommends that FRMPs promote sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event. This will provide input for the assessment of changes in the ecosystem services. The need to consider the impact on the environment, cultural heritage and economic activity will be satisfied through the assessment of ecosystem services that not only reflect the water environment, but also surrounding ecosystem services.
Article 9: Member States shall take appropriate steps to coordinate the application of this Directive and that of the WFD focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of WFD.	Specifically, this entails that the development of the first flood risk management plans (and subsequent reviews) should be carried out in coordination with, and maybe integrated into, the reviews of the river basin management plans provided for in Article 13 of the WFD. The ecosystem services assessment can serve to ensure a common understanding when coordinated with the reviews of the river management plans of the WFD.

Source: COWI on the basis of Directive 2007/60/EC, January 2006.

Additional synergies between Article 5 of the WFD and Article 6 of the FD should be maximised to improve coordination and exchange of information and experiences. When undertaking economic assessments for the FD, WFD aspects should be taken into account. Synergies can also be found when following a Natural Flood Risk Management Approach. This can be done be including Natural Water Retention Measures (NWRMs) in both the FRMPs and RBMPs.

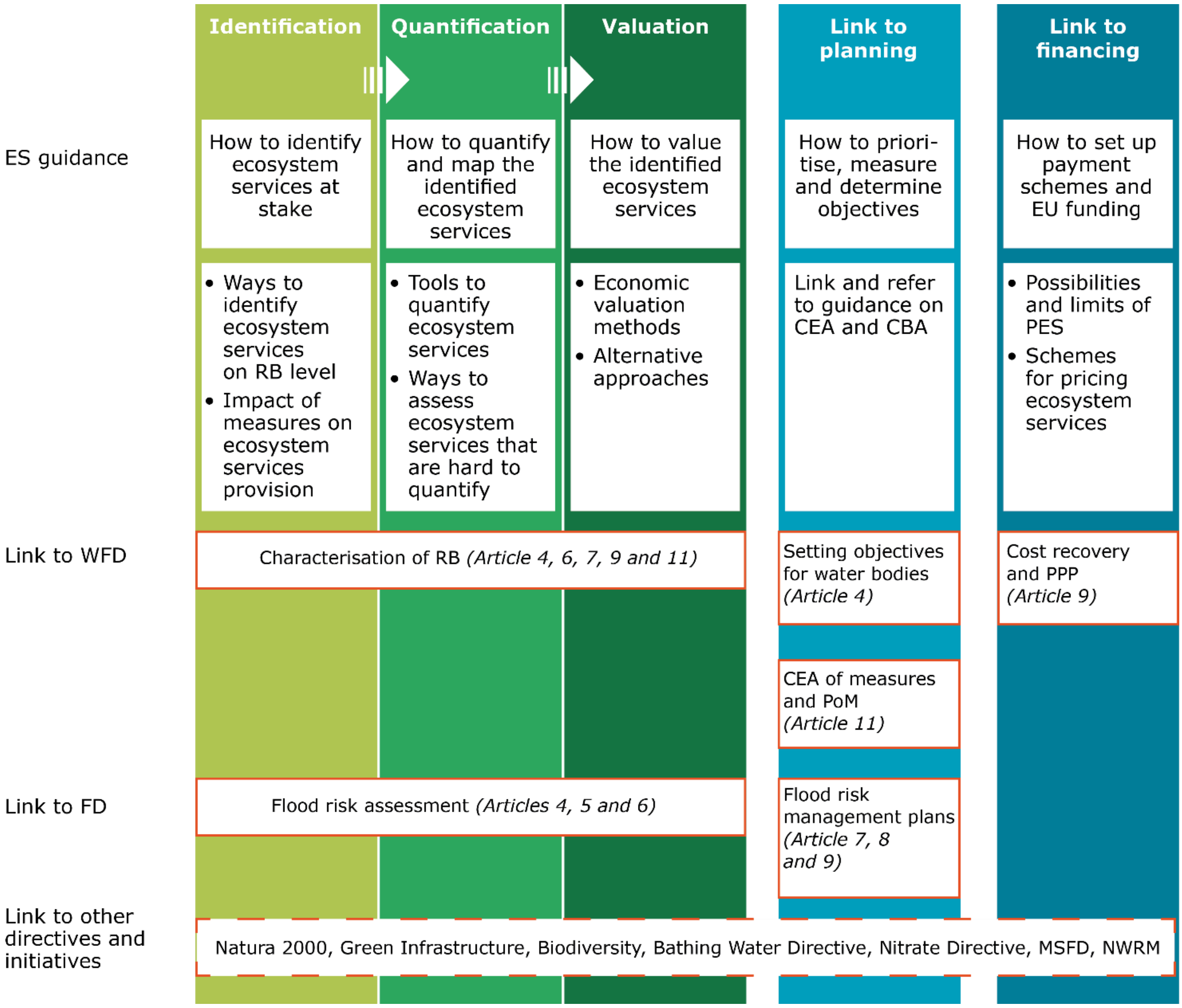
NWRMs are multi-functional measures that enhance retention capacity of aquifers, soil, aquatic, and terrestrial ecosystems[18]. They restore ecosystems, natural features, and characteristics of watercourses and by using natural processes to regulate the flow and water quality. The advantage of the NWRMs is that they offer an alternative or complement to traditional, single purpose and costly flood/water infrastructure, with the addition of multiple benefits. Often, the return from employing NWRMs is a greater return in terms of societal benefits from flood risk reduction and other ecosystem services such as water quality regulation and water provisioning, food or material production, biodiversity protection, recreation, air quality and climate regulation. In addition, NWRMs facilitate greater integration of WFD and FD objectives. Ecosystem service assessment provides an ideal common analysis and planning platform to consider win-wins, synergies and trade-offs across these two directives.

[18] http://ec.europa.eu/environment/water/adaptation/ecosystemstorage.htm, http://www.nwrm.eu.

2.5. Organisation of the document

This document is organised in five chapters each addressing a certain theme. Figure 2-4 below briefly presents each of the five themes. The organisation reflects that integration of the ecosystem service assessment with the directive implementation is about how to assess ecosystem services and how to apply the assessment made in the planning processes.

Figure 2-4 Structure of resource document and ecosystem service assessment



ES: ecosystem services
CEA: cost-effective analysis
CBA: cost-benefit analysis.

Source: COWI.

The first three columns corresponding to Chapters 3, 4 and 5 in the current document – namely, **Identification**, **Quantification** and **Valuation** - describe how to assess ecosystem services in the context of the WFD and FD. These chapters include checklists of the most relevant ecosystem services as well as examples of indicators and tools that can quantify and value ecosystem services.

The subsequent columns corresponding to Chapters 6 and 7 – namely, **Link to planning** and **Link to financing** - include examples on how to apply ecosystem services in the implementation process. The chapter "Link to planning" discusses alternative approaches to applying ecosystem service valuations in, for example, the selection of cost-effective measures for the RBMPs and the FRMPs. The chapter "Link to financing" specifically addresses how funding and pricing mechanisms in relation to ecosystem services can support the implementation of the directives.

Each chapter is structured around the following elements:

- What do identification, quantification and valuation mean?
- What are the tools available to undertake the assessments?
- What are the data sources available to support the assessments?
- Examples of how it has been done and how it can be done
- Links to further guidance and examples.

2.5.1. Identification

This theme concerns the identification of the ecosystem services, the key question being: *What ecosystems services are important in my river basin?*

The chapter includes suggestions for tools and data sources that could assist the RBM planner in identifying the key ecosystems and ecosystem services to be taken into account. To facilitate the identification of relevant ecosystems, two lists of ecosystem services are included.

- One includes the most relevant aquatic ecosystem services related to the achievement of good water status. These are ecosystem services that will be influenced by improving the water status and reaching the WFD objectives.
- A second list includes aquatic and terrestrial ecosystem services that are affected by the application of specific measures. This list indicates which ecosystem services a given type of measure is likely to affect.

The lists are meant to inspire RB managers and other planners working with RBMP and ecosystem services. They should not be considered exhaustive for any river basin, and local assessment is needed in every case.

2.5.2. Quantification

This theme concerns the quantification of ecosystem services (how many, how much?). It determines the units in physical terms to quantify the benefits and impacts associated with changes in ecosystem services. The key question here being: How are ecosystem services quantified in practice?

Ecosystem services can be quantified using available sources, such as existing maps, statistical data, map analysis, proxy methods and process models. The chapter includes suggestions for indicators, tool and methods in general terms to quantify the indicators in question.

Furthermore, the chapter focuses on guiding the RBM planner towards information already available and assisting him in identifying data/information gaps. The starting point should be the available monitoring data and the status assessments made in the RBMPs. Moreover, the EU Initiative “Mapping and Assessment of Ecosystems and their Services” (MAES)[19] and the associated pilot studies could provide valuable inputs.

2.5.3. Valuation

This theme focuses on the valuation of an ecosystem service (what is it worth and to whom?). It includes a valuation of the benefits and impacts of the exploitation of the ecosystem services. The key question is: How is the ecosystem service valuated in practice?

While the concept of ecosystem services lends itself to quantification and valuation, it might not be feasible or necessary to quantify and assign a monetary value to all relevant ecosystem services. The chapter provides suggestions for how "valuation" can be done both when the aim is to obtain a monetary value and when the aim is a semi-quantitative assessment or a qualitative description of the value.

The chapter describes possible sources of information available, and it presents alternative valuation methods and includes examples of values that might support the assessment.

2.5.4. Link to planning

This theme takes as its starting point, the planning process of the RBM planner aiming to provide examples on how to improve the implementation of the WFD and the FD by using ecosystem services assessment as a tool.

The chapter focuses on the key decision processes in the WFD and the FD where the considerations of ecosystem services are most important:

- The identification and selection of a cost-effective programme of measures (WFD Article 11)
- Setting objectives and the potential application of derogations (WFD Article 4)
- The preparation of the flood risk management plan (FD Article 7).

The Member States have applied different approaches to these decision-making processes, and the chapter presents examples of how the ecosystem services can be incorporated into the decision-making processes.

2.5.5. Link to financing

This theme presents suggestions for how the knowledge and understanding of ecosystem services can be utilised in obtaining funding. This theme concerns payments for ecosystem

[19] European Commission: Mapping and Assessment of Ecosystems and their Services. Brussels, 2013: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.

services where the assessment of the ecosystem services is utilised to determine the level of transfers between users of services when a measure is implemented. Further, an overview is given of available EU funding schemes and application of the knowledge of ecosystem services. Suggestions are given for how to use the information on ecosystem services to set up funding mechanisms. It also includes considerations of how the assessment of ecosystem services can be applied in defining payment schemes.

3. IDENTIFICATION

Identification is the first step in the three-step approach (identification -quantification - valuation) of ecosystem service assessments.

The chapter focuses on the ecosystem services that are directly related to the water ecosystems and the ecosystem services that will emerge or may be stimulated through the implementation of measures for achieving the WFD and FD objectives. Case stories, shown in the end of this chapter are used to exemplify how the identification can be done.

The key question of this chapter is:

- How to identify important ecosystem services in relation to the WFD and FD implementation?

The identification is guided by using an ecosystem service classification and the chapter includes a list of ecosystem services that are likely to be relevant in most river basins. Much of the information needed to identify the ecosystem services has already been collected in the implementation phases of the WFD and FD. In addition, stakeholder consultations can also be valuable to identify important ecosystem services.

Key challenges	The identification of ecosystem services may at first seem difficult, and the challenge is to pinpoint the many services that have already been identified during the assessments made as part of the implementation of the Water Framework and Floods Directives. In addition to the most obvious ecosystem services associated with the aquatic environment, there is also a range of additional services, which are tied to the terrestrial area. The key challenge is to be able to identify all the relevant ecosystem services, and ensure acceptance and recognition of these among stakeholders.
Chapter outcome	Presentation of data sources and tools for for identification of ecosystem services. A special effort has been put into describing ecosystem services resulting from the most common measures used during the implementation of the two directives and into describing a range of co-benefit ecosystem services , which will benefit from the WFD/FD implementation efforts.
Approach according to level of ambition	High: The concept of ecosystem services has been used through all stages of the river basin planning process including stakeholder involvment in the identification process. Medium: The relevant ecosystem services are identified with some additional data collection and involvement of stakeholder in the identification process Low: The relevant ecosystem services are identified using check lists of services and existing dat and information gather as part of the WFD and FD implemen-tation.

3.1. Identification – introduction

Identification is the first step in the ecosystem service assessment which comprises the three steps: identification, quantification and valuation. Making sure that all relevant ecosystem services are considered in the assessment is the primary objective of the identification phase. Hence, this chapter includes chapters on:

- Presentation of ecosystem service classifications (what are ecosystem services?)
- Tools and data to be applied for identification
- Specific considerations of ecosystems services relevant to implementation of the WFD and FD, including a listing of relevant ecosystems.

The ecosystem service classifications are ways to organise the ecosystem services and they provide comprehensive lists of ecosystem services that can serve as "check lists" at the identification stage. As discussed in the introduction the outcome of identification step is providing the qualitative description of the significance of ecosystem services.

3.2. Steps towards Ecosystem Service identification

The identification is closely linked to the specific planning process, which is further elaborated on in Chapter 6.

In assessing the benefits of the WFD objectives or in assessing measures as part of developing the PoM or the FRMP, the following steps would be useful:

1

- Use lists of ecosystem services (e.g. MEA, CICES) to screen for the following:
  - What are the effects on provisioning, regulatory and cultural ecosystem services of achieving the WFD objectives? (i.e. what are the effects of the measures?)
  - Consider for each package of measures whether it has impacts on ecosystem provision
- For those identified as important in the screening, do a comprehensive assessment.

2

- Consider first the effects on the water body itself
- Consider then any downstream effects, including transitional and coastal waters (cathment or river basin scale effects)
- Consider last effects on dependent ecosystems and their services (e.g. in the catchment).

3

- Apply the following sources:
  - Existing data and expert assessments
  - Stakeholder involvement, consultation and interviews (incl. stakeholder data and analysis)
  - Expert consultations
  - Visual site inspections and surveys
  - Additional GIS and other types of analysis

The identification of the potentially relevant ecosystem services and the possible further assessment including quantification and valuation is likely to be done in iterative process. What is covered in under the heading of identification is therefore the first "screening" of potential ecosystem services leading to a qualitative description of the relevant ecosystem services.

A lot of the literature on ecosystem services is about assessing existing ecosystem services. However in relation to supporting the implementation of the WFD and the FD it is not only the current provision of ES that is of interest but also the changes in the future provisions of ecosystem services. Hence, the identification should consider both the currently important ecosystem services as well as those that could become relevant when improving the aquatic environment.

The result of the identification step could be a simple scoring assessment of relevance/significance where all relevant historical, current and future ecosystem services are described as illustrated in Table 3-1.

Table 3-1 Screening of ecosystem services in a location (river basin or catchment)

Ecosystem service	Historically important	Currently important	Potential to become important
X	+++	+	++
Y	+++	+++	0
Z	++	0	0

Source: COWI.

The following chapters describe the data source and tools useful for completing this identification screening of the ecosystem services. The starting point is the systems for classification of ecosystem services. These classifications include comprehensive lists of ecosystem services that can be applied as check lists during the identification step.

3.3. Classification of ecosystem services

Basically, there are three main ecosystem service classification systems, each developed with different ecosystem service categories, and all being an accessible source of information for classification, identification and screening of ecosystem services[20]. These include classification by the Millennium Ecosystem Assessment (MA)[21], the Economics of Ecosystems and Biodiversity (TEEB)[22] and the Common International Classification of Ecosystem Services (CICES[23]). To different degrees, these three lists have been used in the attempts to incorporate ecosystem services in the river basin management across Europe[24].

[20] See European Commission, 2013.
[21] MA (Millennium Ecosystem Assessment) 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, D.C.
[22] TEEB 2010: The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation.
[23] See http://cices.eu.
[24] ONEMA (2011), Amigues J.P. and Chevassus-au-Louis B.: Assessing the ecological services of aquatic environments. Scientific, political and operational issues.

To ensure consistency with other EU initiatives on ecosystem service assessments[25], the CICES list of ecosystem services is used as the point of departure for the discussions in this document.

According to the CICES list ecosystem services are the *contributions* of ecosystems to human well-being. These services are final in the sense that they are ecosystem outputs that most directly affect human well-being. A fundamental characteristic is that they maintain a connection to the underlying ecosystem functions, processes and structures that generate them. Furthermore, they require no input of labour or building capital, but services provided may be enhanced through various actions taken to fulfil the goals of the WFD and the FD. In the CICES classification final ecosystem services are divided into three groups:

- **Provisioning services:** All nutritional, material and energetic outputs from living systems.
- **Regulation and maintenance services:** All the ways in which living organisms can mediate or moderate the ambient environment affecting human well-being.
- **Cultural services:** All the non-material, and normally non-consumptive, outputs of ecosystems affecting the physical and mental states of people.

Table 3-2 presents an overview of the main classification of ecosystem services used by CICES. The full list can be seen on the CICES homepage[26], and it includes a further subdivision into classes and provides examples of the specific ecosystem services. In this version, the classification has a separate chapter for purely abiotic outputs from natural systems (e.g. hydro power and wind power). The table includes two columns to the right – titled "WFD" and "FD", respectively. These columns indicate the ecosystem services that are most likely to be relevant in relation to the implementation of the two directives.

[25] European Commission, 2013.
[26]http://webcache.googleusercontent.com/search?q=cache%3Acices.eu%2Fwp-content%2Fuploads%2F2012%2F07%2FCICES-V4-3-_-17-01-13.xlsx&strip=1.

Table 3-2 Common International Classification System of Ecosystem Services (CICES) version 4.3 - Provisioning Services

Chapter	Division	Group	Class	WFD*	FD*
Provisioning	Nutrition	Biomass	Algae and their outputs	X	
			Aquatic animals and their outputs	X	
			Plants and algae from in-situ aquaculture	X	
			Animals from in-situ aquaculture	X	
		Water	**Surface water for drinking**	X	X
			Ground water for drinking	X	
	Materials	Biomass	Fibres and other materials from algae and animals for direct use or processing	X	
			Materials from algae and sea grass for agricultural use	X	
		Water	**Surface water for non-drinking purposes**	X	X
			Ground water for non-drinking purposes	x	
	Energy	Biomass-based energy sources	Plant-based resources	X	

Note: Ecosystem service class marked in **bold**: Ecosystem services for which there is a direct relationship with the water environment are marked in bold
* Ecosystem service class which particularly relevant in relation to the WFD and FD based on own expert judgements.

Source: European Commission, 2013.

Table 3-3 Common International Classification System of Ecosystem Services (CICES) version 4.3 – Regulation & Maintenance

Chapter	Division	Group	Class	WFD*	FD*
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	X	
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	X	
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	X	X
			Dilution by atmosphere, **freshwater** and marine ecosystems	X	X
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	X	X
			Buffering and attenuation of mass flows	X	X
		Liquid flows	**Hydrological cycle and water flow maintenance**	X	X
			Flood protection	X	X
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	X	X
		Sediment formation and composition	Decomposition and fixing processes	X	
		Water conditions	**Chemical condition of freshwaters**	X	
			Chemical condition of salt waters	X	
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	X	

Note: Ecosystem service class marked in **bold**: Ecosystem services for which there is a direct relationship with the water environment are marked in bold
* Ecosystem service class which particularly relevant in relation to the WFD and FD based on own expert judgements.

Source: European Commission, 2013.

Table 3-4 Common International Classification System of Ecosystem Services (CICES) version 4.3 - Cultural

Chapter	Division	Group	Class	WFD*	FD*
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of aquatic plants and animals and land/seascapes in different environmental settings	X	X
			Physical use of land/seascapes in different environmental settings	X	X
		Intellectual and representative interactions	Scientific	X	
			Educational		
			Heritage, cultural	X	
			Entertainment		
			Aesthetic		
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	X	
		Other cultural outputs	Existence	X	
			Bequest	X	

Note: Ecosystem service class marked in **bold**: Ecosystem services for which there is a direct relationship with the water environment are marked in bold
* Ecosystem service class which particularly relevant in relation to the WFD and FD based on own expert judgements.

Source: European Commission, 2013.

Table 3-5 Accompanying CICES classification of abiotic outputs from natural systems

Chapter	Division	Group	Examples	WFD	FD
Abiotic Provisioning	Nutritional abiotic substances	Mineral	e.g. salt		X
	Abiotic materials	Metallic	e.g. sunlight		
		Non-metallic	e.g. metal ores		
	Energy	Renewable abiotic energy sources	e.g. minerals, aggregates, pigments, building materials (mud/clay)	X	X
Regulation & Maintenance by natural physical structures and processes	Mediation of waste, toxics and other nuisances	By natural chemical and physical processes	e.g. wind, waves, hydropower	X	X
	Mediation of flows by natural abiotic structures	By solid (mass), liquid and gaseous (air)flows	e.g. coal, oil, gas, water		
	Maintenance of physical, chemical, abiotic conditions	By natural chemical and physical processes	e.g. atmospheric dispersion and dilution; aquatic dispersion and dilution; adsorption and sequestration of waters in sediments; screening by natural physical structures	X	X
Cultural settings dependent on abiotic structures	Physical and intellectual interactions with land-/seascapes [physical settings]	By physical and experiential interactions or intellectual and representational interactions	e.g. protection by sand and mud flats; topographic control of wind erosion		X
	Spiritual, symbolic and other interactions with land-/seascapes [physical settings]	By type	e.g. land and sea breezes; snow		X

Note: Ecosystem service class marked in **bold**: Ecosystem services for which there is a direct relationship with the water environment are marked in bold
* Ecosystem service class which particularly relevant in relation to the WFD and FD based on own expert judgements.

Source: European Commission, 2013.

The CICES list includes both water and land related ecosystem services. Although the focus is on integrating considerations of ecosystem services into the WFD and FD implementation processes, it is relevant to present the entire list here, because some terrestrial ecosystem services are related to measures that are taken to achieve WFD and FD objectives and provide benefits to the aquatic ecosystems. Further, the catchment management and the interdependency of aquatic and terrestrial services are relevant. Please note, that they have an impact on each other.

An example of a WFD measure that influences ecosystem services beyond the aquatic environment is changes in, or regulation of, land use, such as establishing or re-establishing a wetland (example of a NWRM). This can be used as an effective measure for reducing pollutants entering the water bodies and for stimulating a process towards achieving GES/GEP. Implementation of this measure may influence more terrestrial-based ecosystem services, such as for instance sequestration of water and carbon in these areas, thereby increasing biodiversity and providing additional areas for recreational uses, but it has also a big impact on regulating services related to water.

In relation to the implementation of the WFD and FD, the specific classification used and the associated issues are less important, whereas it is important that a comprehensive list of ecosystem services is used to ensure that all relevant benefits and co-benefits are identified[27]. Both the WFD and FD require assessments that take the costs of the measures into account. By way of example, the effects on the abiotic ecosystem services will typically be covered as part of these assessments.

Considering the list of ecosystem services, it should be noted that many ecosystem services can act as pressures on the water bodies due to the way they are utilised. Provisioning ecosystem services of providing ground and/or surface water for industrial, drinking and irrigation purposes may put substantial pressure on the water bodies and increase the risk of not achieving WFD objectives. The same goes for excessive use of recreational ecosystem services like boating or fishing, which may also increase the pressure on biology, thus working against the objectives of WFD. Other examples of services delivered by the natural aquatic systems that can have such impacts are hydro power and navigation. These activities can reduce flows to levels below acceptable environmental flow levels, disconnect ecosystems, inhibit migration routes for wildlife, canalise rivers and intensify flooding events. Many of the European rivers have been highly modified to support navigation and hydropower and, although both are considered highly relevant and beneficial to society, they still work against the attainment of the goals of the WFD and the FD. However, the advantage of including these services and their benefits in a broad ecosystem services assessment is that it provides an opportunity to look for win-wins, avoid unintended consequences and allow trade-offs that can bring us closer to the objective of the WFD (preamble), which is sustainable water management.

In sum, by using the comprehensive lists and carefully considering whether any of the ecosystem services would be affected and deliver increased benefits, the overall implementation of the directives could be improved.

[27] See Annex I, Chapter 2 for discussion of the different classification systems and description of the advantages of the CICES classification as more consistent in avoiding double counting.

The ecosystem services are not limited to those listed above; rather the list could be used as an inspirational checklist to identify ecosystem services in the river basin. In Chapter 3.5, specific lists of key ecosystem services are provided.

3.4. Tools and data sources for ecosystem service identification

The following chapter presents a selection of tools and data sources that can be used to identify ecosystem services.

3.4.1. General tools and data sources

Ideally, the identification of ecosystem services should depend on a detailed understanding of the River Basin. The information collected during the initial stages of the planning processes of WFD and FD provide relevant information in the form of monitoring data, environmental pressures and risks, analysis of stakeholder interests and needs for measures, such as the need for wetlands to reduce impacts from nutrients, removing obstacles for maintaining river connectivity etc.

More specifically, tools and data sources used to identify ecosystem services could include, but are not restricted to, the following (they can be used either in parallel or in sequential steps, depending on the specific context):

- Existing data from the development of the RBMP and data from previous surveys of the elements in the catchment.
- Authorities: publicly accessible information can be found in municipalities, with river basin authorities or at web sites. The work on the implementation of the Biodiversity Strategy and the biodiversity mapping of ecosystem service by 2014 will provide additional information.
- Site visits to assess actual conditions on site.
- Hydrodynamic and hydrological modelling, possibly in combination with sediment transport, erosion or ecological modelling for identification of flood protection ecosystem services as well as ecosystem services identified by hydro-morphological and habitat assessments.
- Maps, aerial photos and satellite imagery of the River Basin to provide basic information of the area, taking a catchment approach to cover both terrestrial and aquatic elements.
- Stakeholder workshops, consultations and interviews to allow citizens and key stakeholders to express their interest in the river basin, provide additional knowledge, insight and data, help identify key ecosystem services and reconcile interests. If questionnaires are used, design and evaluation must be carefully conducted to ensure that stakeholder views and knowledge are communicated at a level that can inform the study team.
- Action 5 of Target 2 of the EU Biodiversity Strategy to 2020 envisages that Member States will, with the assistance of the Commission, map and assess the state of ecosystems and their services in their national territory by 2014. The result of the

mapping will also provide information that can be used in identifying ecosystem services.[28]
- Cooperation with other regions and other countries will facilitate ecosystem service identification.

The three steps identification, quantification and valuation are closely linked and might be done as one "assessment" activity. The ecosystem services identified might be of greater or lesser importance, and initial quantification/valuation considerations might help focus on the key ecosystem services.

Text box 3-1 Example of identification, quantification and valuation of ecosystem services, Oise River, France

A case study the Middle Valley of the Oise River done by the French General Commission for Sustainable Development (CGDD) in 2012 gives an insight into how ecosystem services can be identified, quantified and valued as part of river basin management.

The most important services in the area were identified as being flood protection, provision of food and materials and biodiversity, while aquifer recharge and water purification are also of great importance.

Flood protection is important as the flood plains and their vegetation protect more than 92 000 inhabitants in the valley from peak flows and great water depths that could severely affect downstream towns. The river plains support extensive agriculture, including cereal production, livestock farming and cultivation of poplar trees. In addition, they serve as grounds for hunting and fishing. Therefore, the provision of food and materials is an important service. With regard to biodiversity, the river basin is host to several protected zones, including two NATURA 2000 sites, as well as four zones of special ecological, faunistic and floristic interest (ZNIEFF).

The wetlands also play an important role in the recharge of aquifers, as they allow runoff or overflow to seep through the soil to the groundwater, which is later used for drinking water in the region. On a similar note, the wetlands also contribute to water purification in the river basin, notably through bacterial denitrification.

Finally, the aesthetic values are deemed as being of “little importance”. The most important services of this category are fishing and hunting, but the use of the wetlands for recreational purposes is not considered of similar importance.

Source: Commissariat Général au Développement Durable, 2012: “Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise”
http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

The use of the tools and the associated data related to the specific ecosystem services are explained in more detail in the chapter on Quantification and in relation to the individual ecosystem services (Chapter 4).

To identify the relevant ecosystem services, it is necessary to answer the following questions:

- At which scale is it relevant to assess the ecosystem services?

[28] MAES has worked with this assessment and suggested indicators to be used by the Member States. See European Commission, 2014:
Source: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

- Are the services temporary?
- Is the provision of the ecosystem service constant or does it fluctuate?

Spatial Scale

The identification of ecosystem services is often most relevant at catchment or river basin scale although ecosystem services typically relate to specific water bodies. However, there are often upstream-downstream relationships that require action at different scales. A typical example is the upstream spawning opportunities for fish species required to support the ecosystem service of commercial fishery downstream. Another example is proper upstream water resource/quality management to ensure a proper supply of water for drinking, irrigation and production in the downstream area. In some cases, it may also be relevant to expand the scale beyond the catchment scale to the sub-basin or even the whole basin because of potential ecosystem service relationship with regional and even global issues.

An ecosystem service that contributes to combating climate changes is an example of such. In the River Skjern case (cf. below), the effort done to secure access to spawning grounds for the Atlantic Salmon was expanded from a single, small catchment to the whole river.

Text box 3-2 Example of identification, River Skjern, Denmark

River Skjern, Denmark

The River Skjern in Western Denmark was changed significantly in the early 1960's, where more than 4.000 ha of wetlands, meadows and swamps were isolated from the river for agricultural purposes. The reclaimed agricultural land was expected to provide a huge increase in agricultural production. Investments in pumping stations, dikes and other features were made to reduce or eliminate the flooding, and the river was completely disconnected from its flood plain. The agricultural practice led to a substantial release of nutrients, which were pumped into the river with the drainage water and transported to the Ringkobing Fjord, a brackish inland water, which responded with an increase in the eutrophication level. In addition, the lowering of the water table in the reclaimed land increased the release of the natural iron deposits, leading to a substantial increase in the release of ochre, an iron-sulphate substance ($FeS2$), which lowered the pH in the river and damaged the riverine habitats. The area lost a huge amount of birds, aquatic plants, invertebrates and mammals and it was soon turned into intensive agricultural land. The biggest recreational loss was the fact that the channelization of the river prevented spawning of the Atlantic salmon (Salmo salar), which had one of its few remaining spawning grounds in Denmark in the River Skjern.

40 years later in 1999, the biggest river restoration project in Denmark started with the aim of bringing the river back to semi-natural conditions and restoring the natural habitats with its original flora and fauna. The restoration was finalized in 2003 and the work done was in line with the intentions in both WFD and FD, since recreating the river connectivity with its natural flood plains provided both better habitats (aquatic and terrestrial) and allowed flooding of the plains at regular intervals. More than 2000 hectares were reclaimed for nature and was turned into a national park. Access to the areas was improved, bird watching towers raised and fishing grounds established.

The ecosystem services gained included an increase in the natural biodiversity in both aquatic and terrestrial habitats (birds, insects, flora, etc.), a lowering of the nutrient loads to the fjord, lowering the ochre release, which also increased the pH, better connectivity and, on top, the return of the Atlantic salmon to the river. The area has attracted a wide variety of people using the natural park for recreational purposes such as bird-watching, canoeing, fishing, hunting and plain enjoying nature.

The improved ecosystem services follows more or less directly from the design of river restoration. For a specific assessment of the ecosystem service improvement, see Text box 4-11 in Chapter 4.

The ecosystem services were identified from general knowledge about the areas, land use information, existing soil type and biotope mapping, environmental monitoring programme, registration of according to EU habitat directive and other nature conservation registrations, stakeholder consultation and public meeting and workshops as well as consultation of specialist with local knowledge.

The main ecosystem service gains from the river restoration project are:

- Fish stocks and recruiting (increase in breeding salmon and other fish species)
- Biodiversity preservation (increase in both aquatic and terrestrial flora and fauna)
- Filtration of pollutants (reduction of pollution loads from agriculture)
- Recreational opportunities (huge increase in boating, fishing, hunting, hiking, etc.)

Source: http://www.skjernaa.info/english.

Temporal Scale

In the process of identifying the ecosystem services, it is relevant to consider how the value of the ecosystem service will develop over time, or in other words the temporal scales. The benefit may occur in the future, only be relevant at a certain time of the year or be temporal, only occurring in a restricted time span. An example of a temporal ecosystem service is nitrogen removal in wetlands and riparian zones. If not properly designed and in case of nitrate overload, the organic content may be burned off over a decade or two, leading to a decrease in removal capacity, because the microbial nitrogen turnover (denitrification) depends on organic matter as energy source. Similar temporal effects can occur for phosphorus in wetlands, where the immobilisation ability will decrease over time because the phosphorus sorption capacity becomes saturated. In addition, nitrogen removal is much higher during summer than during winter and this adds another temporal scale to the ecosystem service. As can be seen, both a long-term temporal scale (years) and a short-term scale related to the time of the year is feasible.

Against this background, it is recommended that the identification consider both spatial and time-scale aspects to the extent possible. This can be done for example by including these aspects in the discussion with the stakeholders or by consulting an expert to gain knowledge about how the ecosystem services are affected by time. The effect will be site specific and will need to be assessed in that context.

3.4.2. Data sources from the WFD implementation process

Information of special relevance to the ecosystem service identification derived from the WFD process includes:

- ecosystem characterisation and pressure and impact analysis (Art. 5)
- register of protected areas (Art. 6)
- information about abstraction of drinking water (Art. 7)
- monitoring of the status of surface water and groundwater (Art. 8).

Additionally, the information and knowledge accumulated during the development of the PoM (Art.11) are important sources of ecosystem service identification. Many activities and stakeholders will have been identified during the development of the PoM and the consultation process with stakeholders is an important source of information (Art. 14).

Knowledge of existing or potential ecosystem services within a river basin is often available from the information collected for the River Basin Management Plans (RBMP) in the form of hydromorphology, water quality, water utilisation, wetlands, riparian zones and assessment of fish stock, vegetation and other important biological elements, etc. Ecosystem services can also be identified through the analysis of pressure/impacts, economic analysis of water use, mapping of water abstractions and registration of protected areas. This identification process can also reveal knowledge gaps where new information is needed in order to obtain a full picture of the ecosystem services of a river basin.

Important information about, especially, the location can be extracted from the ecosystem services identified during the screening process by consulting maps showing basic ecosystem characteristics, such as habitat types, landscapes and land use. Additionally, ecosystem services can be identified by consulting research papers and other documents and by looking at the typical landscape and habitat types that have been mapped. To establish the impact of an ecosystem's function on human activities, a map showing interests and conflicts within the river basin and stakeholder involvement can prove useful.

Consulting experts in specific fields and not least different groups of stakeholders in the catchment can provide very valuable information for the ecosystem service identification process. Working intensively along these lines, the ESAWADI project[29] has made good progress in developing better tools for analysis and advice on how to work with ecosystem services. ESAWADI used interviews with local and regional representatives of water authorities and other stakeholders (tourism, agriculture and nature protection), which were supplemented by workshops at the local level. One of the conclusions was that the approach to be taken depends on the specific conditions in the river basin and the main obstacles to achieve the objectives of the WFD/FD. The French case study (addressed the conflict of hydropower versus hydromorphological status, the German case study (see Textbox 3-6) also focused on hydro-morphology related to large rivers and the pressure they provide on the fish migration and the Portuguese case study also included an economic analysis of the costs and benefits of including ecosystem services.

On the border between the Netherlands and Germany on the shared River Vecht (see Text box 3-6), public consultations showed vast differences across the two populations in the identification of important ecosystem services, the choices being clearly related to e.g. agricultural practices, which different considerably between the two countries.

It is assumed that RB planners have access to the data required to make the initial identification of ecosystem services since these data will mainly be those used for developing the River Basin Management Plan, which was a requirement of the WFD implementation. This process also typically included consultations with different stakeholder and expert groups. Drawing on these sources, ecosystem service identification can be done in most cases.

However, in some cases information from databases or previous analyses and consultations may turn out to be inadequate. Here, site visits or new studies, e.g. in cooperation with authorities and research institutions, can be useful supplements. While this may seem obvious, the gain from including disciplines that were not part of prior catchment analyses is perhaps

[29] http://www.esawadi.eu.

less obvious. By way of example, drawing on the social sciences could help identify ecosystem services that are important to society as a whole.

The extent of supplementary consultations and analyses will depend on available resources, and it is stressed that the first effort to include ecosystem service aspects in the planning process can be based on information already available.

3.4.3. Data sources from the FD implementation process

The direct links to the FD relate primarily to Articles 4, 5 & 6 in terms of the identification of ecosystem services. This specifically entails:

- Identifying locations where the flood risk is significant through Preliminary Flood Risk Assessments (PFRA) and identifying Areas with Potential Significant Flood Risk (APSFR);
- Preparing both flood hazard and risk maps (by 2013);
- Using contextual maps to identify river catchments and flood risk/hazard areas which can be specifically related to ecosystem services, e.g. water regulation - areas and factors potentially contributing to the regulation of surface water run-off. It should be noted that the Flood Risk Maps of the individual Member States may have a higher level of detail.

The PFRA is based on available information and includes the following:

- Maps of the river basin district;
- Description of past flood events that have had an impact on human health, the environment, cultural heritage and economic activity;
- Description of significant flood events in the past, which may be similar to possible future flood events;
- Collection of data: The collection of data and the formulation of preliminary flood risk assessments utilise data sources on topography, watercourses and associated hydrological and geomorphological characteristics, floodplains. These data sources may also be useful for the consideration and assessment of ecosystem services. As the PFRA assesses causes of flood risk, the probability of flooding in the type of water bodies affected and the scale of the effect, the information gathered can also improve the understanding of stocks and flows of ecosystem services. This also includes marginal changes resulting from interventions, policies and plans.

The PFRA process also serves to provide a high-level identification of potential ecosystem services and potential trade-offs and conflicts. For example, the predominant ecosystem service of concern in the context of flood risk and the FD is the regulating service moderation of extreme events (TEEB classification).[30] Many aspects of river basins and flood plains combine to influence the provision of this ecosystem service. These may include physical attributes such as topography or the extent of flood plains, or socio-economic factors around land use. In addition, other services can be directly affected by flood events. Many of these are alluded to in the wording of the FD, which on a number of occasions mentions the links between flood risk, human health, the environment, cultural heritage and economic activity. While the FD does not refer to these as ecosystem services by name at any point, the mere

[30] TEEB 2010: The Economics of Ecosystems and Biodiversity: The Ecological and Economic Foundations. Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation.

identification of them clearly shows the cross-over between ecosystem service thinking and the objectives of the FD.

The Working Group Floods resource document "Flood Risk Management, Economics and Decision Making Support"[31] also highlights the cross-over between the objectives of the FD and ecosystem service thinking (once again, these links are not directly emphasised) by stressing the shared objective of maximising human well-being. It says *"Floods can be considered as a shock in the evolution of society on the path of sustainable development…. the measure for sustainable development is well-being…Vulnerability is a measure for the drop of well-being at the moment of a flood, and resilience is a measure for the speed to recover from the flood to the former level of well-being."*[32] The topics of vulnerability and ecological resilience and adaptive capacity in relation to floods and water scarcity and droughts are also dealt with in e.g. Water resources in Europe[33] with many conceptual graphs and a wide variety of definitions.

The management of river basins and flood plains under the FD is naturally linked with the management of other ecosystem service flows across all types, including provisioning, regulating and cultural (as well as many supporting) services. Examples include raw material production in flood plains, agriculture, wastewater treatment or tourism.

In summary, the role of ecosystems in the protection from and resilience to flooding that damage people or property is an ecosystem service in itself, which the FD seeks to encourage and facilitate. Flooding can interrupt the flow of other ecosystem services to society, such as the supply of drinking water. Enhancing the ability to moderate flood events will help maximise this particular regulating ecosystem service, reduce the risk to other ecosystem services, such as crop production, and help improve well-being.

3.5. Ecosystem services sustained/maintained by good ecological status and by measures

To support the consideration of ecosystem services, two lists of relevant ecosystems have been identified. The first list concerns the ecosystem services provided by aquatic ecosystems and strongly relates to the objectives of the WFD. The second list focuses on aquatic and terrestrial ecosystem services that are influenced by the specific selection of measures. Measures include both those introduced as part of the implementation of the WFD and those that might be introduced in the FRMPs. The first list indicates which ecosystem services depend on the WFD objectives and particular elements of water status (as defined in WFD) and the ecosystem services. The second list links the potential measures with the ecosystem services. Combined, it is possible to relate the PoM with its impact on the ecosystem services striving to fulfil the objectives of the WFD/FD.

[31] http://ec.europa.eu/environment/water/flood_risk/pdf/WGF_Resource_doc.pdf
[32] http://ec.europa.eu/environment/water/flood_risk/pdf/WGF_Resource_doc.pdf, p. 19.
[33] http://www.eea.europa.eu/publications/water-resources-and-vulnerability.

3.5.1. Ecosystem services provided by aquatic ecosystems

The ecosystem services addressed in this chapter originate from the aquatic ecosystems and they relate to the benefits that can be reaped in fulfilment of the WFD objectives.[34]

An overview of ecosystem services indicating where the achievement of the objectives will stimulate the provision of the ecosystem services is given in table 3-5.

The link between ecological status/potential (GES/GEP), as defined by the WFD, as well as other objectives (chemical/quantitative status, no deterioration) and the ecosystem services is not always clear. However, an ecosystem for which the ecological status has been improved will often be able to offer a wider variety of ecosystem services, because the natural conditions have improved (improved water quality and quantity, for example, will support higher production of invertebrate fauna sustaining an increase in the fish population). The improvement in the ecological status can be translated into changes in the supply of ecosystem services, which can be capitalised by society in the form of e.g. goods, protection or uses. This is discussed in more detail in the Annex Report which includes a review of key literature.

However, overexploitation of ecosystem services, and in particular of provisioning services, can exert pressures on water bodies and negatively affect their status. Water abstraction may for example lower the amount of water in river or a stream, eventually lowering the ecological potential, or it may affect groundwater quantitative status. The achievement of WFD objectives may be dependent on the introduction of restrictions on the utilisation of some ecosystem services, such as commercial fisheries (quota restrictions), water supply and recreational and tourist uses. However, these restrictions will lead to sustainable use of water resources thereby ensuring provision of these services in the long run. Making an ecosystem service assessment across the full range of services allows you to identify unintended consequences, look for win-wins or make trade-offs between beneficial services in the short and long term.

Some typical examples of ecosystem services provided by aquatic ecosystems, which are associated with the achievement of the objectives of the WFD and FD, are given below. The examples should not be considered an exhaustive list of ecosystem services, since local conditions always need to be considered. **It is critically important not to exclude any services (e.g. from the MEA or CICES classifications) in the initial (screening) assessment**. In doing so, you are making unjustified assumptions about the significance of other services, people's interests in other services, possible unintended consequences on other services. You are also likely to miss the opportunity to develop win-wins)

[34] See M. Vlachopoulou, et al., 2014 for a detailed mapping of how the provision of ecosystem services depend on specific WFD objectives.

Table 3-6 Some possible key freshwater ecosystem services (CICES classification scheme) associated with WFD quality elements

CICES	Provisioning					Regulatory/ maintenance			Cultural		
WFD Annex 5 elements for water status	Natural production of biomass available for human use e.g. shellfish	Plant, algae and animals from Aquaculture (better water quality)	Fish stocks and recruiting	Genetic material from all biota (e.g. utilisation for biochemical and pharmaceutical processes and industries)	Water supply (drinking, industrial, irrigation, hydropower)	Biodiversity preservation and improvement in streams, rivers lakes, coastal areas (higher diversity and abundance)	Water quality regulation by rivers, lakes, coastal areas	Hydrological cycle and water flow maintenance (e.g. Environmental Flow)	Recreational (and tourism) opportunities directly related to the water (fishing, bathing, water sports, bird watching, etc.)	Aesthetic/cultural value strictly related to the water in streams, rivers, lakes, coastal areas	Education and scientific benefits (Learning and understanding water chemistry and biology)
Chemical and Physico-chemical quality elements supporting biological quality and chemical quality [35] Pollution load reduction measures	•	•	•	•	•	•	•			•	•
Biological quality elements: Restoration and rehabilitation of water bodies		•	•			•			•	•	•
Hydromorphological quality elements: Water (quantity) resource management measures including flood protection					•	•		•			•
Groundwater level and chemical status					•			•			

Source: COWI.

[35] Referring to substances affecting ecological / chemical status of surface water and chemical status of groundwater.

**Water supply** refers to the provision of raw water for drinking water, industrial production and irrigation. This type of ecosystem service will already be known owing to the requirement to assess existing pressures, water use and specifically drinking water abstraction. Achievement of WFD objectives for water quality (including non-deterioration) could lower the costs of providing water supply compared with a situation of non-achievement of WFD objectives (see the chapters on quantification and valuation for the approach to determine the importance of this ecosystem service). This type of ecosystem service illustrates that ecosystem services can also exert pressure on ecosystem functions. While improved water quality might affect the costs of providing clean water supply, excessive provision of water in itself may increase the risk of not achieving the WFD objectives. Therefore, it may be necessary to change the way this ecosystem service is utilised and managed by reducing water abstraction or changing the allocation of water use to safeguard ecological flows and prevent exhaustion of groundwater resources.

**Fish stocks and recruiting and plant, algae and animals from aquaculture** would be expected to be an ecosystem service that would benefit from the achievement of the WFD objectives. Commercial fishing can be stimulated by improving the water quality and by ensuring sufficient environmental flows in surface waters to maintain migration pathways, foraging and spawning sites. The specific improvements are more complex to identify, for example which species benefit so much that increased stocks offer a commercial potential? Review of existing fisheries (including shellfish aquaculture), stakeholder consultations and comparison with similar water bodies or catchments areas could support the identification. For this ecosystem service, the spatial dimension is important. The improved ecosystem service could occur downstream, in the estuary or in coastal waters, rendering an overall river basin approach necessary in most cases.

**Natural biomass production** includes all other aquatic flora and fauna that can be utilised for human use. The CICES system characterises biomass from natural production in the ecosystem as a provisioning service that can contribute to the CICES classes nutrition, material and energy (see Table 3-2). In most cases, it is easy to identify biomass production interest and ecosystem services, as they are typically related to activities such as agriculture, forestry, fishery, aquaculture and harvesting of products of significant economic interest. However, less obvious biomass production can also be relevant, such as collection of wild berries and fruits, mushrooms, honey production based on wild flora, genetic material or other materials from wild plants and animals for medicine production, dye and colour production, etc. It is recommended that information to be used to identify less obvious ecosystem services be collected through stakeholder consultations and interviews.

**Genetic material** from biota (e.g. utilisation for biochemical and pharmaceutical processes and industries) includes aquatic flora and fauna that can be utilised for biochemical and pharmaceutical use. As with biomass from natural production, the CICES system characterises genetic material in an ecosystem as a provisioning service. The genetic material is part of the CICES classes nutrition, material and energy (see Table 3-2). In most cases, it is easy to identify genetic material interest and ecosystem services as they are typically related to biochemical and pharmaceutical activities of significant economic interest. It is recommended that information to be used to identify less obvious ecosystem services be collected through stakeholder consultations and interviews.

Biodiversity preservation, in this context, means aquatic biodiversity. Biodiversity preservation is influenced by each of the three components used to characterise the water bodies. Areas of special interest for biodiversity preservation have already been identified or are being identified as part of registration activities related to national protected areas, the EU Habitats Directive, Natura 2000 and similar on-going monitoring and registration programmes. Areas of existing and potential interest can also be identified from land use mapping and from the monitoring activities carried out under the WFD. Consultations with different stakeholders and green NGOs and interviews with local experts are other sources that can support identification. It should be highlighted that biodiversity preservation outside special protected areas is often also of importance. Biodiversity in farmland and urban areas also needs attention.

Water quality regulation by rivers, lakes, coastal areas.

The aquatic ecosystem has the ability to regulate water quality by retaining pollution for example retention of nitrogen through aquatic plant and microorganism uptake, sedimentation and denitrification. The main problem of insufficient water quality in many water bodies is about the discharge of high amounts of point and diffuse pollution above the ecosystem's capacity to maintain water quality.

Hydrological cycle and water flow maintenance (e.g. environmental flow) is understood as the regulated movement of water (in river basins, sea, atmosphere, etc.). The water cycle includes transportation of water, minerals and energy. These flows are crucial for the maintenance of life and the ecosystem.

It is difficult to collect information about impacts on these types of ecosystem services since the topic is very complex. Good sources of information are local experts and NGOs. The focus needs to be broad to reflect complexity.

Recreational (and tourism) opportunities directly related to the water (fishing, bathing, water sports, bird watching, etc.) relate, in this context, to all uses of waters for recreational purposes. Some of the uses (e.g. bathing, fishing) depend strongly on the quality of the waters whereas others (e.g. water sports) are less susceptible to water quality problems. For this ecosystem service, the availability of substitutes in the surroundings combined with the potential number of users is important. Data and information can be collected from the users either by counting visitors or by interviewing them.

Aesthetic/cultural values strictly related to water in streams, rivers, lakes, coastal areas can take many forms and be related to the value the ecosystem service represents to society by in the form of art, beauty, and taste. The uses of the waters are mostly visual, and the quality will only be relevant if it influences the visual appearance. Examples are the beauty of clear water in a river or the picturesque view of a lake. These ecosystem services are difficult to map as representative users may not have been defined. It is likely that some of the services will be revealed at stakeholder workshops and others though the demand for living space in the area.

Education and scientific benefits (learning and understanding water chemistry and biology). This includes many different elements, for example the quality and the morphology of waters but also the impact on the groundwater from the use of pesticides in crop production. The source of information will be the local research institutions and schools.

3.5.2. Ecosystem services affected by selection of specific WFD and FD measures

Measures used to reach the WFD objectives and to fulfil the objective of the FD will always provide a range of ecosystem services. Firstly, achieving the WFD objectives will by itself enhance and sustain the ecosystem services provided by the aquatic ecosystems (as described in previous session. Moreover, the implementation of these measures may rely on the enhancement of terrestrial ecosystem services (mainly regulatory). And finally, the measure implementation may have resulted in additional services that can be regarded as additional benefits. Regulation of flooding to achieve the FD objectives by use of natural water retention methods (e.g. increased connectivity between river and flood plain) relies on the regulating services provided by terrestrial ecosystems, contributes to achievement of WFD objectives (through positively affecting ecological status) and has additional benefits in terms of climate mitigation enhancing carbon sequestration.

This chapter gives an overview and provides short descriptions of other ecosystem services that are identified during the implementation of WFD and FD measures that have a specific focus, such as pollution reduction, restoration or water resource management. Note that there is an overlap with the ecosystem services presented in the previous section (Table 3-6). For example, biodiversity improvement in aquatic ecosystems is achieved by fulfilling the objectives irrespective of the specific selection of measures. However, certain measures may offer additional improvements, including improvements to terrestrial ecosystems.

The WFD defines measures as "*any type of action or initiative that can be used to mitigate the effect of pressures that affect the water environment*".[36] In the RBMP, measures can be related to the Integrated Pollution Prevention and Control, Urban Waste Treatment or protection measures according to the Nitrates and Habitats Directives. The FD operates in a similar manner with defined mitigating measures for flooding. Several of the measures are highly relevant in relation to both the WFD and the FD. Multifunctional measures that provide multiple ecosystem services need to be given special attention, e.g. natural water retention measures (NWRM)[37], which contribute to achieving the WFD and FD objectives through increasing the turnover and filtration capacity and decreasing diffuse pollution and reducing flooding though increased storage capacity.

Table 3-7 is meant to inspire for RBM planners and stakeholders working with the ecosystem services as part of the implementation of the WFD/FD. It illustrates that most of the categories of measures have impacts on several ecosystem services and some categories such as land use change impacts on the majority of services.

[36] Directive 2000/60/EC of the European Parliament and of the Council.
[37] http://www.nwrm.eu/.

Table 3-7 Ecosystem Services stimulated by implementation of specific WFD and FD measures

	CICES	Provisioning			Regulatory/maintenance						Cultural		Abiotic		
	WFD/FD measures	Water production	Fish stocks and recruiting	Natural biomass production	Biodiversity preservation	CC adaption and combating / GHG reduction / Carbon Sequestration/	Groundwater/aquifer recharge	Flood risk reduction	Erosion / sediment control	Filtration of pollutants	Recreational Opportunities	Aesthetic/cultural value	Navigation	Geological resources	Energy (hydro power)
Pollution load reduction	Treatment plants							•							
	Sewage infrastructure (CSO reduction)							•							
	Point source pollution reduction at source (incl. clean technology)		•		•							•			
	Diffuse source pollution reduction (by source control)		•		•						•	•			
	Urban handling of surface water runoff (Permeable pavements, bio retention and infiltration, green roof, etc.)				•	•	•	•		•	•	•			
	Land use management incl. agricultural pollution policy (CAP)				•	•	•	•	•	•	•	•			
	Wetlands/riparian zones: Restoring, constructing incl. reconnecting rivers and flood plans				•	•	•	•	•	•	•	•			
	In-stream restoration: Restoring natural features of streams, rivers, channels				•				•	•	•	•	•		
Restoration	Water body restoration (in-lake and in–river activities)		•	•		•	•	•	•	•			•		
	Connectivity (longitudinal)		•	•									•		
	Connectivity (lateral) river/floodplain	•	•	•		•	•	•	•	•					
	Riparian zone restoration		•	•		•	•	•	•	•				•	
	Reef/hard-bottom rehabilitation		•	•						•					
	Regulation of Navigation (inland)								•				•		

	CICES	**Provisioning**			**Regulatory/maintenance**						**Cultural**		**Abiotic**		
	WFD/FD measures	Water production	Fish stocks and recruiting	Natural biomass production	Biodiversity preservation	CC adaption and combating / GHG reduction / Carbon Sequestration/	Groundwater/aquifer recharge	Flood risk reduction	Erosion / sediment control	Filtration of pollutants	Recreational Opportunities	Aesthetic/cultural value	Navigation	Geological resources	Energy (hydro power)
Water resources	Regulation of irrigation								•						
	Reg. Groundwater abstraction	•					•								
	Reg. Surface water abstraction		•		•				•		•				
	Flood plain / wetland restoration (connectivity)		•		•	•	•	•	•	•	•	•			
	Regulation of dams (hydropower, drinking water, irrigation)		•		•			•	•		•	•	•		•
	Regulation of water transfer between catchment		•		•			•	•						
	Reuse of water/water savings														
	Artificial groundwater recharge						•			•			•		
	Rainwater harvesting					•		•							

Source: COWI.

In the following, each of the ecosystem services is discussed by directly relating it to the potential impacts of the WFD or FD measures. The focus will be on identifying how the objectives of the WFD/FD is achieved by regulation, or in other words by the implementation of measures. The impact of the implementation of measures on the different ecosystem services will represent a change in the provision of benefits to society.

Water supply refers to the provision of raw water for drinking water, industrial production and irrigation. It is already described above under ecosystem services related to the objectives of the WFD and FD. This ecosystem service is both relevant in when considering the benefits of achieving the objectives of the WFD and the FD and when considering the measures to achieve the objectives. The ecosystem service can be a pressure on the ecosystem through over-abstraction of ground and/or surface water for water supply uses. In such a situation, measures will be needed to reduce the pressure and one could be to reduce this provisional service. Reallocation of water among alternative water uses is another measure that could be applied to increase the overall value of the service.

Fish stocks and recruiting is an ecosystem service that is stimulated by numerous of measures related to restoration and rehabilitation of aquatic ecosystems and biodiversity with the aim of achieving the objectives of the WFD/FD. Commercially valuable fish will indirectly benefit from restoration and pollution load reductions and the fish stock will increase. Commercial fishing can be stimulated by ensuring sufficient environmental flows in surface waters, which will maintain migration pathways, foraging and spawning site. Regulation of surface water abstraction can play an active role in supporting this ecosystem service as it lowers the pressure on the flow regime of a river. Dams can inhibit migration, and thereby reduce reproduction of commercially interesting fish species, by restricting access to spawning grounds. The transfer of water between catchments may have positive and negative impacts on fish populations depending on the regulation and its extent. For marine areas, rehabilitation of hard substrates is known to attract a much wider biodiversity than a soft seabed, and reefs are also known to act as nurseries for many marine species.

Natural biomass production aimed for human use is a very wide term, which can be used to describe all additional increases in (mainly but not only) terrestrial flora and fauna. The CICES system characterises the biomass from natural production in ecosystems as a provisioning service that can contribute to the CICES classes nutrition, material and energy (See Table 3-2). Restoration of ecosystems using the measures mentioned in Table 3-7 will most often increase in biomass production and especially stimulate vegetation along banks, on flood plains and in other habitats. In some cases, increased vegetation, e.g. along river banks, may affect the aesthetic value of landscapes negatively or hinder access to water bodies. In other cases, it can have positive impact both on aesthetic and recreational values. Individual assessments are required.

Biodiversity preservation, in this context, means both terrestrial and aquatic biodiversity – and is an ecosystem services that will be stimulated by several of the measures mentioned. Urban measures for handling surface water runoff often include more green areas and thereby more habitats for plants and animals in urban areas. Restoration of wetlands and riparian zones will significantly increase habitat diversity in the entire catchment not only for aquatic species but also for a number of terrestrial species. In-stream restoration will increase habitat diversity and thereby biodiversity beyond the benefits of improving the water quality. Biodiversity preservation can be significantly influenced by any measure that modifies the flow pattern (hydrography). The impacts can be both positive and negative depending on how the regulation of the flow is managed and how the indicated measures are implemented.

Climate change mitigation (including but not restricted to Green House Gases (GHG) reduction and carbon sequestration) can be obtained through land management and the establishment of a riparian buffer zone, which can accumulate and store organic pools. Land use can also significantly influence GHG production, e.g. wetlands can either be net sinks or net sources of greenhouse gases (GHGs). Whether it is one or the other depends on precipitation and other factors like temperature, vegetation and land use.

A more indirect climate change mitigation effect is from measures such as green areas and green roofs in urban areas. They can have an impact on the local climate which can reduce the energy need for cooling and heating and thereby reducing CO_2 emissions.

Climate change adaptation. The main climate change adaptation ecosystem service is about reduction of the flood risks which described below as a separate service.

The effect on local climate in cities through more green spaces could in addition to be seed as indirect climate change mitigation effect by considered as an adaptation service reducing overall the effects of both higher average temperatures as well as more extreme temperature events.

Groundwater/aquifer recharge can be stimulated by rainwater infiltration in urban areas, changing land use, establishing floodplains/wetlands, managing the riparian zones, and promoting sustainable drainage in rural areas. When measures to restore horizontal connectivity in rivers are implemented and plains are flooded regularly in designated areas, the recharge of the aquifers will increase and ultimately ensuring more groundwater for different uses. An active floodplain/wetland and riparian zone will enable better surface-groundwater exchange, which will also benefit the water body during droughts. Furthermore, this can be achieved through extended and controlled flooding of plains and naturally through artificial groundwater recharge systems. Other NWRM such as sustainable forestry practices provide hydrological and water quality regulating services through the restoration and filtration of water.

It should be noted that groundwater abstraction could put a pressure on other ecosystem services, since abstraction of groundwater will decrease the natural flow of groundwater to the rivers and streams. However, this should not be the case as long as the WFD observed, as measures (e.g. abstraction regulations) need to be in place taking to account the objective for groundwater quantitative status, and the interactions of groundwater and surface water and groundwater dependent ecosystems.

Flood risk reduction is the ecosystem service of increasing the water retention capacities of the ecosystems and thereby reduce the risks of damage caused by flooding. There are many measures, including utilisation of connected wetlands and floodplains (and other NWRMs), that have the capacity to mitigate flood events, which will ease the pressure on the aquatic habitats by reducing the erosive/abrasive characteristics of floods. However, this ability depend on the activities within the flood plain and appropriate flood plain management, e.g. the capacity of different ecosystems (e.g. forests, grasslands) to regulate floods through vegetation and soil cover. Consequently, the ecosystem services delivered by a well-functioning flood plain/wetland are both numerous and significant.

Traditionally, improving sewage infrastructure has been used as a safe, but very expensive measure to mitigate the risk of urban flooding. Measures such as Sustainable Urban Drainage Systems[38] it can have both flood risk and pollution reduction functions (i.e. by reducing urban runoff and reducing the load from combined sewer overflow and storm water runoff from paved areas). In-stream restoration may also lower the risk of flooding, but it can also have a negative impact by increasing flooding. Meandering of rivers and the promotion of aquatic vegetation can increase the flood risk due to the blocking effects.

Reduced flooding resulting from horizontal connectivity measures will improve possibilities of controlling floods and accept designated areas for flooding, which will reduce flooding other places and the measures implemented to reduce flooding will most probably be directed to reduce the damages in urban areas, with the side-effect of reducing impacts from urban pollution, but at the cost of having non-urban areas flooded.

Flood risk protection and water resource management are closely connected, although not all water resource management measures will lead to protection against floods. Combining

[38] http://www.sepa.org.uk/water/water_regulation/regimes/pollution_control/suds.aspx.

measures such as wetland restoration, establishing connectivity between rivers and flood plains, optimising utilisation of dam capacities and ensuring appropriate water transfer between catchments can have some flood protection benefits. These can be obtained in combination with other means of water resource management and can also safeguard environmental flows and other drought management related issues.

Erosion/sediment control are other key ecosystem services related to the FD. They may be a result of spatial measures such as land use management, wetlands and the riparian zone. In some cases, the urban measures for handling surface runoff can modify erosion, but compared with other processes regulating the erosion in catchments, urban runoff does normally not contribute significantly to controlling erosion and sediments. Changes of land use (vegetation cover, type, etc.) and restoration of wetland and riparian zones are examples of NWRMs that can significantly change and reduce erosion to the river system. In-stream restoration such as meandering, ensuring optimal bed substrate and submerged vegetation can highly influence the erosion and sediment transport through the river system.

In case of meandering rivers, it is important to allow the river to act naturally to a certain extent, ensuring eroding and sedimentation zones, which will ensure a much more dynamic system and offer many challenges and possibilities to biodiversity.

Erosion/sediment control and transport in streams and rivers are highly dependent on flow variations and discharge amounts. Accordingly, any measure that modifies these two variables can have a significant impact on the erosion and sedimentation.

Filtration of pollutants and decomposition in the soil can be further stimulated by changes in land use, restoration of wetlands and the establishment of riparian zones. Pollutants (e.g. nutrients and pesticides) can be absorbed and/or degraded before ending up in the water body through appropriate design and management of the areas. In-stream restoration can also accelerate the filtration of different pollutants in the water body due to increased submerged vegetation cover, biofilms, sediment accumulation and increased retention time.

Nutrient reduction may not be the main concern when doing rehabilitation, but in most cases it will provide ecosystem services, mainly through positive changes in the physico-chemical conditions of the water, e.g. higher oxygen concentration, better aeration, oxygenated sediments, etc. The riparian zone and flooding of plains will add to the nutrient reduction due to better hydromorphological conditions that enhance the degradation of externally added nutrients from e.g. storm water overflow and non-point pollution from agriculture.

Filtration of pollutants (nutrients as well as other pollutants) can be obtained from the filter function of wetlands, riparian zones and through infiltration by artificial recharge of groundwater.

Recreational opportunities are very often the most valued ecosystem services because they give the public access to new or restored areas. The possibilities can be significantly increased though land use management, establishment of riparian buffer zones in rural areas, in-stream restoration projects and by establishing green spots in urban areas. Activities like bird watching, hiking, picnicking or simply relaxation can be stimulated if the areas are properly designed and opened to the public. The recreational opportunities can also be used to promote tourism. The case studies referred to in this chapter show how recreational opportunities offer many of the above ecosystem services. In the case of the Tweed River (Text box 3-3) the restoration of the river increased fishing tourism. This generated a number of additional jobs, income and other commercial benefits. In the River Skjern case (Text box 3-2), the restoration resulted in a substantial increase in bird-watching tourism and in boating activities.

As further discussed under quantification and valuation, it is important to consider whether improved recreational opportunities in one location will lead to a substitution effect so that the increase in the number of visitors in this location is offset by a reduction in the number of visitors in other locations.

Aesthetic/cultural values will also be stimulated. Urban green spaces along streets to support infiltration and green roofs to mitigate stormwater run-off increase the aesthetic value. Measures such as riparian zones, land use management and in-stream restoration can be used as part of landscape design to increase aesthetics. The aesthetic/cultural ecosystem services are closely linked to the recreational ecosystem services.

In addition to the ecosystem services described above, **abiotic services** can occur or be changed as a result of the implementation of measures. These services also represent a value to society by the use of the waters:

Navigation. Historically, navigation and access to coastal waters, rivers and lakes have been and still are highly appreciated services. The most obvious places for navigation are already in use, but there may still be water bodies that can offer services to smaller vessels and pleasure boats. In many cases, identification of water bodies for boating activities must be weighed against other interests, such as the wish to protect habitats if there is a risk that access to the areas may negatively affect habitats and species in the area.

Geological resources: Access to the natural transport of geological materials downstream in all water bodies is a service. Geological materials can be used for a wide range of purposes, but striking a balance between the exploitation of available materials and biota living in the sediments may be delicate.

Energy (hydropower) from hydro power is one of the abiotic ecosystem services or water services that often conflicts with the achievement of the objectives of WFD/FD, because a naturally functioning river system has a natural variation and dynamics in its discharge pattern (hydrography) and sediment transport. In addition, energy production will most often counteract the river continuum connectivity, thus preventing the natural upstream migration. Dams and hydro-power utilisation will have a significant influence on these variables.

3.6. Case examples

This section presents a number of case examples on how ecosystem services have been identified.

Text box 3-3 Example of identification: Tweed River, Scotland

Case: Tweed River, Scotland

For centuries, wetlands in the Tweed River catchment had been threatened from expanding agriculture. This was recognised to pose a threat to the wide range of ecosystem services that are provided by the river catchment. Since 2003, the Catchment Management Plan (CMP) for the Tweed River has been updated continuously, and has been guided by seven strategies: water quality, water quantity, habitats and species, river works, flood management, tourism and recreation and finally delivery of the CMP. In 2009, it was decided to combine the CMP with the River Basin Management Plans under the Water Framework and Floods Directives for joint implementation to reach GES. Examples of ecosystem services that have been identified during the drafting of the RBMP are listed below:

- The River Tweed has a long tradition of sports fishing, which is dependent on **fish stocks and recruiting**. Hence, it was identified as one of the main ecosystem services and it has been a priority to preserve and improve current fish populations. This is supported by angling organisations, which also work on a voluntary basis to run a monitoring programme.
- **Biodiversity preservation** is dependent on the availability of habitats for plants, birds, fish and mammals. Wetlands have been identified as a main measure to provide such habitats and achieving GES. Additionally, biodiversity in terrestrial areas is affected positively, which provides additional benefits.
- The riparian zone was identified for providing **erosion/sediment control**. The impact in the water body can be characterised as inherent consequences of achieving GES, whereas the positive impacts within the riparian areas on erosion, flora and fauna are to be regarded as additional benefits that would not have been achieved through other measures that might have been used to contribute to reach GES.
- Wetlands and riparian areas have been identified as providing **recreational opportunities** like hunting, fishing, water sports and bird-watching. They are to a great extent services that can be considered additional to the formulated objectives of the WFD and the FD.

Source: www.tweedforum.org

Text box 3-4 Example of identification: River Vecht between Germany and the Netherlands

Case: River Vecht between Germany and the Netherlands

Objective: To demonstrate the practical usefulness of the ecosystem service concept in water management in a transboundary local/regional setting, taking the implementation of the WFD and FD into account.

The Scenery: River Vecht is a transboundary watercourse between Germany and the Netherlands. The river is highly modified, straightened and regulated and runs in a flat landscape in the study area. Agriculture is the primary land use in both countries. The Dutch side has small-scale agriculture, mainly with cattle and some vegetables, while the German side has highly intensive agriculture focusing on maize, potatoes, poultry and pig farming. The practice in e.g. restoration of the flood plain is different in the two countries, where the Netherlands has allowed the river to meander, while the Germans have not yet done anything to re-naturalise the river.

Perception: German stakeholders are mostly interested in the institutional features (ownership of the land between public and private) and they find the landscape flat. The Dutch do not see the landscape as flat, but their main perception of the area is that of a peaceful and open landscape!

Potentials: The water management in the two countries have planned to look at regulatory possibilities to provide inundation areas to be used during floods and also for storing more water for dry periods.

Identified ecosystem services: The stakeholders in the two countries identified the following ecosystem services, which were affecting them directly or indirectly:

- **Water storage; production & Irrigation**: Natural fertilizer effect from flooding, nutrient turnover, agricultural products, freshwater for consumption, water purification
- **Natural production**: Raw materials (straw, wood, mushrooms, etc.)
- **Biodiversity preservation**: Genetic resources (endangered species of husbandry), habitats, pollination
- **Flood Risk Reduction:** Protection against natural forces, water regulation, connectivity
- **Recreation/cultural:** Inspiration, relaxation, nature hiking
- **Other:** Energy production, transport (navigation).

Which ecosystem services to strengthen?: The identified ecosystem services related to river water management were in line with a development plan for the area and favoured a semi-natural water course with limited regulations, restoration of banks and acceptance of fluctuating water level, benefitting wetlands and aquatic plants.

Willingness to pay for the ecosystem service: The analysis showed that most ecosystem services are at present paid for by conservation foundations. Dutch farmers are paid for maintenance of wood banks and for cutting vegetation in the flood plains. Besides there was not a direct willingness to pay for ecosystem services, except for recreational services due to their ability to attract tourism.

Source: Deltares (2012); Towards practical implementation of the ecosystem services concept in transboundary water management http://publicwiki.deltares.nl/download/attachments/73433334/1204644-000-BGS-0004-DEF.pdf?version=1&modificationDate=1328625600000

Text box 3-5 Example of identification: Hase River, Ems River Basin - a German ESAWADI case study

Case: Hase River, Ems River Basin - a German ESAWADI case study

Objective: The aim is to identify how an ecosystem services approach can contribute to the decision-making process concerning policies and measures particular justification for exemptions to article 4 of the WFD and the "disproportionality of costs" criterion.

The context: The Ems RBMP has identified hydro-morphological modifications as one of the main pressures on the aquatic ecosystems. A case study has focused on river continuity and ecological health. 60% of the water bodies were characterized as heavily modified and 21% as artificial water bodies. The surrounding landscape consists of alluvial pasture landscapes with a rich biodiversity. Ecologically, the river is home to about 30 species of fish, like eel, dace, roach, perch and brown trout. GES was assessed not achievable and the goal was formulated as GEP. Lack of continuity laterally as well as longitudinally was assessed to have a main negative influence on the provision of ecosystem services.

Identification of ecosystem services: Literature was reviewed and water management experts were interviewed to describe the relationships between the state of ecosystems, ecosystem services provisions and the water- and land-uses influencing these services. Based on this, a qualitative description of the ecosystem services was developed and the following relevant ecosystem services in the different categories were identified.
Provisioning services:

- Water provision (drinking and non-drinking) and discharge (households, industries, agriculture)
- Aquaculture (trout), Fish stock and recruitment
- Genetic material and resources.

Regulating services:

- Hydrological cycle and water flow (runoff, retention)
- Filtration of pollutants: Self-purification of water (in water and soil)
- Erosion and sediment control
- Biodiversity preservation, (species regulation).

Cultural services:

- Recreational opportunities (leisure activities & tourism)
- Aesthetics values;
- Education and scientific benefit;
- Heritage (non-use and existence value of biodiversity).

Qualitative assessment was carried out in interviews with local and regional representatives from water authorities and other stakeholders (like tourism, agriculture and nature protection). The results were discussed with local stakeholders in a consultation workshop.

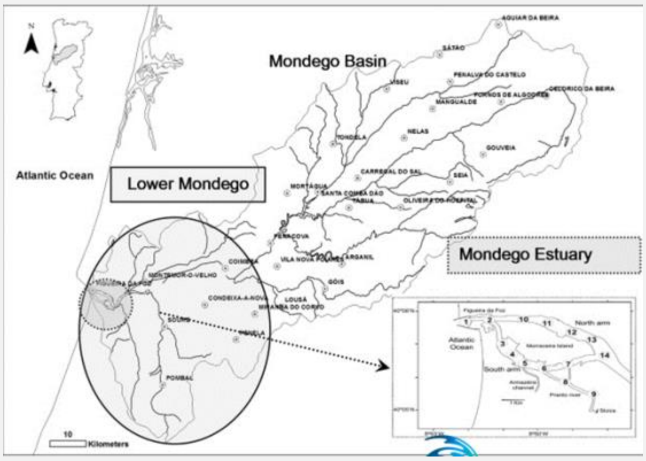
Quantification and valuation: Instead of basing the methodology on quantitative, monetized values of benefits of measures (e.g. ecosystem services), a semi-qualitative way was utilized, using expert judgement and simplified quantitative scales, in a five-step process.

Conclusion: The study showed how and where the acknowledgement of ecosystem services might support the protection and enhancement of healthy river ecosystems. The concept provides an entry point for local data and stakeholder expertise. The ecosystem service approach helped illustrate the complexity of ecosystems and pressures from human usages. For communication purposes, it might be helpful to ask: Which service is provided by an ecosystem? Which service might be dependent on a healthy ecosystem?
Correlations between the ecological status of the Hase River catchment and the effect on the uses of ecosystems are associated with a relatively high degree of uncertainty, which has to be communicated to the public. Implementing this ecosystem service approach is resource intensive. It is challenged by unknown effects of measures – in kind, magnitude and scale- and lack of data. The lack of quantification and generally accepted valuation methods need to be compensated by transparency and good stakeholder cooperation. The approach can help identify potential trade-offs as well as synergies between different stakeholders.
It is recommended that a qualitative (long-term) monitoring of changes in ecosystem services and in use patterns due to measures implemented according to the WFD be carried out. A simple approach to quantifying ecosystem services needs to be developed.

For more details: http://www.esawadi.eu/case-studies/german-case-study.

Text box 3-6 Example of identification: Mondego Estuary, Portugal

A case study from the ESAWADI project performed on the Mondego Estuary in Portugal addressed the main pressures affecting the environmental status of the ecosystem and their effects on human well-being. Anthropogenic pressures include harbour activities, aquaculture farms exploitations, increasing land development, high population densities on the coasts, and agricultural runoff. Natural pressures include flooding in winter and severe, dry conditions in summer. This case is an example of an ecosystem undergoing intense pressure from both social and economic changes and is a case that can be used to examine the effectiveness of water quality improvement measures. Four steps for identifying ecosystem services in the Mondego catchment area were taken. Firstly, relevant biomes were identified and ecosystems were described in order to analyse the main water uses and practices in the area. Secondly, ecosystem services were identified for all services provided in the region. For each service, estimations were made for possible valuation methods, main drivers of change and impacts on biodiversity, among other things (see the table included below). Based on these, a set of methods to value estuarine services was documented. Thirdly, anthropogenic and natural activities interact and produce a complex network of inter-relations. The increasing water nutrients from agriculture and aquaculture in the Mondego Estuary led to the degradation of not only water quality for agriculture, but also influenced aquaculture production and affected aquatic communities'. Therefore, interactions between environmental and socio-economic dynamics at multiple scales were identified. Fourthly, interviews with public stakeholders were carried out and a multi-criteria analysis was conducted to address potentially conflicting uses of measure implementation. They conclude that due to these complex networks of inter-relations and inter-dependencies, any measure implemented to improve an ecosystem service will affect, directly or indirectly, other ecosystems.



	Category	Service/Good	Description/Function
Services	Production services	Food production	Extraction of products for human consumption (aquaculture, agriculture, fisheries)
		Raw materials	Extraction of products for other purposes than human consumption (minerals)
		Pharmaceutics	Extraction of products for medicinal or pharmaceutics purposes
		Ornamental resources	Extraction of products for, for example, decorative purposes
		Renewable energy	Extraction of benefits from natural resources (e.g., electricity extraction)
	Cultural services	Eco-tourism	Use of ecosystems for leisure purposes (e.g., museums, parks)
		Recreation	Use of ecosystems for refreshment and stimulation by people, through the glance of species in their environment (e.g., bird watching)
		Cognitive values	Cognitive development, including education and research
		Cultural heritage	Value associated with the natural system components (e.g., religion, cultural and spiritual traditions)
		Non-use values	Value which we derive from systems species, without using them
	Regulating services	Gas & climate control	Balance and maintenance of the chemical composition of atmosphere and water by species
		Disturbance regulation	Dampening of environmental disturbances by biogenic structures (e.g., storm, flood or drought protection and mitigation; soil erosion and retention)
		Carbon sequestration	
		Bioremediation	Removal of pollutants through storage, dilution, transformation, or burial (e.g., waste assimilation)
	Supporting services	Nutrient cycling	Storage, cycling and maintenance of availability of nutrients by organisms
		Water quality/availability	System capacity to provide water for human usage (both water usage *in situ* or water withdraw)
		Soil health	Soil fertility, formation and habitat measure
		Nurseries	System capacity to provide habitat band suitable conditions to some species juveniles to develop
		Habitat provision	Habitat provided by and for species and that contribute to a higher genetic diversity
		Pollination	System ability to promote genetic variability
		Resilience/Resistance	Extent to which ecosystems can absorb recurrent natural and anthropogenic perturbations and continue to regenerate

Inventory of ecosystem services in the Mondego catchment area, category to which they belong to (according to the Millennium Ecosystem Assessment, MA, 2005), description of the service, indicators that can be used to calculate it, benefits associated and status of evaluation in the study area.

Source: Cunha, M., Marques, J., Pinto, R., Palma, C. (2012) Ecosystem Services Approach for Water Framework Directive Implementation: Mondego catchment area Case Study Report. [*http://www.esawadi.eu/IMG/pdf/ESAWADI_Mondego_estuary_CS_report_vf-3.pdf*](http://www.esawadi.eu/IMG/pdf/ESAWADI_Mondego_estuary_CS_report_vf-3.pdf)

Text box 3-7 Recommended literature

Crossman, N.D. et al (2013). A blueprint for mapping and modelling ecosystem services. Ecosystem Services. http.//dx.doi.org/10.1016/j.ecoser.2013.02.001.

Egoh, B et al (2012). Indicators for mapping ecosystem services; a review. JRC scientific and policy reports. European Commission.

R.S. de Groot et al. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7 (2010) 260–272.

Haines-Young and Potschin (2013). Common International Classification of Ecosystem Services (CICES) Consultation version 4.

Maes, J. et al (2013). Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union, Luxembourg.

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: Synthesis. Island Press, Washington D.C.

ONEMA (2011). Amigues J.P. and Chevassus-au-Louis B.: Assessing the ecological services of aquatic environments. Scientific, political and operational issues. The French National Agency for water and aquatic environments (ONEMA).

TEEB (2010). The Economics of Ecosystems and Biodiversity – Ecological and Economic Foundations.

4. QUANTIFICATION

Quantification is the second step in the three-step approach (identification -quantification - valuation) to assessing ecosystem services.

After the initial screening across all ecosystem services using simple checklists, quantification of the services most relevant to the catchment or river basin might improve the assessment.

Quantification of ecosystem services aims to provide units in physical terms (e.g. m², litres etc.) which can be used to measure changes in ecosystem service provision.

Therefore the key question is:

- How can we quantify the ecosystem services in practice?

Some services are relatively easy to quantify, such as provisioning services, e.g. fish catches, as they provide marketable products. Regulating and maintenance services and cultural services are usually more difficult to quantify. Other ecosystem services and especially regulatory & maintenance and cultural ecosystem services are often quantified using indicators and proxies that are related to the ecosystem services provision.

This chapter includes descriptions of relevant indicators and guidance on how to estimate the indicators for selected ecosystem services.

Key challenges	While some services are relatively easy to quantify, such as provisioning services (e.g. fish catches) the regulating, maintenance and cultural services are usually more difficult to quantify. Here, quantification requires an understanding of the functions of the ecosystem which can be restricted either because of lack of resources or due to lack of knowledge.
Chapter outcome	The objective is to guide and inspire the river basin management planners to quantify the identified ecosystem services at an appropriate scale. The final selection of the indicators and the methods for quantification will be highly dependent on the specific river basin and have to be based on local knowledge. The examples included give hints for the use of direct quantification, quantification based on proxy indicators as well as for the use of process models. This should give inspiration for quantifications at different levels of ambitions.
Aproach according the level of ambition	High: Quantification of indicators for all identified ecosystem services based on addtional data collection, stakholder consultation and model assessments. Medium: Quantification of the most important ecosystem services identified based on existing knowledge and stakeholder consultations. Low: Use of existing quantitative data and attempting to relate it to the ecosystem services identified. Ecosystem services that cannot be related to the existing data should be described qualitatively.

4.1. The merits of quantification

Already during the identification, a first appraisal of important ecosystem services, which should be included in a further analysis, is made. For some purposes, this knowledge might be sufficient and can serve as the basis for communicating information to stakeholders at workshops and as input to the planning process.

It is important to stress that there is a risk that the quantification comes to focus on the ecosystem services that can be readily quantified, instead of on those that are considered most important. It is therefore very important that to consider carefully which ecosystems are most important even if they are difficult to quantify.

Quantification is particularly relevant when measures are to be implemented, either to achieve the objectives of WFD/FD or to meet the pronounced goal of enhancing ecosystem services. Most measures will change the functioning of the ecosystem and influence ecosystem service provision. Identification may be able to point to the direction of such a change, but it is hard to estimate the magnitude of this change simply from the identification. Knowing the magnitude of the change is important when comparing different measures, and later on when assessing the proportionality of the costs. That is not to say that quantification is a completely objective assessment of these changes, as some of the 'quantifications' can be based on subjective opinion and might even be described in relative or qualitative terms. In the end, it is important that stakeholders and/or experts accept the metrics or accounts of magnitude used.

The following steps are proposed to provide a structured and coherent approach to the quantification exercise:

1

- Screen the ecosystem services to identify those that need to be quantified

2

- Select indicators that are suitable for the ecosystem services that are to be quantified

3

- Identify potential sources of data and tools that can be used to quantify the selected indicators

Many of the relevant data source and tools for the quantification provide input to the assessment of several ecosystem services, and therefore this chapter starts by a chapter on data sources and models. This chapter is followed by a chapter on the selection of indicators and a specific discussion of the quantification of the key ecosystem services.

4.2. Tools and data sources for quantification

The quantity of an ecosystem service can either be directly measured or indirectly estimated. In many cases, it is not feasible to measure the ecosystem service provision directly and therefore one or more indicators have to be applied as approximations to the real provision of the ecosystem service. Examples: the extent of riparian buffer strips can be regarded as a proxy for filtration capacity; area and extent of potential spawning sites can be regarded as a proxy for actual spawning and recruitment of fish population; indicator species can be used as proxy for a full mapping of the entire biodiversity.

In an assessment of the effects of achieving the WFD/FD objectives, the assessment of ecosystem services address changes in the future provision of services. Changes in the provision of ecosystem services have to be estimated though they build on the mapping of the current level of ecosystem service provision. It means that it relies on some form of "model" of how ecosystem characteristics and functions relate to service provision. The knowledge and understanding of the quantitative relationships for many ecosystems and ecosystem services are still limited. As long as these relationships are not clearly understood and established, the quantification of changes in the ecosystem service provision will be subject to uncertainty.

An example of quantification using indicators to assess the possible change in service provision is given in Text Box 4-1 below for a case involving services provided by wetlands. Wetlands are capable of reducing nitrogen and binding phosphorus, but each wetland has its own specific capability, which can only be assessed through specific analyses. However, the literature values for the N-reduction capabilities and P-binding capacity can be used as first indicators to quantify the ecosystem service of nutrient filtration from the creation of new wetlands. Text Box 4-1 explains how literature values, GIS analysis and land use mapping were used to develop the Danish RBMPs with regard to quantifying the nitrogen and phosphorus filtration in a restored riparian wetland.

Text Box 4-1 Example: wetland filtration in Danish draft RBMPs

Identification:

The draft Danish River Basin Management Plans identified the ecosystem services provided by wetlands with respect to filtration capacity of the nutrients N and P. In a Danish context, N reduction is the most important measure to ensure GES/GEP in coastal zones, whereas P reduction is of high importance to inland water bodies and especially lakes where GES/GEP have to be achieved.

Quantification:

Potential wetlands and flood-prone areas along streams and rivers close to the coast were identified by GIS analysis and their sizes were quantified. Within the Danish river basins, 10,000 ha additional wetland and flood-prone areas were identified. Based on literature values from earlier investigations and research projects, a reduction capacity of 113 kg N/ha was estimated. Based on these values, the total potential N-reduction, utilising the filtration/degradation capacity of wetlands, is in the order of 1,130 tons N/year. Reconstruction of 10,000 ha was incorporated as a measure in the PoM of the RBMPs to achieve GES in the costal zones.

The potential capacity of wetlands and other riparian areas with respect to P-reduction is typically highly relevant to quantify in the upstream parts the catchments and in lake catchments. Potential areas were identified based on size and the Strahler Order[39] of the river system. Only along the second and higher order of streams was it assessed realistic to identify significant floodplain-sizes that could function as nutrient filters. Localisation of potential areas was done through GIS analysis with focus on lake catchments. The area and number of flooding days were estimated. Streams with high nutrient transport were located based on monitoring data. Focus was especially on levels of suspended material. Based on the size of area, number of flooding days and the transport in the streams, the potential retention was calculated using an empirically developed relationship. Streams with a high capacity were selected and

[39] The Strahler Order is a term used to define stream size based on a hierarchy of tributaries for a river catchment.

included in the RBMPs. 1500 ha of P-wetlands were assigned to achieve GES/GEP in P-limited lakes. These measures were estimated to retain totally 30 tons of P/year with an average capacity of 20 kg P/ha/y.

Source: http://naturstyrelsen.dk/vandmiljoe/vandplaner/vandplaner-(2009-2015)/hoeringer/offentlig-hoering-2013/.

The exact tool to be used for a quantification of a specific service is highly dependent on the type of service in question. At the level of provisioning, regulating and cultural ecosystem services some general considerations are presented below.

For *provisioning ecosystem services*, it is often possible to use statistical data collected at regional or national scale. The analysis from the first cycle of the WFD will include consideration of relevant quantities (e.g. fish production). Also, the stakeholder consultation will have provided input on the economic interests in the river basin. It is very likely that the stakeholders have presented the expected impact of a measure in the discussions of the PoM. This information can be utilised to determine the quantity of provisioning services that will be affected in the river basin. Overall, data on the existing provision are likely to be available, while the estimation of changes will require expert assessment.

For *regulatory ecosystem services*, it is more common to base the analysis on existing data from land use maps, habitat maps and different environmental survey and monitoring programmes. The map analysis often uses the river basin as the basic delimitation. Knowledge of landscape, land use and main biotopes combined with on ground monitoring data will often make it possible to determine the status of the ecosystem, its extent and to define relevant indicators to be used for further quantification.

For *cultural ecosystem services* such as tourism and recreation, the quantification can be based on data for example on the number of visits to the relevant nature sites. For less tangible cultural ecosystem services, for example the aesthetic value and spiritual enrichment, the quantification and the valuation are typically done simultaneously as there is no "quantity" as such.

It is important to highlight that quantification even at the lowest level of ambition, where only a semi-quantification or a rating is possible, can contribute to improved understanding and awareness of the benefits that can be achieved from ecosystem services during the implementation of the WFD/FD. Inherently, the quantification of ecosystem services is often rather uncertain, and it is important to communicate this clearly to the end-users in order to avoid misinterpretations. Independently of the tools and data used, the assessment will require expertise and time to achieve a sound and robust quantification.

Only a few tools can be generically applied to support quantification of ecosystem services. One such general source deserves mention. The MAES initiative under the EU Biodiversity Strategy has carried out a wide range of ecosystem service assessments, and the website provides access to the results of a number of pilots, including one on freshwater ecosystems[40]. The MAES initiative has developed a number of indicators for the ecosystems covered by the pilots and for these indicators there are links to relevant data sources. Chapter 4.3 on Indicators provides more details about the MAES work.

[40] See: http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-ecosystem-services-freshwater.

Secondly, the initiative "The Natural Capital Project (NatCap)"[41] led by universities and NGOs has developed a tool to support the assessment of ecosystem services. The downloadable tool InVEST includes suggestions on how a number of ecosystems can be assessed including the identification, quantification and valuation. The software consists of a part that can do biophysical modelling and a part that can do economic modelling. For a number of ecosystem services, InVEST provides a description and a specific model using typically GIS based data and links/references to relevant scientific literature.

4.2.1. Data sources

Much of the information gathered during the earlier stages of WFD/FD implementation offers useful knowledge and data on the effect of implementing measures on various indicators, s Data sources from the WFD implementation process. See Chapter 3.4.2 for data on the WFD and Chapter 3.4.3 for data on the FD.

Additionally, documents produced for the reporting on directives and conventions, such as the Habitats Directive (NATURA 2000), the Birds Directive and the Urban Waste Water Directive also include valuable information that may be relevant for quantifying ecosystem services in the river basin. Documents and project sites are therefore valuable starting points for further analysis.

The land cover classes (Corine Land Cover) can be accessed from the internet[42] and be used in combination with local/regional digital maps to help identify catchment features for additional analysis of ecosystem services.

Another source of inspiration can be found in the PRESS project headed by the JRC, which has carried out a spatial assessment of ecosystem services in Europe[43]. The project studied several tools and methodologies to map ecosystem services and found that most ecosystem services are of the provisioning type (e.g. production of food from agricultural and marine sources). The two other key groups of ecosystem services, regulating and cultural ecosystem services, are scarce and in many cases lacking. Similar to the findings of a number of other studies and as shown in the cases at the end of this chapter, many ecosystem services are available and have been quantified in the recreational area and in the provision of clean water.

In addition, environmental data sets from national reporting, including bathing water quality, water quality are available from European bodies, such as the European Environment Agency in cooperation with the European Topic Centres (ETCs), Eurostat, the Joint Research Centre (JRC) and DG Environment through the European Data Centres and Information Systems. Relevant environmental data/information is also available from other EU services and related agencies (e.g. Marine data series on nutrients, salinity, temperature, biodiversity etc. from International Council for the Exploration of the Sea - ICES for marine information, urban atlas data from EU[44]). These data are compiled on a pan-European scale; hence, not directly applicable to studies on a local scale, even though they can serve as sources of inspiration.

[41] The Natural Capital Project (NatCap) aims to integrate the values of nature into all major decisions affecting the environment and human well-being. The project is partnership among Stanford University, The Nature Conservancy, the World Wildlife Fund, and the University of Minnesota. They have developed the free downloadable software InVEST which can be used to support ecosystem service assessments. http://www.naturalcapitalproject.org/InVEST.html

[42] http://www.eea.europa.eu/data-and-maps/data/european-catchments-and-rivers-network.

[43] http://www.peer.eu/projects/press-project/.

[44] http://www.eea.europa.eu/data-and-maps/data/urban-atlas.

WISE[45] also provides a central access point to several web-services: interactive maps, data viewers, European datasets and indicators. These services are mostly based on reporting from countries as part of implementation of EU directives or via the Eionet framework. The contents of these sources are improving and expanding all the time. In addition to data gathered at the European level, it is important to look for national data that often have a higher level of information and detail.

The quality and validity of the data used is a very important factor, since assessments will be based on them. It is also important that data that vary in time and space be carefully assessed before being used to identify an ecosystem service. For such data, time series spanning several years are preferable to understand seasonal and annual differences, which may be important in quantifying specific ecosystem services.

4.2.2. Modelling

Modelling analysis of water quantity and water quality is useful for analysis of data in spatial and temporal scale, and it can be shaped to address the stock, quality and any changes in these. However, not all relevant variables and indicators can be included in available modelling tools. Modelling analysis can be very useful in the quantification process as it is well suited for quantifying spatial and time dimensions.

Analysis of water quality monitoring data in combination with hydrological and hydraulic data can be used to establish mass balances thereby providing planners with information about functions in different water bodies and ecosystems. Analysis of trends in hydrological, hydraulic, water quality and biological data in combination with information on environmental pressures can provide information about the changes in ecosystem service provision. The modelling also makes it possible to test various scenarios, including analysing and evaluating the consequences of various PoMs and their impact on ecosystem services. The scenarios can also be used to quantify ecosystem services related to wetlands and flood plains, after e.g. intentional flooding of an area is carried out to help obtain a picture of flooding events. Intentional flooding can provide a better picture of hectares flooded, temporary wetlands becoming permanent, potentials of nitrogen removal (kg/ha/Y) or deposition of sediments on plains during flooding events (tonnes/ha/y).

To identify and quantify the change in the provision of ecosystem services due to the implementation of PoMs, hydrological and hydraulic models and water quality models have been widely applied on several occasions, and the results have then been used to assess future changes, from changing e.g. hydromorphology, reducing sewage load, etc. Advanced modelling systems coupling hydro-morphology and water quality have for example been utilised for the implementation of the requirements of the WFD in Bulgaria[46]. Another example of the use of models is the development of the river basin plan for the Odense Fjord Catchment, Denmark[47], where a regional groundwater-surface water model (DK-model, MIKE-SHE) was used together with the empirical Vollenweider model for the lakes and an advanced, coupled hydrodynamic-water quality and ecological model (MIKE3) for the costal fjord system.

[45] http://water.europa.eu/.
[46] The Study on Integrated Water Management in the Republic of Bulgaria" carried out by CTI Engineering International Co., Ltd. (2007) for Ministry of Environment and Water, Bulgaria.
[47] Vandplan 2010-2015. Odense Fjord. Hovedvandopland 1.13 Vanddistrikt: Jylland og Fyn. Ministry of Environment. http://naturstyrelsen.dk/media/nst/66599/1_13_OdenseFjord_VP.pdf.

These tools can also be used to quantify at least some of the ecosystem services. In order for the effect of the provision of ecosystem service to become an output of modelling, the characteristics of the ecosystem service must be able to be measured in physical units.

Based on the above-mentioned models, the interaction and potential interaction between rivers and floodplains can be estimated with respect to both water quantity and quality (e.g. estimation of filtration capacity). Hydromorphological and hydrological models can also be used to assess potentials for habitat diversity, which, in turn, can be used as a proxy for biodiversity. Such assessments can be based on a combination of expert knowledge and model simulation of variables such as flow velocities, water depth, variation in different parts of an ecosystem, water retention, flooding and drying frequency and soil humidity variation in riparian areas over the year.[48]

The typical ecosystem service provisions associated with the implementation of FD are often well understood, as the FD requires Member States to assess (as well as manage) the flood risk. The scope of the FD is more specific than the scope of the WFD, which makes it easier to understand. To understand flood risks, data and information are needed, such as the preliminary flood risk assessments and the flood hazard mapping (required under Articles 4-6 of the FD), which represents research into the quantification of flood risk resilience. Modelling assessments have been widely used in this context[49]. Examples of such model assessments covering several transnational problems are the Danube catchment [50] and, more locally, the Slovak-Austrian border chapter of the Morava River, which were carried out under the framework of the EU-funded international project CEFRAME[51]. Such sources of data and information can be useful for ecosystem service assessments, particularly at the quantification stage.

4.3. Selection of Indicators

For each identified ecosystem services where quantification would be relevant, the starting point is to find the most appropriate indicator. Ideally, existing service provisions should be measured directly and the change in provision should be estimated using the measured current provision as the starting point.

However, it is only possible for some ecosystem services to quantify the direct benefit (e.g. in the form of goods that are used by people), while for other ecosystem services this is not possible or at least very resource consuming, which is why proxies and indicators have to be used. The selection of indicators will depend heavily on an understanding of the relationship between ecosystem functions and the provision of ecosystem services.

According to CICES, the relationship between the supply of an ecosystem service and the demand for it can be monitored by specific indicators, however, always depending on the case.

[48] See also the development of EU level water accounts: http://www.eea.europa.eu/publications/water-assets-accounts-report.
[49] Misik et al. (2013): Experience from flood mapping and implementation of flood directive. Proceedings of conference Flood Management 2013, Bratislava, Slovakia.
[50] Danube Atlas 2012, Atlas of flood hazard and flood risk maps of the Danube. Published in Bucharest in 2012 in the frame of international EU funded project Danube FLOODRISK.
[51] http://www.ceframe.eu/.

Thus, water quantity and quality parameters can for example be used as indicators to assess the status of areas that are vulnerable to pollution.

The selection of indicators will naturally largely depend on the specific ecosystem, the ecosystem service in question and the local circumstances. The indicators are to be selected on the basis of knowledge of the physical, chemical, biological and ecological processes as well as of the specific good or service provided.

Under the MAES initiative an analytic framework for mapping and assessing ecosystem services has been developed[52]. The MAES Analytical Framework[53] focusing on the relationship between the ecosystem services and biodiversity includes mapping of stock and quality and the changes to these induced by changes to the framework conditions, such as the implementation of a measure. A similar approach can be adopted for other types of ecosystem services. Prior to the MAES project, the JRC was involved in creating an atlas of ecosystem services in Europe. The report provides inspiration for each type of ecosystem service in terms of which indicator to use. For each service, suggestions are given for to how to quantify the capacity of the ecosystem service, the flow and the benefits.[54]

Based on the analytical framework further work under the MAES initiative has elaborated a number of pilots on specific ecosystem types. The MAES freshwater pilot has identified 110 indicators for ecosystem services and examples of these indicators are illustrated in Table 4-1 below.

There are four categories of freshwater indicators where the categories are defined by the degree to which there are harmonised spatially-explicit data available and the quality of the indicators. The definition of the categories are illustrated in Text box 4-2. Many of identified indicators are of the “lowest” quality (the indicators marked in red are those were data are less available or uncertain; see Table 4-1 for examples).

The MAES report also includes a listing of data sources, and the report is therefore a very useful source of suggestions for data and approaches to selecting indicators and for estimating indicator values.

[52] Further information about the MAES can be found at: http://biodiversity.europa.eu/maes.
[53] http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.
[54] More information is available in the report "A European assessment of the provision of ecosystem services", JRC 2011.

Table 4-1 Examples of indicators for freshwater ecosystem services – illustration from MAES 2014

Division	Group	Class		Lakes	Rivers	Ground water	Wetlands
Nutrition	Biomass	Cultivated crops					
		Reared animals and their outputs					
		Wild plants, algae and their outputs		● Wild plants used in gastronomy, cosmetic, pharmaceutical uses (data on industries collecting the plants)			***see lakes and rivers***
		Wild animals and their outputs		● Fish production (catch in tonnes by commercial and recreational fisheries) ● Number of fisherman and hunters of waterfowls (anglers, professional and amateur fishermen) ● Status of fish population (Species composition, Age Structure, Biomass kg/ha)			***see lakes and rivers***
		Plants and algae from in-situ aquaculture					
		Animals from in-situ aquaculture		● Freshwater aquaculture production (e.g. sturgeon and caviar production)			
	Water	Surface water for drinking	● Water exploitation index (WEI)	● Water consumption for drinking ● Surface water availability ● Water abstracted			● Nitrate-vulnerable zones
		Ground water for drinking				● Ground water bodies ● Ground water abstraction	
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing					● Wood produced (tons or volume) by riparian forest ● Surface of exploited wet forests (e.g. poplars) and reeds
		Materials from plants, algae and animals for agricultural use					
		Genetic materials from all biota					
	Water	Surface water for non-drinking purposes	● Water exploitation index (WEI)	● Water use per sector ● Surface water availability ● Water abstracted ● Volume of water bodies			● Surface of flood-prone areas
		Ground water for non-drinking purposes				● Ground water bodies ● Ground water abstraction	

Source: European Commission, 2014 (http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf).

In addition to freshwater ecosystems, the MAES 2014 report includes pilots and indicators for forest, cropland and grassland and marine ecosystems. In particular, the forest and cropland and grassland chapters are very relevant to the assessment of ecosystem services in relation to WFD and FD. The regulating services related to the terrestrial ecosystems can be used for the development of the Programme of Measures where measures that imply changes to land use will affect these ecosystems and their services.

Text box 4-2 Characterisation of indicators for ecosystem services – illustration from MAES 2014

The indicators that are suggested here were each evaluated according to 2 criteria: i) data availability and ii) ability to convey information to the policy making and implementation processes (4).

● available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level for which harmonised, spatially-explicit data at European scale is available and which is easily understood by policy makers or non-technical audiences. Spatially-explicit data in this context refer to data that are at least available at the regional NUTS2 level or at a finer spatial resolution. CICES classifies ecosystem services at 4 hierarchical levels. Sometimes, it is more cost-effective to consider an assessment of ecosystem services at a higher CICES level than at class level, especially if aggregated indicators are available. Indicators that aggregate information at higher hierarchical CICES level can therefore also have a green label.

● available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level but for which either harmonised, spatially-explicit data at European scale is unavailable or which is used more than once in an ecosystem assessment, which possibly results in different interpretations by the user. This is typically the case for indicators that are used to measure ecosystem condition, which are reused to assess particular ecosystem services. This colour also includes indicators that capture partially the ecosystem service assessed.

● available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level but for which no harmonised, spatially-explicit data at European scale is available and which only provides information at aggregated level and requires additional clarification to non-technical audiences. This category includes indicators with limited usability for an ecosystem assessment due to either high data uncertainty or a limited conceptual understanding of how ecosystems deliver certain services or how ecosystem condition can be measured. The ability to convey information to end-users is limited and further refined and/or local level assessments should be used for verifying the information provided by this type of indicators.

● unknown availability of reliable data and/or unknown ability to convey information to the policy making and implementation processes.

Source: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf, p. 23.

Examples of indicators for the previously presented range of ecosystem services, listed in Chapter 3, are given in Table 4-2. The list is a non-exhaustive selection, as other indicators may be of relevance, depending on the situation in the particular river basin. Most of the indicators included in Table 4-2 will also be found the MAES 2014 report though there are some differences (The Table 4-2 list was developed prior to the publication of the freshwater indicators in the MAES 2nd report)[55].

[55] http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

Table 4-2 Key ecosystem services in relation to WFD and FD and examples of indicators and units for quantification[56]

	Ecosystem Services	Examples of indicators
Provisioning	Water storage. e.g. for energy production, irrigation, drinking and industrial water use	• Velocity (m/s - min, average, max.) • Minimum/average/maximum discharge on seasonal basis (l/s) • Discharge in relation to defined Environmental flow (%) • Surface and subsurface flow (m^3/year) • Water balance (generated minus abstraction and losses : +/- m^3/year) • Water storage / retention capacity (m^3/ha/y) • Water provision capacity (m^3/year or % of demand)
Provisioning	Fish stocks and recruiting	• Fish Production (tons/year) • Catch (ton/effort, ton/year) • Spawning grounds (m^2 , km length of river) • Fish population (biodiversity index) • Active fishermen (no.)
Provisioning	Natural production	• Production (ton/year) • Harvest (ton/year) • Areas/habitats available/suitable for production (m^2)
Regulatory & maintenance	Biodiversity preservation	• Protected areas of different types (m^2) • Diversity of physical habitats (no. of habitat types per ha or shares in %) • Physical habitat index • Occurrence of threatened species/species groups / indicator species (Number and biomass of species per m^2)
Regulatory & maintenance	Climate change adaptation and mitigation/GHG reduction/Carbon sequestration	• Carbon bound in ecosystems = C sequestration, (ton C/year, ton C/year/ha) • O_2-CO_2 balance (+/- kg C /year) • Production or reduction of other GHG (Kg/year, kg ha/year)
Regulatory & maintenance	Groundwater/aquifer recharge	• Groundwater generated (m^3/year/ha; m^3/year) • Groundwater potential (well observations) • River Basin Water Balances (m^3/year)
Regulatory & maintenance	Flood Risk reduction	• Natural water retention capacities (m^3) • Risk of flooding under different scenarios

[56] Selected and proposed by the consultant; see Appendix report Chapter 3 on Quantification for more details. Note that this list was prepared prior to the publication of MAES second report

	Ecosystem Services	Examples of indicators
	Erosion/sediment control	• Sediment transport (kg/ha catchment; tons/y) • Riparian buffer strips (length in km; width in m; area-m^2) • Vegetation (submerge and emergent) coverage along lake shoreline and in coastal zones (m^2 with a certain coverage, % coverage)
	Filtration of pollutants	• Removed / immobilised pollutants (kg N, P, C, heavy metal, pesticide and other pollutants per year)
Cultural	Recreational opportunities	• Water sport activities (boating, sailing, swimming, etc. - no. of people) • Nature with public access, parks/public green areas adjacent to water environments (ha; no. of visitors/tourists in an area)
Cultural	Aesthetic/Cultural value	• Scenic landscapes (ha, no. of visitors/tourists, users of scenic roads) • Interviews and surveys
Abiotic	Navigation	• Sufficient access for vessels
Abiotic	Geological resources	• Stone, gravel and sand abstraction from the river
Abiotic	Energy production (hydropower)	• Amount of energy produced (KWh)

Source: COWI.

A short discussion about the quantification of each of the services included in the above table is provided below. The examples illustrate possible quantification methods and processes. As indicated above, the quantification can be carried out at very different levels based on data availability, resources, knowledge and the ecosystem as well as the ecosystem service in question.

Provisioning services

For provisioning services, production figures as well as market prices are usually available and allow for a proper quantification. Hence, primary data for provisioning services are normally relatively easy to obtain from e.g. statistical sources. However, it is important to bear in mind that market imperfections, resource scarcity or altering production patterns can distort the results. It is however important to assess to what extent the current level of a provisioning service is within the sustainable capacity of the ecosystem service to provide the service; for example over-exploitation of fish stock.

Water supply can be measured through the yearly discharge, which can be gathered from gauging stations or from calculations based on precipitation/evapotranspiration data and catchment size (m^3/ha/y). Hydrological models can be very useful for the estimation of this variable. The yearly discharge is usually not a sufficient means of quantification. The minimum as well as maximum discharges are relevant indicators and as is the yearly distribution. The requirements for support of wildlife will typically vary from one season to another.

Water balances as those mentioned above for the quantification of the ecosystem service for providing surface drinking water is an additional way of quantifying the amount available for wildlife or for human consumption.

These evaluations have been carried out for several River Basin Districts in which water scarcity was identified as a problem during the first round of the WFD planning process. The RBMP and the technical background reports may include data that can be used for quantification of this ecosystem service.

Text box 4-3 Example: Oise river – quantification of water supply

Supply of freshwater: In the case of the Oise River, this service was hard to distinguish from the regulation and recharge of the aquifers, as they all concern the stock of water available for extraction. The freshwater supply also benefits from the purification of water in the RB, as described above. In other contexts, however, one way to quantify this ecosystem service is through measuring the recharge of groundwater from the wetland area.

Source: Commissariat Général au Développement Durable, 2012: "Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise"
http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

Fish stocks and recruiting can be quantified through catch per effort or catch per year. The number of people actively practising fishing (commercial or recreational fishing) can be used as another indicator. Such data may often be retrieved from statistics but may not give a full picture of the level of sustainable fishery. Over-exploitation or under-exploitation may occur, and the catch will depend on many other factors than those relevant for evaluating the impact of the WFD/FD. Therefore, supplementary assessments and use of models may be required for obtaining a realistic picture of the ecosystem service.

Fish production may be a more direct measure for this ecosystem service. It is, however, time and resource consuming to arrive at a sound estimate. Moreover, production estimates are often rather uncertain, although they can be made through analysis of the age and size structure of the fish population. Depending on the areas and the species, survey fishery can be utilised as a means to estimate the fish stock and the production. If resources are not available, values can be obtained from studies of other, similar areas. In many salmon fishing rivers, the licensing system for catch per day may provide helpful information about the fish stock. In the case of the Tweed River (UK), the number of anglers that could be allowed at the same time and the necessary stock of salmon/trout to sustain the expected catch-efficiency were calculated.

Text box 4-4 Example: Skjern River – Quantification of fish stock

In the Skjern River, the potential for increasing fish stock (no/km) and recruitment was mapped and quantified based on existing knowledge and supplementary mapping of suitable biotopes (m^2/km) especially for sea trout, salmon and lamprey and registration of obstruction (blocking) of migration routes (km stream without obstruction).

Source: http://www.skjernaa.info/english

Natural biomass production of other natural sources than fish can be estimated in similar ways. Such values will be influenced by many factors other than those relevant to

WFD/FD evaluations. However, estimates of the biomass and production per year are easier and more certain than similar estimates of the fish population. In case information about the resources are unavailable for carrying out direct production studies, monitoring data for biomass together with biomass-production ratios from literature can be utilised. As a more indirect proxy indicator, the area suitable for growth of the species in question can be estimated based on information about the physical condition (e.g. depth, substrate) and the water quality conditions. Literature values for productivities can then be used in combination with the size of suitable areas. For shellfish, the annual production varies very much from year to year, and accordingly a quantification of the available production may vary with plus/minus many percentages.

Text box 4-5 Example: Oise River – quantification of production

Quantification of direct production activities In the Oise River valley, the majority of the agricultural area is grassland used for production of animal feed, about 5 to 7 tonnes of dry matter per hectare per year. Livestock farming is the major agricultural activity in the area, and it is dependent on the nutrient rich soils resulting from regular flooding. The annual yield of the most important products in the wetland area can be used to quantify the scope of the ecosystem services on which these products depend.

Source: Commissariat Général au Développement Durable, 2012: "Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise"
http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

Regulatory & maintenance services

These services are more difficult to quantify as they relate primarily to ecosystem functions. Therefore, most assessments of these services are based on proxy methods and model calculations.

Some components of the regulatory and maintenance services overlap with ecological integrity processes; e.g. processes related to nutrients or water regulation interacting with the ecological status. Therefore, the built-in risk of double-counting has to be recognized by ensuring that results are valuated separately.

Biodiversity preservation, and through this conservation of the gene pool, is an example of a service that to some extent appears to be part of achieving GES/GEP. It can also be stimulated by flood management measures working on the basis of Natural Water Retention Measures (NWRM), such as the (re-)establishment of wetlands and connection of rivers and floodplains. In some cases, conservation of gene pools (according to the CICES classification) can be regarded a provisioning service, if species for commercial utilisation are found in the areas. Quantifying the services of improving biodiversity is possible from primary data through collection of data on species occurrence and abundances as well as calculation of biodiversity indexes. For some areas, these data were collected as part of the monitoring programme for characterising the water bodies for the WFD process. Similar data were also collected from the bird and habitat surveillance in relation to NATURA 2000. However, they do not exist for all water bodies and parts of a catchment, which is why proxy methods focusing 'only' on indicator species or indicator species groups may be useful. Other proxies indicating potentials for biodiversity are also achievable from maps indicating land uses, registration of physical diversity in the water bodies and at relevant land area.

Text box 4-6 Example: Skjern River – quantification of biodiversity

In the Skjern River, the impact on biodiversity was quantified based on landscape characterization form, land use maps and earlier registration and investigation. Information from the registration made for the EU Habitat Directive played an important role as the basis for this mapping and quantification. These were updated by additional biological surveys to fill in knowledge gaps. An importance scoring was made for plants, fish, birds, insects and mammals. The assessment covered both the aquatic environment and terrestrial biotopes in the floodplain. Quantification included the number of different migratory birds in the river basin/year, number and density of fish species, population density of otter (no/km² or no/km), vegetation biomass (g/m²) and density (index) in stream.

Source: http://www.skjernaa.info/english

Climate change adaptation and mitigation/GHG reduction/Carbon sequestration are other issues that can be highly influenced by the WFD/FD. Establishing wetlands, changing land use and achieving GES/GEP may halt or reverse the degradation of organic material in the soil, which releases CO_2. Establishing wetlands will most often lead to an increase in the production of organic matter, which will act as carbon storage in the ecosystem. A carbon balance (O_2-CO_2 balance) for these areas can be used as an indicator and for quantification. In most cases, values for binding carbon will be available from literature or from mass-balance modelling.

Several ecosystems and their management have influenced the release of greenhouse gases (GHG). Literature values on the function of different types of ecosystems in relation to production and consumption of GHG together with ecosystem mapping can be utilised for this quantification[57].

Text box 4-7 Example: Oise River – quantification of climate change mitigation

Climate change mitigation: This ecosystem service was assessed in case study for an alluvial plain on the river Seine. In the studied site of Bassée, the value of the carbon stored in the 113 ha of peat land was estimated using values from the literature. Referring to UNEP and its assessment that peat-lands are "the best reserves carbon of all ecosystems ", with an average storage capacity of 1,400 tons of CO_2 per hectare a total amount of CO_2 stored of 158,000 tons. This is an example of the value of the existing wetland.

Source: Commissariat Général au Développement Durable, 2012:

"Evaluation économique des services rendus par les zones humides : le cas de la plaine alluviale de la Bassée" (http://www.developpement-durable.gouv.fr/IMG/pdf/ED77.pdf**)**

Groundwater/aquifer recharge is relevant, e.g. to ensure different vegetation types in the landscape and thereby to be able to stimulate biodiversity as well as recreational and aesthetic values. Groundwater recharge is also the basis for the provisioning service of providing drinking water in many areas and even for irrigation. The methods generally used for quantification of the available groundwater and recharge include well observations and description of the development in groundwater level and potentials. The quantification will be relevant for larger areas than those only important for the drinking water resource. For such analysis and quantifications, hydrological mass balances are often used. The mass balances

[57] See for example: William J. Mitsch, Blanca Bernal, Amanda M. Nahlik, Ülo Mander, Li Zhang, Christopher J. Anderson, Sven E. Jørgensen, Hans Brix (2012) *Wetlands, carbon, and climate change in* Landscape Ecology
DOI 10.1007/s10980-012-9758-8. This article includes a discussion of the carbon balance and provides estimates of the effects for different types of wetland.

can be described by hydrological models from which estimates of groundwater storage and the supply capacity for different purposes can be assessed (provisioning services as well as regulatory services in relation to support of vegetation types and other biotopes). In this way, the models can be used to quantify the support to a range of ecosystem services, such as water for drinking water, water for irrigation, natural production, maintenance of base flow in streams, etc.

Groundwater recharging is an important ecosystem service that often is provided by NWRMs. It means that when assessing the effects of alternative measures for PoM or the FRMPs it is important to consider NWRMs. For example, changing the land use and/or land cover are NWRM that affect the water run-off and thereby the recharge of the aquifers. The currently ongoing NWRM project aims at proving guidance on NWRM[58]. The JRC 2012[59] report on effectiveness of NWRMs includes EU level assessments of the impact of alternative NWRM scenarios; for example on aquifer recharging based on various EU wide models for example on land use (LUMP) and hydrology (LISFLOOD).

Flood risk reduction is an ecosystem service that typically can be quantified. The flood hazard and flood risk mapping required by the FD will provide estimates of the current level of flood risk protection. The FRMPs will include quantification of flood risk reductions achieved by the proposed measures.

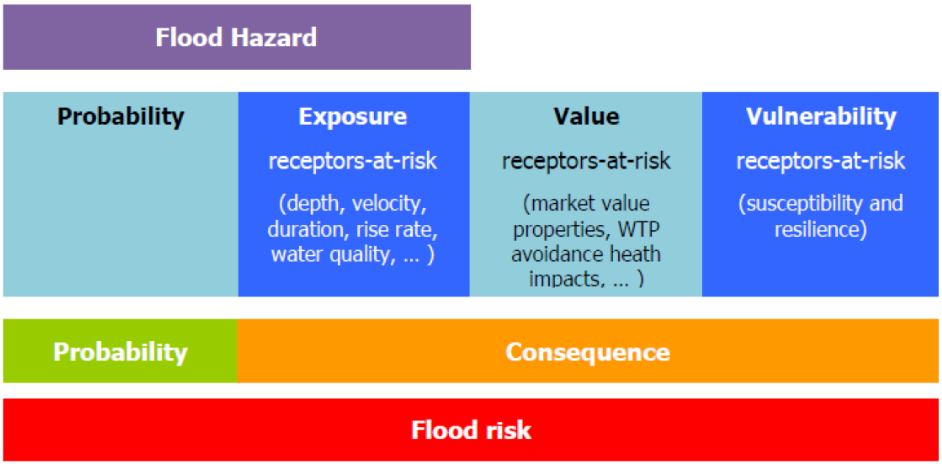
This ecosystem service is a very important service that needs to be taken into account in coordination of the implementation of the WFD and FD. It also links to other policies such as those related to nature and biodiversity protection. NWRMs and other green infrastructure comprise important measures that have flood risk reductions as one of their multiple benefits; see the links to the NWRM initiative described above under the groundwater recharging ecosystem service.

The below illustration (Text box 4-8) show how different key concepts in relation flood risk assessments are related.

[58] The NWRM initiative is a project of DG ENV for collaboratively building knowledge and promoting best practice on Natural Water Retention Measures in Europe. It includes the key concepts used and resources to help develop measures. Progressively, it will include a catalogue of case studies along with a practical guide to implement NWRMs. See the website of the initiative: http://nwrm.eu/.
Specific document defining NWRM and including an extensive list of NWRM see: http://nwrm.eu/sites/default/files/documents-docs/nwrmconceptnote_to_regional_stakeholders.pdf.

[59] JRC 2012 *Evaluation of the effectiveness of Natural Water Retention Measures*, Joint Research Centre Institute for Environment and Sustainability.

Text box 4-8 Example: Elements in assessing flood risks



Based on (Messner and Meyer, 2005)

The illustration presents the elements in assessing flood risks. The flood hazards are the probability of a flood event happening and the exposure defined as the characteristics of the flooding event (area being flooded, duration of flood, etc.). The flood risk adds to the flood hazard the type of natural and man-made assets being affected by the flooding event described by the value of the assets and the vulnerability (their resilience to withstand the flood).

In relation to the quantification of the flood risk reduction ecosystem service, all the elements except the value of the assets at risk need to be quantified (the monetary valuation of the assets is described in the next chapter on Valuation). To some extent, the quantification of current situation and scenarios for how the flood hazards and flood risks will develop in the face of climate change will have been assessed to meet FD requirements. The Resource document from the WG Floods includes more details on the many issues involved in assessing the flood hazards and flood risks.

Source: Working Group Floods (CIS) resource document "Flood Risk Management, Economics and Decision Making Support", 2012.

The quantification of flood risks will often comprise the use of hydrological models in order to assess the flood hazards and flood risks. The below example suggests the importance of having appropriate data and models at hand to be able to quantify the flood risk reduction effects from alternative measures.

Text box 4-9 Example: Oise River – simple initial quantification of flood risk reduction

Flood prevention: In the case of the Oise valley, two simple methods were used to quantify the ecosystem service of flood risk prevention. The Oise valley case study acknowledges the need for complex hydrologic models in order to make accurate estimations of the retention potential of wetland. Such models were not available and the study applied two simple approaches to provide an initial estimate of the retention capacity of the valley's wetlands.

The first approach, which used a mapping software (Mapinfo) and a digital model of the terrain, estimated the volume of water held by the wetlands to 2 billion m^3. This provides a very rough estimate that should be adjusted for the hydraulic reality, gravity flow of the entire sector as well as aquifer size. The second method considered an average water level of 1 m above the regularly flooded plains, (5 343 hectares), and estimated that 54 million m^3 are retained by the wetlands. The report concluded that the likely storage capacity of the wetlands is somewhere between the two estimates, probably towards the lower estimate, based on studies in neighbouring areas.

Source: Commissariat Général au Développement Durable, 2012: "Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise"

http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

Erosion/sediment control can be an important part of ensuring GES/GEP. Rivers are dynamic by nature, hence some erosion and sediment transport is natural, although changes in land use and the regulation of rivers (e.g. canalisation and damming) can increase or decrease erosion and transport significantly. The erosion and sediment control rely very much on the local geology (solid rock, alluvial deposits, etc.).

A primary indicator could be quantification of the sediment transport in the rivers. It is technically challenging to quantify both the suspended transport (mg/l) and the bed-load transport (g/m^2). Sediment transport modelling can also be used to estimate this indicator.

Another direct indicator is the quantification of embankment erosion. This can be done by making visual observations along the river and from aerial photos and quantifying eroded sediment areas or amount per year, estimating the changes in m^2, m^3 or hectares/year, which can be converted into tons/year.

Erosion in riparian areas may contribute significantly to the sediment load in rivers, and proper land use practices in the catchment can reduce the input of eroded surface material to the water body. Registration and mapping of land use practices and vegetation types, such as the riparian zone as well as coverage can be valuable proxy indictors for erosion or potential erosion.

Filtration of pollutants is an example of an ecosystem service, which can be estimated from primary data, setting up mass balances or performing specific process measurements that together with mapping the size of relevant areas may result in estimation of the amounts of pollutants retained (e.g. kg N/year or kg N/ha/year). Alternatively, land cover mapping (maps and GIS analysis) can be utilised and provide a proxy for the potential ecosystem service. Furthermore, the estimate can be quantified through combining the size of the areas with literature values for capacity per area. Additionally, the actual and potential filtration capacity may be estimated from combining hydrological/hydraulic models with water quality and ecological process based models.

Text Box 4-10 Example: Oise River – quantification of water purification

Water purification: In the case study from the Oise River, no individual study was made to quantify the purifying capacity of the wetlands, but a large literature study on the theme was used as the starting point. By considering the most well-known purification services of wetlands, and looking at site specific determinants such as vegetation, temperature, pH, slope of the landscape, etc., as well as information about the use of pesticides and fertilizers used for agriculture in the region, an estimation of the de-nitrification rate in different areas of the wetlands was made. The resulting analysis estimated de-nitrification of 144.1 kg of nitrate per hectare per year. In other areas, the de-nitrification rate has been quantified by measurements of the nitrate rate in surface and sub-surface water over time, and between upstream and downstream areas.

Source: Commissariat Général au Développement Durable, 2012: "Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise"
http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

Text box 4-11 Example: Skjern River – quantification of water purification

In the Skjern River, the filtration and turnover in the wetland and the stream of pollutants (focusing on nitrogen, kg N/year) were estimated based on dynamic mathematical process models calibrated for the existing river system and used for scenario simulation based on knowledge on filtering efficiency for studies of the catchment and experience from similar river systems. The filtration of N was estimated to around 210 tons per year based on per ha reduction of 350 kg. N per ha.

Source: http://www.skjernaa.info/english

Cultural ecosystem services

Assessments of cultural ecosystem services are complex. Several factors such as experience, habits, belief systems, behavioural traditions and judgement as well as lifestyles have to be considered. They are all related more to the observer/individual than to ecosystem conditions. The quantification and selection of units for changes in cultural ecosystem services are perhaps more challenging than for the other ecosystem service categories. In an ecosystem service assessment, it may be found that data on 'cultural heritage' receptors (and their use/value) at river basin level has been collected as part of the FD requirements (especially under Articles 4-6).

Nevertheless, quantifications based on interviews, questionnaires or additional information sources can provide useful and spatially explicit results, although with a subjective impact. For certain cultural ecosystem services, for example recreation, tourist numbers or the numbers of overnight stays at particular locations may be used. Example needed

 **Recreational opportunities** provided by ecosystems include organised, active uses (water sports, hiking, swimming, visiting historical remains, or religious monuments, etc.) of the areas as well as uses such as picnicking, walking, enjoying, relaxation, consciousness of the existence of historical and religious monuments and nature elements, etc.

It can be quite difficult to quantify these services, and the results achieved may be rather uncertain, such as figures of the amounts of people using, appreciating or otherwise benefitting from the existence of the areas. Counting the number of cars parking at or close to the recreational facilities may be used and proxy indicators of the number of people utilising the services. Quantification in relation to improved wellness from the water and water-related landscape types will be based on a high level of uncertainty as many other factors influence the perception of wellness. Attempts have been made to use different proxy indicators of the importance, such as the house prices in populated areas. To some extent, the growth of local income from tourists buying various commodities in the local shops may be used. In the River Skjern case, it was estimated that the increase in local economy was in the order of EUR 1.5 million.

Text box 4-12 Example: Skjern River – quantification of recreational use

In the Skjern River, hunters' game areas, game fishing localities, bird watching localities, canoeing facilities, tracks for hiking/biking, etc. were mapped. Cultural sites were identified and mapped. Based on existing and future ownership of the areas, the potential expansion of such activities in a sustainable manner was assessed. The potential increase in tourism through guided tours, fishing and hunting licences, overnight stays and hotels, etc. was evaluated. The quantification is estimated, among other things, as the number of licences issued for canoeing, fishing and hunting, number of picnic sites, number of primitive nature camp sites, overnight stays in hotels, cottages, camp sites, and hotels, number and use of handicap fishing locations, km of bike and hiking tracks, number of visitors at museums and nature information centres, number of visitors to bird watching sites, guided tours, etc.

Source: http://www.skjernaa.info/english

Aesthetic and cultural values offer uses similar to recreational opportunities, and these two categories certainly overlap. However, aesthetic and cultural values do not require a direct utilization to be considered ecosystem services. People just like to know that they exist, be they a unique landscape only known from the media, or a religious/cultural site, which has a spiritual value. While some of the quantification can be determined from visit-related numbers (e.g. visitors/year), it is mostly more relevant to conduct interviews or surveys to quantify aesthetic and cultural values.

The number and size of areas of interest from a scientific and educational point of view can be assessed by interviewing local/regional universities and schools. The number of students visiting and the number of articles and papers published about specific areas can also be used as indicators

Abiotic services

Abiotic services are somewhat easier to quantify, as the relationship between the abiotic ecosystem elements and the services provided is somewhat clearer. This is mostly because, within abiotic services, there are less feedback effects that might result in unexpected outcomes.

Navigation: In many of the European countries, access to navigable rivers and channel systems is very important as vast amounts of goods are transported on rivers. Without this ecosystem service, the goods would have to be transported by road in trucks. River transportation is generally considered to have a lower CO_2 emission per ton than road transport of the same amount. Quantification of transport of goods can be supported by information from harbours, customs declarations, and other national and international statistics. In addition to the transport of goods, the ecosystem service of providing navigation possibilities is also utilised by the cruise industry with both short trips (hours) and longer, sometimes transnational trips (days). The quantification of the utilisation of this service must again be based on information from harbours, cruise ship companies and tourist organisations, e.g. in person-kilometre/day.

Geological resources: Extraction of geological materials from especially rivers and coastal waters provide substantial ecosystem services to society. In rivers, the extraction of sand and gravel may help keep rivers navigable and the dredged material can be utilised in all types of construction. The same is true for marine materials. Huge amounts of sand are removed every year to maintain access channels to many harbours at the required depth. The material can either be used to coastal protection, construction purposes or for land reclamation. The downside of this ecosystem service is the pressure put on the biology affected by the extraction activity.

The ecosystem service can be quantified in amount of materials abstracted and subdivided into specific fractions, such as stones, gravel and sand, typically calculated as tons/year.

Energy (hydropower) can be quantified by receiving data on the electricity generation, either by kW/h per year or by generating capacity. However, it should be recognised that hydropower is a major pressure on GES/GEP. Therefore, the positive contribution to human well-being usually comes at a high price, which should also be quantified, e.g. through the negative impact on other ecosystem service metrics.

Text box 4-13 Recommended literature

Burkhard B., Kroll F., Nedkov S. & Müller F. (2012). Mapping ecosystem services supply, demand and budgets. Ecological Indicators 21(2012) 17-29.

Crossman, N.D. et al. (2013). A blueprint for mapping and modelling ecosystem services. Ecosystem Services. http.//dx.doi.org/10.1016/j.ecoser.2013.02.001.

R.S. de Groot et al. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7 (2010) 260–272.

Maes et al. (2013). Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union, Luxembourg.

Maes, J Paracchini M.L. & Zulian G. (2011) A European assessment of the provision of ecosystem services. Towards an atlas of ecosystem services. JRC Scientific and technical Reports. Eur 24750 En – 2011.

Weber J-L. (2011): An experimental framework for ecosystem capital accounting in Europe. European Environmental Agency. EEA Technical Report No 13/2011.

5. VALUATION

Valuation is the last step in the three-step approach – identification, quantification and valuation. Valuation does not necessarily mean monetary valuation, so this chapter includes discussions of non-monetary assessments, as well.

The key question to answer is:

- How are ecosystem services valued in practice?

The general structure of assessing most of the ecosystem services in monetary terms will be a quantified number or amount (from a quantification stage) multiplied by a unit price/cost. The uncertainty with regard to the valuation therefore concerns both the quantification and valuation stages. Overall, it is to be expected that most ecosystem services can only be estimated by an order of magnitude value.

This chapter briefly describes a number of alternative valuation methods and gives suggestions for sources of data on unit values. In particular, it discusses the use of benefit transfer (transferring values for a specific ecosystem service from one location to another location).

Key challenges	Making a valuation will always be subjective to some extent. The functions and services of our natural environment are related to the uses by society. What is deemeed important or valuable very much depends on who is making the valuation. Formal approaches help make the valuation more structured and transparent, showing where judgement has been made and the reasoning behind this.
Chapter outcome	Awareness among river basin management planners and decision-makers that ecosystem services offer a value to society that can be estimated by means of different methods. It is not expected that planners should learn to use all methods presented in this chapter, but they should get a good overview of them, which can help them in their further work.
Approach according to the level of ambition	High: Several ecosystems are analysed and possible methods for valuation are considered, possibly leading to monetary or non-monetary valuation. Medium: Some effort is invested in determining the impact of different ecosystem services on well-being and some simple analysis has been made, e.g. a scoring. Low: It is understood that economic valuation can help get a better idea of the value of the environment to society and that these values can be described in qualitative terms.

5.1. Rationale for valuation of ecosystem services

Chapter 4 on quantification explained how the assessment of ecosystem services can be done through ways of quantification. As such, valuation does not necessarily mean monetary valuation. In the next chapter on planning, examples are given of qualitative assessments that are used to support the decision-making process.

Given that an increasing number of monetary valuations are made, the purpose of this chapter is to present some of these key data sources and approaches to valuation in the context of ecosystem services.

The outcome of the valuation stage should be a reasonable idea of the importance of the identified ecosystem services to human activity and well-being and of the impact on different stakeholders. In this way, the valuation will provide an important input to a more comprehensive decision-making process in the context of the WFD and FD implementation.

5.2. What is valued?

In most cases the assessment will try to value the change in the provision of the ecosystem service (or services). In cases where the WFD or FD will improve water quality or quantity, the ecosystem service provisions are likely to increase and the valuation will address that increase. Considering other WFD objectives, for example the one on preventing deterioration of water quality, the assessment will also aim at valuing a change – in this case the difference between the situation without the WFD, where the ecosystem service provisions would have been reduced due to the deterioration in water quality or quantity, and the situation with the WFD, where the introduced measures have prevented the deterioration and, hence, the ecosystem services are maintained. Even though focus is on the change it might be relevant or most feasible to assess the total value of the currently provided ecosystem service and use that total value to estimate the change resulting from the introduction of measures.

Please note that it is important to differentiate between ecosystem stocks, quality and flows. In valuing benefits derived from ecosystem services, we are in the latter category, since the flows of services create the benefits.

5.3. Steps in a valuation

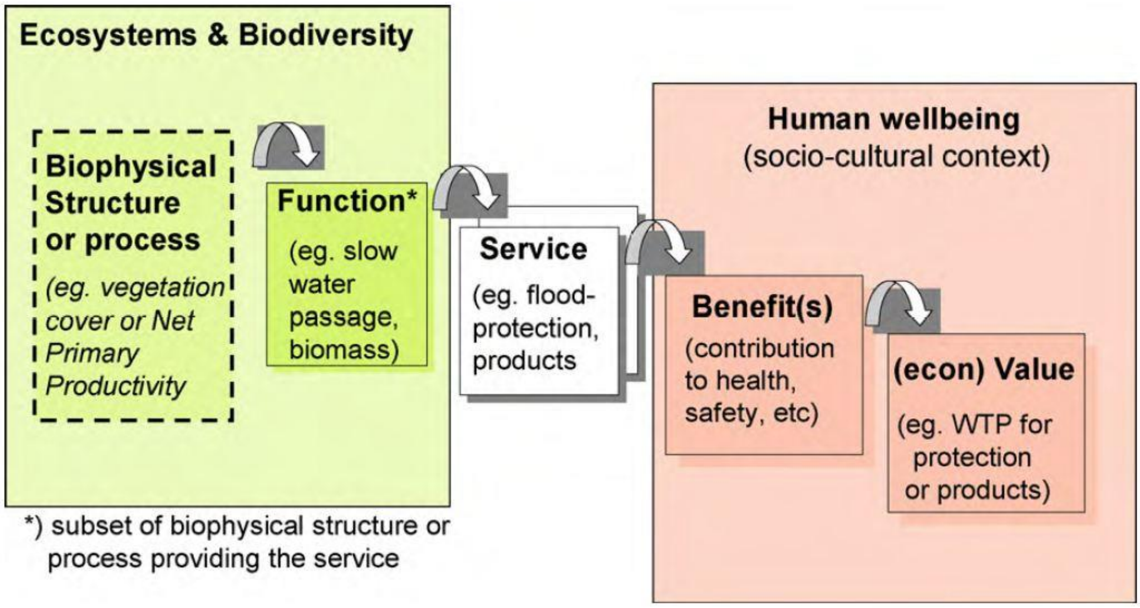
The aim of the valuation stage is to value the identified ecosystem services. This process involves a few steps:

1. • Relate the quantified ecosystem services to human use
2. • Determine an appropriate way to value the ecosystem services
3. • Establish the value of the ecosystem services

Step 1: Relating the quantified ecosystem services to human use

As a first step, it is necessary to establish the relationship between an ecosystem service and the benefit it provides, as illustrated in Figure 5-1. The benefit provided can then be valued in a monetary or non-monetary way. The difference between benefits and services is important to understand. It is best illustrated by the fact that the same ecosystem service can provide different benefits, depending on when and where it is provided. An example would be a pristine forest on the edge of a city compared with the same forest in a remote area with only a few houses nearby. Clearly, the recreational benefit is much higher when there are people around to make use of it, even though the service itself is identical. This highlights another crucial aspect of valuing the benefit of ecosystem services: values that are received at one point are not necessarily valid in another location.

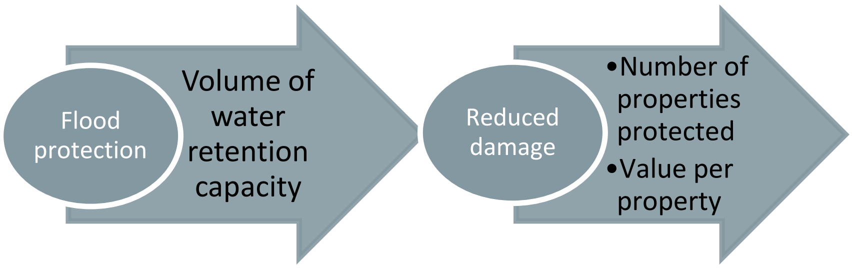
Figure 5-1 Link between ecosystems and human well-being



Source: De Groot et al., 2010.

Typically, the link between the service and the benefit is rather obvious, but the description has to be well structured and supported by a quantification of the service in question, preferably through the state of the environmental indicators. The benefit that is provided can be quantified through performance indicators, which are then used as a basis for the actual valuation. Figure 5-2 below illustrates this for flood protection. A key feature of a flood protection service is the water retention capacity. This capacity affects the total amount of damage and losses caused by a flooding event related to human health and natural and man-made assets. The reduced likelihood of damage can then be valued.

Figure 5-2 From flood protection to reduced damage



Source: COWI.

Table 5-1 below gives a number of examples of ecosystem services and outlines their benefits to people and related values:

Table 5-1 Benefits from ecosystem services and their value, Examples

Ecosystem Service	Benefit	Value
Water storage: production and irrigation	Irrigation	The use of water for irrigation purposes can increase productivity in agriculture, creating additional value in production.
Natural production	Fish or shellfish production	The value of the fish or shellfish on the market.
Recreational opportunities	Sailing, swimming, boating, etc.	The value of using nature for recreational purposes. Visitor numbers can be used for valuation
Filtration of pollutants	Filtration of nutrients	Can replace man-made infrastructure and can therefore be valued by comparing it with the cost of providing such infrastructure[60]
Energy (Hydropower)	Electricity	Value of electricity on the energy market

Source: COWI.

The examples illustrate the large variation in types of ecosystem services. Some ecosystem services resemble other services in society, such as drinking water or crop production. Other services are more indirectly linked to society, such as filtration of nutrients. This understanding of services is important when a value is to be attached to a service, as this will help value a service for which there is no market.

Step 2: Determine an appropriate way to value ecosystem services

Ecosystem services are very different, which is also reflected in the many methods available to value them. The economic valuation method is probably the most formal approach, and natural scientists and planners are often somewhat sceptic about using it. This is especially the case when it comes to ethical considerations and ecosystem functions. Therefore, it should be ensured that the approach used in valuation is appropriate. This, in turn, depends on the

[60] Please, be aware that estimates of benefits determined by the use of replacement cost cannot be used in a CBA as the estimate will be similar to the costs.

existing tradition for valuations and the overall planning approach (see discussions in Chapter 6) and how stakeholders are normally involved.

First, it should be decided whether monetary valuation is deemed acceptable, or if a more deliberative approach would be more appropriate. Table 5-2 gives a brief overview of each of the service categories (provisioning, regulation and maintenance, cultural):

Table 5-2 Different ecosystem service categories, Examples

Provisioning services • *Commercial and sports fishing* • *Water storage: production, irrigation, drinking water* • *Natural production of biomass*	Provisioning services are often goods that are traded in the market and they can therefore be valued through (adjusted) market prices. This can be food, timber or fishing licenses. *In this case, valuation is relatively easy and numbers are mostly unambiguous. The main difficulty therefore lies in the quantification of the change in the services, which is the result of a particular measure.*
Regulation and Maintenance • *Erosion/sediment control* • *Biodiversity preservation* • *Flood risk reduction* • *Filtration of pollutants* • *Climate change adaptation and mitigation*	Regulation and maintenance services are often more difficult to value through economic methods, but indirect market valuation and stated preference methods can be used for example for flood risk reduction and biodiversity preservation. However, alternative methods are often more appropriate, as it is not always possible to clearly identify the benefit to human well-being.
Cultural • *Recreational opportunities* • *Aesthetic and cultural value*	Recreational opportunities can often be captured through the travel cost method and aesthetic value by using hedonic pricing methods. Aesthetic and cultural values are somewhat harder to estimate, so alternative methods might be more appropriate here.

Source: COWI.

Step 3: Establish the value of ecosystem services

As stated above, establishing a set of unit values that can be used in the valuation stage for the specific river basin can involve different levels of detail. The choice of detail reflects the ambitions and resources available. In the end, this will affect the level of detail of the analysis. If the cost data are described in much detail, a more advanced assessment of the benefits is required to match the level of detail of costs.

Some ecosystem services values can be approximated by using market prices; other ecosystem services that are not bought and sold on markets require valuation studies. A number of different methods can be used to value ecosystem services as illustrated in Table 5-3 overleaf. These are described in general terms on the next pages. Benefit transfer is a viable shortcut that uses values found in other studies and applies them to the local context. Valuation results that can be found in the literature depend on local factors such as level of use, user income and the availability of ecosystem services. Using values from literature and reusing them in another river basin is a simpler exercise compared with a full valuation study.

Table 5-3 Overview of economic valuation methods

Examples of ecosystem services where the methods are likely to apply	Method	Description
	Direct market valuation	
Water storage: production, irrigation	(Adjusted) market prices	When ecosystem services are traded in competitive markets (e.g. water and agricultural goods), prices have to be adjusted for taxes and subsidies. This will facilitate estimation of the value of the good without including other effects.
Natural Production	Production function methods	Ecosystems services enter into the production of marketed goods and services. When the ecosystem services input into production changes, the price of the final product will change as well. The method benefits from the knowledge of the link between the input of ecosystem services and the final output.eg..
	Indirect market valuation	
Flood risk reduction	Damage cost avoided/replacement costs	An improved flood risk reduction service would prevent property damage. Flood risk reduction services provided by natural water retention measures might replace hard engineering flood protection measures.[61] There might be additional costs of flooding related to the subjective welfare loss that would require a non-market valuation approach.eg.
Filtration of pollutants	Replacement cost	In cases where an ecosystem service can be replaced by another services/measure, the cost of the alternative constitutes the replacement cost (e.g. mechanical or chemical water treatment).
Recreational opportunities (marketable)	Factor income (value added)	The method aims to measure the impact that ecosystem services have on income in a specified region (e.g. value added by tourism).
Recreational opportunities (non-marketable)	Travel cost method	Revealed value of ecosystem services via the additional amount of time and money that visitors spend on their trip.
Aesthetic value	Hedonic pricing	Ecosystem services affect the price of market goods (e.g. beautiful nature may influence property prices nearby).
	Stated preferences	
Cultural values	Contingent valuation and discrete choice experiments	Asking how much individuals value the benefit they receive from ecosystem services.

Source: COWI.

Conducting a primary valuation study

The ecosystem services are often grouped into categories that describe how humans use the services. Some ecosystem services are of *direct use*, e.g. water flow for hydropower, while others are only of *indirect use*, e.g. nutrient cycling. In addition, there are ecosystem services

[61] Often the trade-off is about higher dikes or a more ecosystem oriented solution to achieve the same level of flood risk reduction. If the avoided damage is the same, there is no difference between the two options, and avoided property damage is not the value we should focus on.

that provide *non-use values*, e.g. simply the knowledge that an endangered species exists, or *option values* that relate to e.g. maintaining the possibility of visiting a recreational area.

Thus, when estimating the value of the ecosystem services, several methods can be used. In some cases, it might be necessary to combine different results to capture the whole value, e.g. to include estimates representing the use value, the non-use value and the option value. Decisions on information needed to describe the value of the ecosystem services must be taken at river basin level.

There are three broad approaches to valuing the benefits provided by the environment; direct market valuation, indirect or non-market valuation and stated preferences. Each method has its advantages and limitations. Text box 5-1 below provides such an example. For a more detailed description, please consult the Annex Report where key literature has been reviewed.

Text box 5-1 Example: Valuation of ecosystem services, Oise River

When the most important services are identified and quantified, the next step can be to value their worth. Depending on whether the key services provide direct benefits (such as agricultural production, flood protection, etc.) or other types of benefits (such as recreational, cultural or aesthetic services) different valuation methods should be used. In the French case study, the main ecosystem services were valued inter alia by calculating the "costs avoided", some examples of which are shown below:

Examples:

Flood prevention: Two different approaches were used to estimate the value of the flood protection service:

- Calculating what it would cost to remedy a flooding situation by artificial means, e.g. building a dam (including costs of work, acquisition of land, compensation, and exploitation).
- Calculating the cost of building underground storage reservoirs that could compensate for the natural storage capacity of the wetlands

Water purification: Several methods were used to calculate the value of this service, notably

- The avoided costs of treating drinking water for nitrates

Production activities (such as agriculture, forestry) were equally valued using several different methods:

- By identifying the units of use (hectares of production) and the associated net gross products.
- Angling and hunting were estimated to be worth at least the price of fishing/hunting permits and costs of accommodation and travel for those who participated in the activity.

The value of climate regulation, more specifically carbon sequestration can be calculated by multiplying the amount of CO_2 stored in the river basin with a (shadow) price of carbon.

In estimating the total value of the ecosystem services provided by the wetlands in Oise river valley the CGDD obtained a value of €2100-3400 per hectare.

Source for case study: Commissariat Général au Développement Durable, 2012: "Evaluation économique des services rendus par les zones humides, -Le cas de la moyenne vallée de lÓise" http://www.developpement-durable.gouv.fr/IMG/pdf/ED76.pdf

Transfer benefit values from other studies

If it impossible to conduct valuation studies based on the methods above due to lack of resources, time or expertise; benefit transfer is a cheaper and less time-consuming alternative. This does not mean that a benefit or value transfer is easy. This exercise will most likely require a person with some economic training to identify good quality studies and extract the values so that they can be applied to the river basin in question[62].

The main idea is that a monetary value estimated at a study site can be transferred to the policy site. Benefit transfer is most useful in cases where the study and policy sites are quite similar. Even in Europe, there are large differences in the characteristics of ecosystems and their utilisation, which are reflected in study results and which should be considered in benefit transfers. The most common factors to consider are climate, biophysical conditions, number of users, flows, composition of different activities and related characteristics. Text box 5-2 overleaf provides an example of this.

Clearly, the quality and appropriateness of the study from which benefits are transferred determine the quality when transferred and applied to the policy site. The guiding rule for practical benefit transfer is to use valuation studies that have been carried out at sites that are similar to the policy site in terms of ecosystem services, socio-economic conditions and geographic features. A good starting point is usually to find studies that have been made in the same region or country.

There are three different ways of conducting a benefit transfer: simple unit transfer, benefit function transfer and meta-analysis. The latter two are quite technical and more elaborate to apply. Since it is often found that a simple unit transfer is just as accurate[63], it is the recommended choice for this document. There are still some adjustments to be made to the values, which are to be transferred. All values have to be recalculated and converted into the same currency value at the same time. Obviously, it is not possible to add up different currencies, and the values should also be adjusted for inflation by multiplying them with a price index. Additionally, all the nominal currency values should be recalculated in Purchasing Power Parity values. The Purchasing Power Parity compensates for differences in income, currency values and cost of living.

[62] See TEEB training manual for introduction and key issues of benefit transfer: http://www.teebweb.org/resources/training-resource-material/module-4/.

[63] NAVRUD, S (2009), *Value Transfer Techniques and Expected Uncertainties*; Part of the NEEDS project (New Energy Externalities Developments for Sustainability).

Text box 5-2 Example: Valuation of a number of ecosystem services by the use of various methods, Skjern River, Denmark

In traditional cost-benefit analysis, the uses and benefits of a potential measure are calculated and compared with the costs of the measure. A classic example is the Danish Skjern River. As mentioned, it is a small river, which was straightened out in the 1960's turning marshes and meadows into arable land. The later restoration measure was implemented to improve biodiversity in the area through re-meandering of the River.

The following uses of the ecosystems were identified and valued in the following ways:

Provisioning services:

- The value of the production factors, such as the soil facility and the fish stock, etc.

Regulatory services:

- Ecological services, such as nutrient retention, flood reduction and CO2 sequestration

Cultural services:

- Input for consumption like hunting, recreational fishing, recreational use of nature
- Option value (experience of having the possibility of exploiting the resource later)
- Existence value (the satisfaction of knowing that the ecosystem is restored)
- Bequest value (the satisfaction of knowing that the coming generation will be able to enjoy the area).

More specifically, the following ecosystem services were valued (all values are provided in net present values over an indefinite time horizon and with a discounting rate of 3%):

- The redistribution of land between farmers has led to savings due to shorter distances between farms and farmland worth EUR 4 million.
- The restoration of the river is expected to increase growth of reeds. The reed production in the area is expected to represent a value of EUR 1.3 million.
- The restoration of the river will reduce the risk of flooding. The value of flood reduction is estimated to EUR 100,000 based on a potential number of houses that are no longer at risk of flooding.
- Reduction of N, P and ochre are estimated to EUR 4.8 million, EUR 5.9 million and EUR 5.4 million respectively based on the reduction in arable land.
- The value of the CO_2 sink has not been estimated, but it is suggested done by estimating the alternative costs of the reduction of the same amount of CO_2.
- The hunting possibilities will improve in the area, and the value of hunting is estimated to EUR 2 million based on the expected additional number of hunters in the area multiplied by the price of a hunting licence in the specific areas. The price of one licence is used as an expression of the value.
- The value of the recreational fishing is estimated to EUR 11.9 million based on the willingness-to-pay for recreational fishing multiplied by the number of visitors in the area. A study has estimated the willingness-to-pay for recreational fishing by asking anglers to indicate their perceived value of recreational fishing.
- Finally, the recreational use of the area is assessed by a willingness-to-pay study made in another location by transferring and multiplying the results of this study with the expected numbers of visitors. The value of being able to visit the area is estimated to EUR 16 million. Again, the visitors to a recreational area were asked to indicate the value they would attach to their visit.
- The existence value is transferred from an English study and is estimated to EUR 11.5 million by adjusting value to the size of the area in question.

Source: INSTITUT FOR ØKONOMI, SKOV OG LANDSKAB, Alex Dubgaard, Mikkel F. Kallesøe, Mads L. Petersen, Jacob Ladenburg, COST-BENEFIT ANALYSE AF SKJERN-Å-PROJEKTET

Using catalogue values of ecosystem services

If it is not possible to carry out targeted valuation studies or transfer benefits based on literature studies, the planner can rely on catalogue values to get a rough idea of range of the benefits of a given ecosystem service. Examples of unit values can be seen in the table below. These values represent a great range in results indicating that there are major variations depending on local characteristics, methods applied, etc.

When used in the analysis of a specific river basin, the user can for instance choose to use a conservative value in the range or calculate the minimum and maximum values applying the full range shown in table 5-4 below.

Table 5-4 Catalogue values can give a rough indication of ecosystem service values

Chapter	Division	Examples of valuations
Provisioning	Nutrition	Mangrove provisional value: USD 27,264 – 35,921 per ha Only mangrove-fishery linkages: USD 21 – 69 per ha
		Net Returns under alternative floodplain management scenarios: % change from base model mean returns: Low embankment → -13.82% Medium embankment →-14.49% High embankment → -10.58%
	Materials	Irrigated Agricultural water: USD 413 per hectare for Madachi area
		Best point estimate for value of 30% reduction in nitrogen loadings: USD 2.56 million (values range from USD 195,000 – 7,510,000)
	Energy	
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	
	Mediation of flows	Loss incurred per household in 3 Indian villages: Bandhamal: US 153.74 Singdi: USD 44.07 Bankual: USD 32.31
		Storm Protection: FAO → USD 25.5 million Thailand → USD 4.9 million
		Annual Value of Storm Protection Services from coastal wetlands: USD 250 to 51,000 $ha^{-1}yr^{-1}$ (mean of USD 8240 $ha^{-1}yr^{-1}$) Coastal wetlands in the US have a value of USD 23.2 billion in storm protection services
		Average opportunity cost of saving a life by retaining mangroves: 11.7 million rupees per life saved (Given in 1999 price levels)
		8% reduction of casualties with forest in front of settlement, 5% with rubber plantations, 3% with agroforestry, and an average of 5% reduction of causalities with existing coastal vegetation in front of settlements
		Proposed Regulation and Maintenance measures effect on damages avoided: 300 billion euro (economic growth of 2% and 4000 year return period, 4% discount rate: PV of damage avoided over next 100 years is 3.3 billion euro)
		Economic Net Present Value of Commercial Shrimp Farms with Mangrove Forest Rehabilitation (USD/ha): 10% discount rate → -5,447.97 12% discount rate → -4,917.66 15% discount rate → -4,239.75

Chapter	Division	Examples of valuations
	Maintenance of physical, chemical, biological conditions	Use of wetlands as nitrogen sinks can reduce the total abatement costs of nitrogen emissions by 30% in Sweden
		Total Economic Value for a constructed wetland ecosystem in a 20 year period: Contingent Valuation Method → 800,000 yuan Shadow Project Approach → 23.04 million yuan
		Net social benefit of restoring wetlands: USD 1435 – 1486/ha/year Individual ecosystem services benefit estimates GHG mitigation: USD 171-222 Nitrogen mitigation: USD 1248 Waterfowl recreation: USD 16
		Preventing mangrove loss has potential of reducing global emissions for a cost of 4 – 10 USD ton^{-1} CO_2
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Travel Cost Method Swimming: USD 8.59/person Non-Residential Bird Watching and Wildlife Viewing: USD 49.83/person Fishing Value per trip: USD 40.25 Boating Value per trip: USD 19.23
		Dynamic Mangrove-Fishery Linkage: FAO estimate → USD 1.5 – 2 million Thailand estimate → USD .28 to .37 million
		Net rent increases from fishery rationalization: USD 180-270 million Net rent increases from 30% reduced nutrient pollution: USD 1-7 million
		Annual productivity of mangrove ecosystem: USD 25,000 – 50,000 (median value of USD 37,500 US$/$ha^{-1}$/$yr^{-1}$)
		Annual Mean WTP for preservation of Taiwanese wetland: USD 21 – 65
		Marginal WTP for: High biodiversity → 673-720 SEK Medium Biodiversity → 493-505 SEK Walking Facilities → 601-648 SEK Fish → 292-348 SEK
		Marginal WTP Biodiversity: 15.10-15.62 euro/respondent Open water surface area: 9.86-11.02 euro/respondent Re-training of farmers (per person): .122-.154 euro/respondent Research and education: 8.69-10.79
		Marginal WTP (£/respondent) Wetland area: 8.3-36.2 (average → 13.8) Otter holt creation: 19.1-82.8 (average → 31.6) Protected bird species (per species): .8-3.3 (average → 1.2) Employment (per person): .04-.17 (average → .06)
		Net social benefit of preservation program: USD .52 million to 1.84 million Marginal WTP for: Vegetation: VND 854 (USD .06) Birds: VND 84 per bird (USD .005)

Chapter	Division	Examples of valuations
		Farmers: VND -92 (USD .005)
		Net social benefit of restoring wetlands: USD 1435 – 1486/ha/year Individual ecosystem services benefit estimates GHG mitigation: USD 171-222 Nitrogen mitigation: USD 1248 Waterfowl recreation: USD 16
		Mean Real WTP Values for wetland conservation from 1991 and 1996 Surveys (£/respondent/year) 1991: 248.1 1996: 215.8
		Values in 2004 prices Alternative management scenario 1: Environmental forest area increases by 10 per cent, Number employed unchanged, Number of migratory bird species unchanged, Visitation rate increases by 50 per cent: RM 12.7/year (USD 3.3) Alternative management scenario 2: Environmental forest area increases by 10 per cent, Number employed unchanged, Number of migratory bird species unchanged, Visitation rate unchanged → RM 8.5/year (USD 2.24) Alternative management scenario 3: Environmental forest area increases by 10 per cent, Number employed decreases by 10 per cent, Number of migratory bird species unchanged, Visitation rate unchanged: RM -11.8/year (USD -3.11)
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Average WTP per household annually Korean Won 2,731-3,960 (USD 2.10 – 3.05)

Source: See Annex Report I, Chapter 4 and Table 4-2 for the source of each valuation data.

A preferable approach is to search for national catalogues of ecosystem service values. In many cases, Member States or research institutions have gathered results from literature that can be applied to river basin valuations. Table 5-5 below provides an overview of various valuation methods.

Table 5-5 Valuation methods

Measures of attitudes, preferences and intentions	Includes approaches such as surveys, narrative methods and focus groups. The idea is to uncover perceptions and judgements that are relevant for establishing a value for an ecosystem service. Normally, these perceptions and judgements are presented in the form of choices, rankings or ratings between different sets of alternatives, for example different levels of protection or preservation. Although surveys might be sent out to a large number of people, narrative methods and focus groups usually only include a small group of people.
Civic valuation method	Aims to capture the value that citizens place on ecosystem services when acting as part of society. Therefore, the idea is not to identify the individual benefit expected by a member of society, but rather the benefit to society as a whole. One tool of civic valuation is referenda or initiatives, which ask society about a particular policy. Another possibility within the civic valuation method is civic juries or representative groups that are informed about the issues at hand and the possible consequences of different actions. They are then tasked to set a value on a specific ecosystem service.
Ecosystem benefit indicators	Draws on quantitative metrics that show a strong correlation with ecosystem contribution to human well-being. An example could be the clarity of water as a proxy for the pollution level in the river, which in turn affects human well-being. However, they do not provide a value that can be directly related to human well-being. Therefore, the outcome needs to be weighed against other parameters.
Biophysical ranking methods	Is based in the idea that what is good for the ecosystem is also good for human well-being. This implies that the alternatives that give the highest increase in ecosystem functioning are preferred. Two ways to achieve such a ranking are the conservation value method and methods that try to measure flows of materials and energy needed to produce a product or service. The conservation value method assesses the value of a landscape through attributes such as rarity, persistence, threat, etc. The conservation value can then be used in prioritising land acquisition, conservation or other land uses. Methods that try to measure flows of materials and energy do this by employing a life-cycle approach. A prime example of this is the ecological footprint, which measures the area of an ecosystem required to satisfy a certain type or amount of consumption of a good or service.

Source: COWI.

Non-monetary valuation

Economic valuation methods have the advantage that they give the planner a monetary value that can be used directly in a cost-effectiveness or cost-benefit analysis. However, there is no consensus, theoretically or politically, that economic valuation is the right way to approach an ecosystem service, especially when it comes to ethical considerations to preserve landscapes or species. In other cases, it is just not possible to put a monetary value on a service due to lack of information or knowledge. In the following, the ideas behind some non-monetary methods are described, however, it is important to note that many of these methods are not strictly delineated.

Monetary and non-monetary valuation methods are not mutually exclusive. It is possible to use multiple valuation tools and draw on them for decision-making. In fact, this is encouraged, as the only alternative is to ignore certain ecosystem services and their underlying ecosystem functions. Even an insecure or imprecise value can be used in discussions and communication with stakeholders. Alternatively, a qualitative description can be used; a good story is often much better and more important than imprecise numbers. The important thing is not the discussion about numbers or methods but how to improve the ecosystem. One such example is given in Text box 5-3 below.

Text box 5-3 Example: Participatory Action Research approach, Hase River, Germany

The Hase river is a sub-basin of the Ems river basin in Germany. As part of the ESAWADI project (Ecosystem Services Approach for Water Framework Directive Implementation) a case study was conducted in 2011-2012 to assess the suitability of the ESA in river management practice on the ground. The case study was designed to follow the concept of participatory action research, which means that it was to work with existing management processes and get input directly from water management actors. A deliberative process was started, which involved interviews, workshops and questionnaires, to identify relevant ecosystem services and assess their importance. The table below presents the scoring or relevance of the different ecosystem services and their weighting coefficients, which were determined in cooperation with the public and experts from the field. The final benefit value arrived at was then used to increase the cost threshold of measures. This allowed the ESA analysis to have a direct influence on the planning process.

Ecosystem Services Category	Relative level of improvement (0-5)	Weighting coefficient	Percentage of Total Benefit Value	Benefit Value
Ecology	4.6	8.25	41.25	38
Provision and cleaning of water	2	3.25	16.25	6.5
Flood protection	3.7	3.25	16.25	12
Soil protection	3.2	2	10	6.4
Tourism and cultural heritage	3.5	3.25	16.25	11.4
Total benefit Value				**74.3**

The general results of the case study were that the ESA can contribute towards a better understanding of the possible effects of measures, which can benefit the economic assessment of the WFD. This supports the knowledge basis upon which decisions are made on the ground. Especially the communicative power of the ESA was highlighted by the authors, to be used in workshops and interviews.

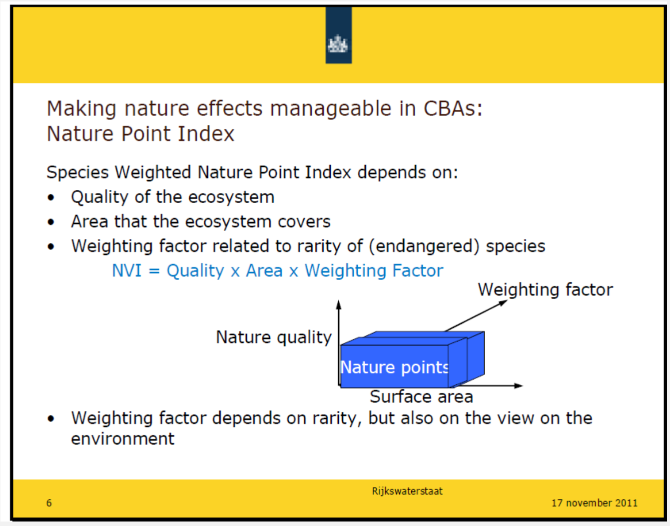
Source: www.esawadi.eu

Another example is the approach using nature point indexes developed in the Netherlands as shown in Text box 5-4 below.

Text box 5-4 Example: Non-monetary valuation (Nature Point Index), Netherlands

The approach of nature points developed in the Netherlands focuses on the value of habitats and ecosystems. It provides an assessment of the overall value of different ecosystems and not specific ecosystem services. It seems to capture in particular the biodiversity aspects of the ecosystems.

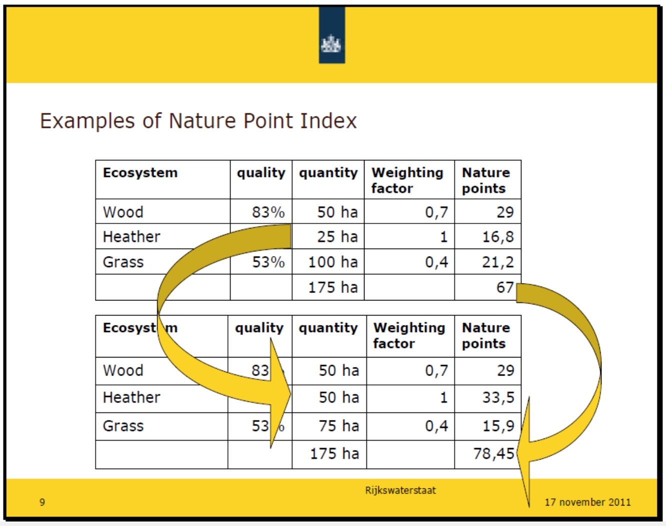
The Nature point approach has been used in assessments in the Netherlands related to the WFD and more recently to the Marine Strategy Framework Directive. The factors in the valuing system include the quality of the ecosystem, the area that the ecosystem covers, and a weighting factor related to the rarity of the species living in the area. This index therefore provides a supplementary way to value ecosystems; one that delivers a standardised aggregation of nature assessments, and offers the opportunity to disaggregate individual parameters.



The Nature Point Index improves the insight into the trade-offs between nature and euros, and it provides a systematic measurement of nature effects that, if integrated with a CBA, increases the usefulness in decision-making processes.

Examples of Nature Point Index

	Net costs	Nature Improvement (nature points)	Nature points per mln euro's
Variant 1	16,4	180	11.0
Variant 2	26,9	450	16.7
Variant 3	14,4	180	12.5


Examples of Nature Point Index

Ecosystem	quality	quantity	Weighting factor	Nature points
Wood	83%	50 ha	0,7	29
Heather		25 ha	1	16,8
Grass	53%	100 ha	0,4	21,2
		175 ha		67

Ecosystem	quality	quantity	Weighting factor	Nature points
Wood	83	50 ha	0,7	29
Heather		50 ha	1	33,5
Grass	53	75 ha	0,4	15,9
		175 ha		78,45

Source: http://www.pbl.nl/nieuws/nieuwsberichten/2009/20090703-Natuurpunten-voor-een-transparante-afweging.

5.4. Description of valuation by selected ecosystem services

The ecosystem services listed in the chapter on identification and described in terms of possible quantification are here presented from the perspective of the last step in the assessment – the valuation.

Provisioning services

For provisioning services, market prices are usually available, which enable a monetary valuation. Hence, primary data for provisioning services are normally relatively easy to obtain for example from statistics. However market imperfections, resource scarcity or altered production can distort results, and these factors need to be considered. In other words, it is important to be aware that the benefit of the ecosystem provision might not be linear.

 **Water supply.** Ecosystem service changes can be valued by the market price of drinking water or by the production costs of water supply. The specific valuation depends on the nature of the change in the service.

Improved **water quality** can reduce the need for treatment of the abstracted water (mainly relevant for drinking water and some industrial water uses). In that sense, the improvement of the services could be the result of changes in regulatory services like filtration. Here, consultations with water suppliers will be necessary to determine the specific value. As is the case with all stated preferences and options, they can be biased. There are examples where assessments of actual treatment efforts found that the treatment level did not change in response to changes in the quality of the abstracted raw water[64]. Type of substance(s), volume of water, applied technology are factors that determine the costs of water purification and hence the avoided costs in case of a change in the need for treatment.

Avoiding and reducing pollution of water resources (for example groundwater aquifers) can be valuated using a similar approach with avoided treatment costs. Again, consultations with water supply companies or technical water supply experts (universities or consultants) will facilitate an estimate. The costs of avoided treatment can be estimated relatively accurately.

The improved quality of water can have a negative impact on the provision of other services. These interactions and reciprocal influences between ecosystem services are important to be aware of in a valuation situation.

Regarding **quantity effects:**

Providing more water to one use would typically imply that less water is available for other uses. The impacts of water reallocation should be estimated by the marginal value of water for each use. For public drinking water supply and industrial uses, the price of water might be used as a proxy. For irrigation, it is necessary to apply more specific investigations and probably consult with irrigation experts as the marginal value of water depends on the specific crops. Further, the value will vary between dry and wet years, and this information will not be available to the farmer upfront. Given alone the variations in most crop prices, the marginal value of irrigation water will be subject to some uncertainty. Naturally, for some water uses, the quality will be crucial and will have a major impact on the value.

[64] Rob J. H. M. van der Veeren and Luuk C. Rietveld (20019, The monetary benefits of nutrient abatement in the Rhine basin for the water treatment plant of WORK at Andijk. http://www.iwaponline.com/jws/050/jws0500263.htm.

Alternatively, an estimation of the willingness to pay for e.g. drinking water could be used to assess the value of an improved quality or accessibility. For drinking water, the population's willingness to pay for good quality and regularity might exceed the production costs and hence the price. Using the price/cost approach will therefore be a lower bound estimate of the value of this service.

Fish stocks and recruiting. The sectors that are mostly like to benefit from increases in the fish stock and the recruiting sectors (the provisioning service) are commercial and recreational fishery sectors.

For the commercial sector, if the fish stock increases, the value can be approximated by the market price of the species in question. If current fisheries are unsustainable and the fish stock is being depleted, then the "real" price is higher than the market price. In most cases, the market price can be an acceptable approximation as the regulation of the fishing sector aims at regulating it to secure sustainable fish stocks.

If the changed fish stock affects recreational fishery, valuation is different. In this case, the change is quantified by the change in the number of anglers (fish trips, expenditures) and hence the valuation will estimate the value based on the benefit shared by the increased number of anglers. The unit value (for one visit or one angling day, etc.) can be estimated using either the travel cost approach or stated preference assessments. The travel cost approach would look at the total costs of a typical visit (transport costs, value of time spend, fishing permit, etc.) and assuming the "welfare" of the angler is higher or equal to the costs. This approach provides a "minimum" estimate of benefit as the fisher will also invest in equipment in order to be able to fish. Willingness-to-pay surveys provide an alternative estimate which, in principle, can display the "full" value. The survey methods will ask about willingness to pay and can include all aspects of the trip/event. The advanced choice experiment approach presents the choices in ways that does not directly ask about a "value". This approach is considered to provide more reliable estimates than the more simple contingent valuation approach. Irrespective of the approach to valuation, the estimates will be subject to some uncertainty.

For recreational fisheries, it is important to consider whether additional fishing opportunities are truly additional or just mean a substitution from another recreational fishing site. Recreational fishermen are often affected by time constraints in terms of the time they can spend on a leisure activity. Additional fishing opportunities will be used if they are more conveniently located, but this might in turn reduce fishing at more remote locations.

Natural biomass production can be valued by using the market price of the natural biomass resource. As described in chapter on identification, it might difficult to identify such an ecosystem service if it is an animal or plant species with a potential future production. If it has been identified and quantified, consultations with the producers might provide estimates of the value. The value of natural resources used in, for example, the pharmaceutical industry might be a commercial secret.

Given that valuation does not necessarily mean monetary valuation, the assessment can be based on expert judgements of the potential future value of the species in question. Hence, it could be qualitative assessments of the potential being more or less significant combined with a description of what specific product or services might come out of the use.

Regulatory & maintenance services

These services are more difficult to valuate just as they are more difficult to quantify. Many of the services will represent benefits to society that only indirectly affect a concrete benefit as many will be regarded as rather abstract and therefore difficult to value. As described in the quantification chapter, it is likely that more proxies will be used to describe these services. If the change has been measured by the use of proxies, then the proxy will be the one to value.

Biodiversity preservation is an ecosystem service that it is difficult to value. While there are overall estimates of biodiversity preservation, they are based on extrapolation of examples of using natural biomass for various purposes (e.g. pharmaceutical industry). As such, these estimates include the value of the above provisioning services.

The value of biodiversity as a regulatory ecosystem service in monetary terms is therefore more related to non-use values. It means that only willingness-to-pay methods can be used to provide monetary values. Willingness-to-pay studies are likely to be very uncertain as it might be difficult for survey respondents to distinguish the non-use value of biodiversity from the cultural use value of preserving specific species. People can relate to the despondency of an abandoned baby seal but not to a small insect. Examples of willingness-to-pay studies are provided in Table 5-5 below.

Alternatively, if the estimates of the value cannot be determined in monetary terns, one can categorise the effects by using the categories such as low, medium or high. This non-monetary valuation will still allow decision-makers to visualise the trade-offs between the choices of measures. In yet other cases, just having the changes identified and quantified for the specific species and ecosystems being preserved might be sufficient.

Text box 5-5 Example: Willingness-to-pay studies, UK and Denmark

Using the choice experiment method for willingness-to-pay studies allows more ecosystem services to be valuated separately.

In 1997, the UK carried out a willingness-to-pay study estimating the willingness-to-pay for different levels of improvement to the water environment.

Another example is the Danish wetland area Store Åmose where a choice experiment study was made including a number of attributes and estimation of the willingness-to-pay for each attribute. The attributes included were the level of biodiversity in the area, the restoration of ancient artefacts, the size of the area and access to the area.

The biodiversity attribute was estimated by showing the respondents visual illustrations of the site under different alternative improvements or modifications.

The results were (EUR per person) :

- Improved biodiversity: EUR 8-120 annually depending on the improvement level
- Restoring of ancient artefacts: EUR 160 annually
- Size of the area: EUR 1 annually
- Access: - EUR 18 annually.

The negative willingness-to-pay for access to the area is due to the fact that only few respondents live in the surrounding areas. When these are analysed separately, the willingness-to-pay for access is positive.

Source: Nera, 2007, The Benefits of Water Framework Directive Programmes of Measures in England and Wales.Danish Ministry of the Environment, 2005, Valuation of Nature Restoration and Protection of Ancient Artefacts in Store Åmose in West Zealand.

Climate mitigation / GHG reduction / Carbon sequestration can be partially valued in monetary terms using a unit price/cost per CO_2-equivalent both when looking at mitigation. To ensure consistency across national policies, it is recommended that the national authorities responsible for meeting national GHG (greenhouse gases) emission targets be consulted. When assessing the impact from adaptation measures, the focus will be on the damage avoided due to the measures taken. There are two ways of assessing the value: either by looking at the investment costs needed to avoid an incident or an assessment of the damage costs in case of an incident.

At EU level, the CO2 -equivalent cost is based on the long-term EU ETS (EU emissions trading system) scenarios. The reference scenario includes the following minimum values:

Table 5-6 Illustration of carbon price evolution in the EU 2020-2050

Carbon price evolution	2020	2025	2030	2035	2040	2045	2050
Reference (frag. action, ref. fossil f. prices)	16,5	20	36	50	52	51	50
Effect. Techn. (glob. action, low fossil f. prices)	25	38	60	64	78	115	190
Effect. Techn. (frag. action, ref. fossil f. prices)	25	34	51	53	64	923	147
Source: Annex 7.10 to http://eur-lex.europa.eu/LexUri/Serv.do?uri=SEC:2011:0288:FIN:EN:PDF.							

The lowest scenario specifies a value of EUR 20/ton CO2-equivalent until 2025, EUR 36/ton up to 2030 and EUR 50/ton beyond 2030. If national, agreed prices for CO2 equivalents are higher than the above, they should be used instead of the above values. Member States may have estimated the marginal cost of achieving the national target for reduction of GHG emissions as being higher. Values based on EU ETS scenarios or national reduction costs can be revised as new reduction targets are agreed on or policies are updated. Hence, it is recommended to consult the national authority responsible for meeting national GHG reduction targets to obtain updated values at the time of the assessment.

An example of a measure taken that would have increase the carbon sequestration ecosystem service is establishing wetlands. Climate change mitigation will be influenced as the wetland works as a CO_2 sink. The value can be assessed by estimating the capacity of the CO_2 sink and multiplying it with the carbon price indicated in the table above. This is also an example of a NWRM and the initiative on NWRM should be consulted as it will provide case examples of NWRM[65].

[65] http://nwrm.eu/

Climate change adaptation ecosystem services comprise most importantly the effect on flood risks presented below as a separate service. Other effects for example the impacts on local climate conditions from establishing green spaces in urban areas could be valued by estimating the citizen's willingness to pay for the improvement.

 **Flood risk reduction** as an ecosystem service can be valuated using either of the following approaches: Estimates of the avoided damage cost or the avoided investments in other types of flood defence (hard infrastructure measures). As flood risk reduction is a key ecosystem service linking the WFD and the FD, it is important for reasons of coordination to consult the national approach to assessments of flood defence measures.

Since flood risk reduction is an ecosystem service that can be monetised, it is relevant to undertake this type of assessment given the requirements in the FD to include considerations of costs and benefits when developing the FRMPs. Examples of flood risk reduction valuations could include estimates of avoided damage based on property values and value of assets and infrastructure affected but also negative impacts on health by avoiding pollution of bathing waters and avoiding damage to cultural heritage monuments by flooding. The impacts on human health and social aspects, environmental aspects, cultural heritage are often more difficult to value than those related to economic activities for which there is already a value in the market. In addition to direct, financial damage costs, the welfare of the affected population should be considered as there might, among them, be a willingness to pay for the reduced risk of flooding, reflecting the discomfort of the event. Another example is where there is a choice between different measures which can achieve the same protection level. In this case, the difference between the two will be the additional benefits that follow from the implementation of either measure.

Flood protection is complex to assess as it is about risks. The risk associated with specific flood event depends on the probability of the event times the damage from that particular event. As the risk of flood events is influenced by climate change, valuation of flood protection is likely to include assessing several alternative scenarios and making judgements about which are the more probable descriptions of the future situation[66].

 **Erosion/sediment control** can be valued by considering the changes in the need for dredging. As described in the quantification chapter, assessing sediment transport is a complex task, and it is likely that a sediment transport model is needed in order to assess the impacts of measures that affect erosion and sediment transport. It will be necessary to consult the authorities responsible for maintaining the water course, including coastal and port authorities in order to estimate the value of changing to the dredging regime. When valuing sediments, not only the quantity but also the quality is relevant to consider, as both can have major impacts on the value, given that the cost of disposal depends largely on the quality.

 **Filtration of pollutants.** When considering which measures to include in the PoM, pollution reduction is typical the main effect parameter in a cost-effectiveness assessment. The cost-effectiveness analysis will consider and compare different measures in terms of their

[66] See Working Group Floods (CIS) resource document *"Flood Risk Management, Economics and Decision Making Support"* 2012, for many details and references to specific Member State guidance and examples.

ability to remove pollution compared with their costs. So typically, the value of this ecosystem services is captured by its level of cost-effectiveness.

When considering filtration of pollutants as a side-benefit, for example when assessing natural flood defence measure, the value can be estimated by using the avoided costs approach. If a natural flood defence measure reduces the need for specific WFD measures to remove certain pollutants, the costs of the cheapest alternative could be used to estimate the value per unit of pollution removed.

Cultural ecosystem services

Valuation of cultural ecosystem services can be subjective and value-laden as each individual or each group of individuals have different perspectives and perceptions. Several factors like experience, habits, belief systems, behavioural traditions and judgement as well as lifestyles have to be considered. They are all related more to the observer/individual than to ecosystem conditions.

As discussed in the quantification chapter, the valuation of the cultural ecosystem services will typically be based on an estimation of the number of people visiting and using the specific ecosystem services multiplied by a unit value per person per visit.

The estimation of such unit values will typically be based on interviews and questionnaires using a stated preference approach. It could also be based on the travel costs method but this method only includes the direct use of recreational opportunities. Non-use values can only be estimated by a stated preference approach.

Recreational opportunities are most commonly being valued by using a travel costs, hedonic pricing or a stated preference assessment. Which one to choose depends the way the area is used and the type of benefits it provides. If the most common use is that the area is visited by people living some distance away, then the value should be asses by estimating their travel costs. On the other hand, if the area is mostly visited by people living in the area, then the hedonic pricing (measurement of the effect on house prices) could provide a better estimate. In the Italian example beneath in Text box 5-6 the recreational benefits are estimated by using contingent valuation. Finally, if the use of the area is mixed or more uncertain, then a stated preference method could be most suited. Here, you ask the public in general of their willingness to pay for improvements. The stated preference and the hedonic pricing will not only capture the use value but also the value that expresses the option and bequest values.

If a monetary valuation is not possible, another method can be to score different areas to allow for comparisons. Again, categories like high, medium or low could be used.

When looking at recreational opportunities, it is very important not to treat them in isolation as the possibility of substitution will have a major impact on the value that they represent. In other words, if there are two parks in your neighbourhood, it is likely that their value is lower than if there was only one park due to the fact that the time available for recreational activities is limited. Further this will help avoid double counting.

Text box 5-6 **Benefit assessment of recreation and water supply services, Emilia-Romagna, Italy**

The Emilia-Romagna is a wealthy, highly developed region of Northern Italy with an economy largely comprised of agriculture and mechanical industries. There are three main river basin districts; the Po River Basin, the Northern Apennines River Basin and the Central Apennines River Basin. A study by Galioto *et*. al (2013) calculates the costs and benefits generated from having good status by creating a procedure that evaluates qualitative and quantitative pressures affecting both surface and ground waters.

This study was driven by the water status objectives of the Emilia-Romagna Region. Types of pressures threatening water resources were defined and consultations with local stakeholders identified a number of measures for each type of pressure. Then, a cost minimization analysis was performed to find the most efficient set of measures and levels of activation. The findings show that for a cost of about 349 million euro per year, a good status can be achieved for all regional surface and ground waters with corresponding benefits of about 53 million euro per year and a benefit/cost ratio of 0.15. For the overall region, the costs for implementing measures to achieve good environmental status are too high compared with the benefits, but implementing measures in areas with a high cost-effectiveness could be targeted. The benefit/cost ratio is high (0.67) in the hill belt, due to the fact that most of the sources of drinking water and most of the recreational sites stem from this region. These two value estimations were the only benefits measured though, and they produced a much lower valuation than the costs associated with intervening in the high polluting plains areas. The benefit/cost ratio is significantly lower (0.11) in the plains region because sources of pollution from most of the industrial activities, urban sites and intensive agriculture sites are located here. Therefore, the costs of implementing intervention measures in the entire region far outweighed the benefits gained. Other secondary effects on the economy and society were not considered, providing a significantly lower benefit valuation than expected. It was concluded that if the estimated benefits are significantly lower than costs for the specific areas, then a finer scale analysis may be required.

Approximate river basin locations within the Emilia-Romagna region of Northern Italy¶

Source: Galioto, F., Marconi, V., Raggi, M., Viaggi, D. (2013) An assessment of Disproportionate Costs in WFD: The Experience of Emilia-Romagna. Water. 1967-1995

Aesthetic and cultural values can be estimated using a stated preference assessment. Some of these values can be estimated as described under recreational values. It is important to take into account the risk of double counting, as some of the values might overlap with the ones used to assess the recreational value. It is possible to ask the public about their willingness to pay for certain non-market goods, but these types of services will often be the most difficult to estimate in monetary values, as they are less concrete and there are no goods on the market that can support the valuation. Examples of such values are scenic views, monuments or combinations for landscapes or land uses.

Again, hedonic pricing can be used to assess the aesthetic value of more scenic views for nearby residential houses.

Valuing these services in non-monetary terms is as challenging as making the monetary valuation due to the fact that the values of services depend on the users' opinions. The users or the population could be asked to score or rank the services that are affected to reveal their preferences.

Abiotic services

These services can often be valued using market prices, maybe adjusted for external effects if these are not included in the market price.

 **Navigation:** Changing waterway navigation can be valued as the difference between the costs of navigation and the costs of the relevant alternative transport (which in many cases might be rail). Consultation with the stakeholders can provide the relevant estimates. There might be national values for external costs of transport that can be applied. A study and handbook have been published advice on the estimation of external costs using suggested EU average values for each mode of transport[67].

 **Geological resources** can be valued based on market prices of aggregates, dredged or extracted. Similar to the case of navigation, the value of a change in the provision of this type of service is the difference between the costs of dredged materials compared with the costs of the relevant alternative, including transport costs.

 **Energy (hydropower)** resembles other abiotic services in that the valuation can be based on market prices adjusted for external effects. Also here, it is a question of the difference between the costs of electricity produced by hydropower and the relevant alternative electricity production. The cost per kW/h should include the costs of the externalities. Member States might have practices for handling such costs, for example in climate policies, and the relevant authorities should be consulted. Several studies have made estimates at EU level – for example estimating the external costs by energy source[68].

5.5. Who is affected (distribution of burdens)?

Ecosystem services can represent a different value to those who are affected and others less affected, who might consider the service less beneficial. Examples are nice views or areas used for leisure. On the other hand, there might also be losers from measures d, which could be others than those benefitting. When the selection of measures has been made, the winners and losers can be identified. In political decision-making, the question of equity is important and should not be disregarded. Therefore, the distribution of burdens should be analysed, even if this is only possible in a qualitative way or as a ranking. This information is also of use in the decision-making process and for alternative funding mechanisms, e.g. Payment for Ecosystem Services.

It is therefore important to assess not only the direction of the change in value, but also the losers and winners, which can be across e.g. regions, sectors or generations. A strong communication tool resulting from the valuation stage is a table showing the impacts on the different stakeholders of changes to ecosystem services.

[67] CE Delft 2008 Handbook on estimation of external costs in the transport sector
Internalisation Measures and Policies for All external Cost of Transport (IMPACT)
Version 1.1 Delft, CE, 2008.
[68] See, for instance: http://www.eea.europa.eu/data-and-maps/figures/estimated-average-eu-external-costs.

5.6. Literature and links

The TEEB includes guidance on valuation, case examples and links to relevant literature and new material is constantly being published. The Nature Capital initiative has developed a support tool InVEST which is public software that includes guidance on most of relevant ecosystem services regarding both quantification and valuation.

Text box 5-7 Recommended literature

TEEB (2013) The Economics of Ecosystems and Biodiversity
for Water and Wetlands. IEEP, London and Brussels; Ramsar Secretariat. http://www.teebweb.org/.

Natura Capital website including support tool InVEST http://www.naturalcapitalproject.org/.

De Groot et al. (2006), Valuing Wetlands: Guidance for valuing the benefits derived from wetland ecosystem services.

UK National Ecosystem Assessment (2011), Ch. 22.

EFTEC (2010), Scoping Study on the Economic (or Non-Market) Valuation Issues and the Implementation of the Water Framework Directive.

6. LINK TO PLANNING

This chapter supports the decision-maker by incorporating the information gathered in the assessment of ecosystem services (Chapters 3 to 5) and linking it to the decision processes already taking place as part of the WFD and FD implementation.

The key question is:

- How can the WFD and the FD planning processes be improved by including considerations of ecosystem services?

The focus of this document is on applying the ecosystem service considerations to the WFD and FD implementation processes where they could be most useful. In doing so, the exercise should take into account the nature of the assessment that Member States have undertaken already as part of the first rounds of RBMPs and PoMs.

The main challenge, in terms of planning is to identify the most cost-effective solutions that can fulfil the WFD objectives. For the FD, the requirement is that a cost-benefit analysis be undertaken in case of international action plans.

Key challenges	Extensive work has already been done in the Member States on WFD implementation, and introducing ecosystem service considerations should not distract attention from existing efforts on WFD and FD implementation. Nevertheless, it can assist current planning and decision-making, to achieve better consideration of benefits due to an increase in the provision of ecosystem services while fulfilling the objectives. The complexity of assessing measures with multiple benefits is a key challenge.
Chapter outcome	The chapter presents examples of how the ecosystem service assessments can be integrated in the key planning and decsion process of the WFD and the FD implementation inlcuding. The includes with regard to the WFD derogations, exemptions and developing the programme of measures. In relation to the FD implementation, the use of ecosystem service assessments is presented in relation to developing the Flood Risk Management Plans.
Approach according to the level of ambition	High: Ecosystem service assessments using MCA or CBA types of approaches are integreted in all planning and decsion process of the WFD and FD implementation. Medium: Ecosystem service assessments are included using MCA or CBA type of approaches in the main decsion processes of WFD and FD implementation. Low: Qualitaitve assessments of ecosystem services are taken into account in the main decision process of WFD and FD implementation.

6.1. The link to WFD/FD implementation

The previous chapters discussed how ecosystem services can be identified and assessed. This chapter elaborates on how ecosystem service assessments can be integrated into the process of implementing the WFD and the FD to support the work.

The key implementation processes where the ecosystem service assessments will be most useful and beneficial were identified in Chapter 2. This chapter presents the specific issues of introducing the consideration of ecosystem services.

- The identification and selection of a cost-effective programme of measures (WFD Article 11)
- The potential application of derogations (WFD Article 4)
- The preparation of the flood risk management plan (FD Article 7) including Art. 7.3 specifies that the plans should take account of the costs and benefits.

The selection of the most cost-effective measures for the **PoM** is the area where the introduction of ecosystem service considerations could have the most significant impact on the decision-making process. A comprehensive consideration of all relevant ecosystem services could mean that measures which deliver multiple benefits and which maintain the integrity of the ecosystem to deliver services may come out better in the assessment and improve their ranking. They typically provide additional benefits such as increased flood protection, increased biodiversity preservation and some also recreational opportunities. The inclusion of such co-benefit considerations is one main advantages of integrating ecosystem services considerations in a more systematic way. Chapter 6.2 presents considerations and examples of how to take into account all relevant ecosystem services in the development of the programme of measures.

The specific approach to how the ecosystem services considerations should be integrated will depend on the decision framework applied by the individual Member State regarding exemptions for the next planning cycles.

In principle, this could be done using one of the following approaches:

- Cost-benefit analysis (CBA)
- Multi-criteria analysis (MCA)
- Combination of CBA and non-monetised criteria.

The latter option could be termed an "extended CBA"[69]. An expert workshop on the use of economics in the Floods Directive implementation suggested that combining CBA and MCA would render it possible to account for both the monetised and the non-monetised effects in a systematic way.

In the Blueprint[70], it is proposed to provide better calculations of cost and benefits by means of a CIS guideline.

[69] A Working Group Floods (CIS) resource document "Flood Risk Management, Economics and Decision Making Support" 2012.

[70] http://ec.europa.eu/environment/water/blueprint/pdf/brochure_en.pdf.

The discussion of **pricing and cost recovery** is covered in the next chapter on **Link to financing and economic instruments**.

The WFD includes provisions for possible exemptions. The use of exemptions can be based on considerations of whether costs are disproportionate. Taking the value of ecosystem services into account could support this type of assessment.

Text box 6-1 below exemplifies a typical decision making process.

Text box 6-1 Example of decision making in Mondego Estuary in Portugal

The study on the Mondego Estuary identified two main concerns regarding the management of estuarine ecosystems and came up with recommended planning measures. Firstly, an increase of economic activities that relies on a good system quality will continue to put pressure on the ecosystem. Each year from June to September, the number of tourists increases by 47%, adding extra pollutants to the waters. Therefore, efforts to boost in ecotourism activities, such as bird watching or eco-friendly tours, were recommended for this region to promote economic and social development and preserve the sensitive system. Secondly, the water quality needs to improve and be maintained. A recommended planning action is the creation of buffer zones for the removal of nutrients added by out-of-date agricultural practices and changes in agricultural practices to improve water use efficiency. It was concluded that to design and implement management policies and ecosystem restoration schemes, a fundamental understanding of complex water use trade-offs among ecological, social and economic goals is necessary.

Source: Cunha, M., Marques, J., Pinto, R., Palma, C. (2012) Ecosystem Services Approach for Water Framework Directive Implementation: Mondego catchment area Case Study Report. URL: < http://www.esawadi.eu/IMG/pdf/ESAWADI_Mondego_estuary_CS_report_vf-3.pdf>

Concerning **exemptions** and time derogations, the inclusion of broader coverage of benefits expressed as the improved ecosystem services could reduce the need for applying derogations as the benefits would then be better appreciated and accounted for. Often, derogations have been applied due to affordability constraints, and Member States have had to prioritise the implementation of measures. A more comprehensive assessment of the benefit or the benefits that can be capitalised for each water body could increase the level of benefits achieved (for a given amount of financing). This would improve the justification for taking early action. Chapter 6.3 gives a number of examples of the use of ecosystem service considerations in relation to applications for time derogations.

Compared with the WFD, the FD (Art. 7.3) places more focus on the need to integrate costs and benefits into the **Flood Risk Management Plans** of the individual river basins. The Directive requires the FRMP to take into account relevant aspects such as costs and benefits. The Directive furthermore stipulates that international action plans should undergo a cost-benefit analysis. In both cases, integration of ecosystem service considerations could allow systematic analysis and communication of relevant costs and benefits. A systematic consideration of ecosystem services in both the WFD and the FD will support the required coordination of the implementation of the two directives.

6.2. Implementation process of the WFD

6.2.1. Selection of measures for Programme of Measures

The selection of measures based on a cost-effectiveness consideration is the key decision process into which it is important to integrate ecosystem services. The apparent lack of progress in certain areas such as diffuse pollution and hydromorphological pressures is an important motivation for promoting ecosystem service considerations[71].

The integration of ecosystem service considerations into the development of the programme of measures needs to be tailored to the assessment framework applied in each Member State.

Ecosystem services can be incorporated into the cost-effectiveness analysis in alternative ways:

- Listing the relevant ecosystem service co-benefits (qualitative or semi-quantitative) to support the selection of measures
- Estimating values of ecosystem services where possible and calculating the net costs
- Combining the development of PoM and considerations of disproportionate costs in an integrated appraisal approach.

An example of the first approach is illustrated in Text Box 6-2. Here, the cost-effectiveness of a list of measures has been estimated as the financial costs per unit of pollution removed. A few additional environmental effects are scored in a semi-quantitative way.

[71] COM (2012) 670 final REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Implementation of the Water Framework Directive (2000/60/EC). It should also be noted that the integration of ecosystem services can only support a comprehensive assessment that identifies all relevant co-benefits. The final decision on implementation of measures is affected by other constraints such as affordability and financing.

Text box 6-2 Example of costs-effectiveness analysis with scoring of additional environmental effects

Assessment of the cost-effectiveness of individual measures with regard to nutrients, where additional ecosystem services have been assessed qualitatively.

Table 0 Effects and costs per year measured at the source

	Primary effect	N-emission	P-emission	Financial economic cost	Welfare economic cost	Welfare economic cost per unit of primary effect	Derived environmental effects: Climate gasses	Ammonia	Pesticides	Biodiversity and landscape
Changed farming methods										
1. Conversion of extensive cattle production to organic production methods	N	6-41 kg/ha	-	0	0	0	+	+	+	+
2. Ammonia fertilisers in stead of NO_3	N	6-8 kg/ha	-	0	0	0	+	-		
3. Catch crops – current practice	N	12-55 kg/ha	-	330-660 DKK/ha	386-772 DKK/ha	7-64 DKK/kg N	+		(-)	
4. Optimised use of catch crops	N	20-95 kg/ha	-	315-700 DKK/ha	368-820 DKK/ha	4-41 DKK/kg N	+		(-)	
5. a. Demand for "injection of manure" from harvest to April 1. b. No tilt or plowing from harvest to April 1	P	a. -6-0 kg N/ha b. 10-25 kg N/ha	a. 0,01-0,125 kg/ha b. 0,025-0,250 kg/ha	a. 50-150 DKK/ha b. 250-750 DKK/ha	a. 60-175 DKK/ha b. 300-880 DKK/ha	a. 480-17.500 DKK/ kg P b. 1.200-35.200 DKK/ kg P	a. – b.	b. + b. +	b. +	b. +
6. Reduced N-application by 80%	N	3,4-5,0 kg/ha	-	87-151 DKK /ha	101-176 DKK /ha	20-52 DKK/kg N	+	+		
7. Harvest of hey in stead of permanent cattle grassing	N	26-109 kg/ha (pure mowing)	-	0	0	0	+	-		
		13-54 kg/ha (2 x mowing)		0	0	0				
8. Reduced N-application to pastures	N	18-77 kg N/ha (clower grass)	-	295-1.375 DKK/ha	345-1.610 DKK/ha	4-76 DKK/kg N	+	+		
		20-85 kg N/ha (pure grass)								
9. Catch crops in two years after plowing of permanent pastures	N	55 – 110 kg/ha		415 DKK/ha	485 DKK/ha	2-4 DKK/kg N	+			
10. Early sowing of winter crops	N	5-7 kg/ha	-	0	0	0	+		-	
11. Only winter crops and under sowing of catch crops on fields with high risk of soil erosion	P	12-55 kg/ha	0,06-0,250 kg/ha	250-750 DKK/ha	300-880 DKK/ha	1.200-14.600 DKK/kg P				
12. Reduced P-application	P	-	0,003-0,10 kg P/ha	25-50 DKK/ha	30-60 DKK/ha	300-20.000 DKK/kg P				
13. Fertilisers in stead of manure	N	24-28 kg N/ha	0,01-0,1 kg P/ha	200-250 DKK/ha	235-290 DKK/ha	8-12 DKK/kg N		-		-

Source: INSTITUT FOR ØKONOMI, SKOV OG LANDSKAB, UNIVERSITY OF COPENHAGEN, Alex Dubgaard, Mikkel F. Kallesøe, Mads L. Petersen, Jacob Ladenburg, COST-BENEFIT ANALYSIS OF THE SKJERN RIVER RESTORATION PROJECT

By this approach, the co-benefits are made visible. In the subsequent decision-making process, decisions will have to be made on how to take ecosystem services into account.

Alternatively, the monetary value can be determined where feasible, and a net cost can be estimated where the benefits enter as negative costs. This means a deviation from the narrow interpretation of the concept of cost-effectiveness analysis as a method that only includes costs.

A review of specific cost-effectiveness studies undertaken in a number of Member States indicated that only about 20% of the CEA studies had included environmental costs[72]. This means that most of the cost-effectiveness analyses have focused on the financial costs of the measures.

[72] ACTeon 2011 Research project on the use of the Cost Effectiveness Analysis with regard to the European Water Framework Directive.

An example of the full monetisation of a measure is illustrated in Table 6-3.

Text box 6-3 Example of costs-benefits with comprehensive assessment of ecosystem services - Skjern River restoration case

Reverting to the Skjern River restoration case. The full cost-benefit assessment is presented in the below table. It illustrates different assumptions about the discount rate and the lifetime over which the costs and benefits is considered.

Taking the case of 3% over a 20-year period, the direct cost of the river restoration project was estimated to approximately EUR 21 million, including the initial investment and the costs of maintenance and monitoring.

Additional costs will be EUR 300,000 in compensation for the closedown of an aquaculture facility. The river restoration will have an impact on land use will limiting the area that can be exploited for agricultural purposes. Loss of arable land is estimated to EUR 6 million.

The total costs are estimated to EUR 27.5 million.

The estimation of the ecosystem services arrived at EUR 30 million. The description of each ecosystem service valuation is included in Table 5-4. Savings on wastewater treatment of the aquaculture facility and on pumping (not necessary when the area is no longer drained) are included. These account for about EUR 1 million.

Table 9. Cost-benefit analysis of the Skjern River project

	Present values					
Time horizon	20 years, mio. DKK			Indefinite, mio. DKK		
Discount rate	3%	5%	7%	3%	5%	7%
Project costs	143.7	143.0	142.2	143.7	143.0	142.2
Operation and maintenance	12.9	13.3	14.0	17.0	14.9	14.7
Forgone land rent	44.8	36.4	32.3	101.4	63.0	46.1
Closing of fish farm	2.2	2.2	2.2	2.2	2.2	2.2
Total Costs	**203.6**	**194.9**	**190.7**	**264.3**	**223.1**	**205.2**
Termination of emission from fish farm	2.8	2.5	2.4	6.1	3.9	3.0
Saved pumping costs	6.0	5.1	4.5	12.1	7.4	5.4
Better land allocation	15.9	14.2	13.0	29.7	19.4	15.2
Reed production	4.6	3.6	2.9	10.1	5.0	3.0
Reduced flood risk	0.5	0.4	0.4	1.1	0.7	0.5
Reduction of nitrogen	20.3	17.0	14.5	35.8	23.7	18.5
Reduction of phosphorous	20.2	16.9	14.4	43.9	25.8	18.1
Reduction of ochre	18.6	17.7	16.9	40.5	27.0	21.3
Better hunting opportunities	7.0	5.9	5.0	15.3	9.0	6.3
Better angling opportunities	40.9	34.3	29.1	89.0	52.4	36.7
Outdoor recreation	55.2	46.3	39.3	120.1	70.7	49.6
Biodiversity, existence value	39.5	33.1	28.1	85.9	50.6	35.5
Total benefits	**231.5**	**197.0**	**170.5**	**489.6**	**295.6**	**213.1**
Welfare gain	**28**	**2**	**-20**	**225**	**73**	**8**

When comparing costs and benefits, benefits show a surplus of EUR 1 million over a 20-year time period. As the lifetime of the river restoration is much longer and probably indefinite, an alternative assessment would give a net surplus of EUR 30 million.

It follows that the measure is a good investment from a societal perspective. However, this does not mean that the measure is financed as the surplus to society is not directly capitalised.

Source: INSTITUT FOR ØKONOMI, SKOV OG LANDSKAB, University of Copenhagen, Alex Dubgaard, Mikkel F. Kallesøe, Mads L. Petersen, Jacob Ladenburg, COST-BENEFIT ANALYSIS OF THE SKJERN RIVER RESTORATION PROECT

Using the above example: If the cost-effectiveness of the river restoration is measured as the cost per kg of N removed, the ratio would be around EUR 9 per kg of N (the project was estimated to remove around 210 tons of nitrogen per year)[73]. If all the benefits are included in the calculations as negative costs, the result is a cost of EUR -0.3 per kg of N removed.

This approach means calculation of economic costs in addition to the financial costs typically included in the cost-effectiveness analysis.

The last example shows how considerations of ecosystem services are included in an appraisal process that combines the identification of cost-effective measures and the assessment of potentially disproportionate costs. To determine whether costs are disproportionate, the cost assessment should be based on the most cost-effective package of measures. This is included in the approach used by the Environment Agency in England.

The **appraisal process** comprises a staged assessment framework where the benefits are initially described and quantified following a two (or three) step valuation approach. The benefit categories are defined as ecosystem services, and the approach includes a gross list of ecosystem services that help the river basin management planners review the situation in each water body or at catchment level; see the example in Text box 6-4. The process can be viewed as a description in more applied terms of how a CBA can be carried out.

Text box 6-4 Example of comprehensive appraisal process with valuation of ecosystem services

Appraisal process in England for next RBMP cycle

The appraisal process for selection of measures and assessment of disproportionate costs involves a comprehensive assessment that includes a cost-benefit type of assessment where benefits are categorised based on an ecosystem service assessment.

To support the development of the CBA, the Environment Agency in England has developed a guidance document with supporting Excel sheets and trained a team that can support river basin managers in making CBAs. Local environmental staff are instructed in doing the assessments locally. The guidance document focuses mainly on assisting river basin managers in valuating changes in the ecosystem services identified.

The guidance document introduces three different levels of valuation, and the process includes the following steps:

- Qualitative description
- Quantitative description
- Stage 1 valuation
- Stage 2 valuation
- Primary valuation study (exception).

The two first steps concern identification and quantification. An example of how the qualitative description is recorded is illustrated below along with the categories of ecosystem services.

[73] Calculation using 3% and 20-year period and converting from DKK to EUR by 0.14 EUR/DKK.

Category (Please see further guidance in comment boxes)	**Category Filter**- please select which categories will be likely to be impacted by the measures
Provisioning services	
Fresh water	Impact expected
Food (e.g. crops, fruit, fish etc.)	No impact expected
Fibre and fuel (e.g. timber, wool, etc.)	No impact expected
Biochemicals, natural medicines, pharmaceuticals	No impact expected
Ornamental resources (e.g. shells, flowers, etc.)	No impact expected
Water for non-consumptive use	Impact expected
Regulatory services	
Air Quality regulation	No impact expected
sequestration)	No impact expected
Water regulation (timing and scale of run-off, flooding, etc.)	No impact expected
Natural hazard regulation (i.e. storm protection)	No impact expected
Erosion regulation	No impact expected
Water purification and waste treatment	Impact expected
Cultural services	
Cultural heritage	No impact expected
Recreation and tourism	Impact expected
Aesthetic value	Impact expected
Spiritual and religious value	No impact expected
Intellectual and scientific, educational	No impact expected
Inspiration of art, folklore, architecture, etc	No impact expected
Existence Values	No impact expected
Social relations (e.g. fishing, grazing or cropping communities)	Impact expected
Supporting services	
Soil formation	No impact expected
Primary production (in river)	Impact expected
Nutrient cycling	No impact expected
Water recycling	No impact expected
Photosynthesis (production of atmospheric oxygen)	Impact expected
Provision of habitat	Impact expected

Stage 1 valuation concerns a general estimate to be made using a set of benefit values. The approach is therefore one of benefit transfer. Based on a major willingness-to-pay study (NWEBS) for improvements to the water environment conducted in 2007 (and updated for second cycle), benefit values have been "estimated" and they are applied to the ecosystem services identified. The Stage 1 valuation includes a limited set of ecosystem services.

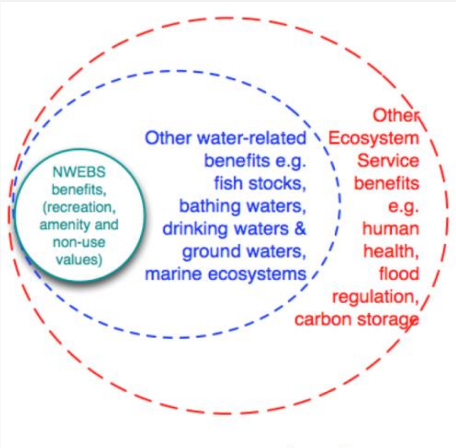
The Stage 2 level of valuation introduces more benefit categories, again based on the benefit transfer method. At the third level, a primary valuation study for a specific river basin is made but it is noted that is not expected that such valuation will be undertaken.

If the first level valuation shows a clear result (a ratio below 0.5 or above 1.5, the cost being twice the benefit or the benefits being twice the cost) when comparing the benefits and the costs of the measure, it is recommended not to spend more time on making a more precise estimate of the value of the benefits. If, however, the result is less clear, it is recommended to proceed to Stage 2, which includes a more complete set ecosystem services and also allows including benefit transfer values to reflect better the individual characteristics of the local area. Finally, if this is not possible, then a primary willingness-to-pay study could be carried out, but it is not expected to happen.

The below table illustrates the benefit categories which are all described as ecosystem services. Note that the classification used here has a chapter termed supporting services. In the CICIS classification, these supporting services are part of the Regulatory chapter.

The inner circle below includes the categories that are monetised and applied in the Stage 1 assessment. The next circle (blue) covers the additional ecosystem services that can be monetised while the outer circle are services which presently are not monetised.

The assessment of the impacts on ecosystems services – the quantification of the effects – depends on the specific measure and measures applied. The appraisal approach works with bundles of measures. These bundles could for example be measures needed to improve the status of a water body to good status. The table below illustrates a scoring of the expected impacts of three alternative bundles of measures.



	Significance of change		
	Do something option		
Category	A	B	C
Provisioning services			
Fresh water	^	^	0
Food (e.g. crops, fruit, fish etc.)	0	0	0
Fibre and fuel (e.g. timber, wool, etc.)	0	0	0
Genetic resources (used for crop/stock breeding and biotechnology)	0	0	0
Biochemicals, natural medicines, pharmaceuticals	0	0	0
Ornamental resources (e.g. shells, flowers, etc.)	0	0	0
Energy Harvesting (non MA)	0	0	0
Regulatory services			
Air Quality regulation	0	0	0
Climate regulation (local temperature/ precipitation, greenhouse gas sequestration)	^	^	0
Water regulation (timing and scale of run-off, flooding, etc.)	^	^^	^
Natural hazard regulation (i.e. storm protection)	0	0	0
Pest regulation	0	0	0
Disease regulation	0	0	0
Erosion regulation	^	^	0
Water purification and waste treatment	^	^	0
Pollination	0	0	0
Noise and Light regulation	0	0	0
Cultural services			
Cultural heritage	0	0	0
Recreation and tourism	0	^^	0
Aesthetic value	^	^^	0
Spiritual and religious value	0	0	0
Intellectual and scientific, educational	^	^	0
Inspiration of art, folklore, architecture, etc	0	0	0
Social relations (e.g. fishing, grazing or cropping communities)	^^	^^	^^
Supporting services			
Soil formation	0	0	0
Primary production (in river)	^	^	0
Nutrient cycling	^	^	0
Water recycling	0	0	0
Photosynthesis (production of atmospheric oxygen)	^	^	0
Provision of habitat	^^	^^	^^

Legend:

Improvement
significant ^^
noticeable ^
no noticeable change 0
Decline
noticeable v
significant vv

The results can be used to choose between different combinations of measures and there the appraisal approach supports the cost-effectiveness analysis.

The guidance document includes various reference values and links to further sources on valuations.

Source: Environmental Agency, 2013, Water Appraisal Guidance; Assessing Costs and Benefits for River Basin Management Planning, http://www.restorerivers.eu/Portals/27/Publications/Water%20Appraisal%20Guidance.pdf

The above case on the appraisal process in England is an example of an approach that incorporates cost-benefit analysis in the development of the PoM. It includes assessing packages or bundles of measures that all achieve good status and then comparing them with the total benefits they achieve in relation to the costs. In this approach, the ecosystem service co-benefits are included as part of total benefit, while costs are the direct costs of implementing the measures.

The examples have illustrated different approaches to including ecosystem service considerations in the cost-effectiveness assessment of measures. The most important points to including ecosystem service considerations starting from a comprehensive list of ecosystem services to ensure that all potentially relevant services are identified.

It is less important whether the ecosystem service considerations are included based on qualitative, quantitative or monetised assessments. However, the following pros and cons need to be considered:

Table 6-1 Overview of the pros and cons of different assessment approaches

Assessment approach	Advantages	Disadvantages
Qualitative	Can cover all ecosystem services; Easier to communicate a good qualitative description than uncertain numbers; Less resources required for the assessment	Difficult to compare with monetary values; Risk of carrying less weight if the decision framework includes monetary values.
Quantitative	Can cover most ecosystem services; Supports the assessment of importance better than a purely qualitative assessment	Difficult to compare with monetary values; Risk to carry less weight if the decision framework includes monetary values; Uncertainty on the effects (order of magnitude estimates).
Monetised	Can be included in CEA and CBA decision frameworks Easy to communicate (though the uncertainty might be an issue)	Estimates are often only order of magnitude Requires more resources for the assessment.

Source: COWI.

It should be noted that not all ecosystem services can be monetised and even for those ecosystem services that than can be monetised, the estimates are rather order of magnitude estimates. It might not only be the valuation itself but also the quantification in physical terms that might provide only order of magnitude estimates. It should be noted that the overall uncertainty of a monetary valuation might not be much higher than the uncertainty about the quantification of the physical effects. The uncertainty about the quantification and the monetary valuation are typically not correlated and hence, the overall level of uncertainty is the same as the most uncertain element[74]. In other words, the assessment of the uncertainty will depend on the least certain estimate being the quantification or the valuation. However, it is important to note that the assessment is of the change and it is this marginal change that is valued. The fact that it is a marginal change also provides the certainty of the result, as it is relative compared with the total.

The empirical evidence on valuation of ecosystem services points to the importance of these benefits, which is why it is important to take them into account. Whether it is done through monetised valuations or with qualitative/semi-quantitative assessments is less important as long as the results are included in the decisions about the measures to include in the PoMs.

6.2.2. Application of exemptions

In the first round of RBMPs, the application of exemptions has only to a limited extent been based on cost and benefit considerations under the disproportionate cost criteria.

An example from one Member State where a national framework was a set up illustrates the complexity of assessing disproportionate costs[75]. The framework was aimed at testing for disproportionate costs and subsequently for financing and affordability. As a first step, it included tests of whether costs exceeded benefits by a defined ratio. The results of testing the

[74] Assuming that the monetary valuation is of the form: *Value = physical unis * unit price* and the uncertainty is a factor 2 on both the elements , the total uncertainty on the value is also more or less in the order a factor 2 if the assessments of the physical units and the unit price are independent.
[75] Presentation as CIS Working Group Economics' meeting October 2013.

framework on a large number of water bodies suggested that, in many cases, the costs were disproportionate according the relatively simple test. The issues were among others:

- Benefits are very difficult to quantify and assess in monetary terms
- Costs often outweigh benefits, especially in low-density places
- Generally, local stakeholders did not engage in the CBA assessments
- Some local stakeholders required CBA as they hoped for disproportionate costs and hence arguments for not having to implement river restoration measures.

Including considerations of the ecosystem services will not rectify all these issues but it could facilitate an improved assessment process.

One of issues could be interpreted as being about the comprehensiveness of the coverage of ecosystem services in order to capture all important benefits. Including only a few or some services increases the risk that the benefit value will be low and therefore lead to the above conclusions. This stresses the importance of considering all existing and potential ecosystem services.

It should be noted that the more comprehensive benefit assessment, which the consideration of ecosystem services can facilitate, does not necessarily mean that no exemptions are allowed. Considering all relevant benefits would improve the justification of the proposed exemptions – exemptions can for example be justified in cases where there are trade-offs between sustainable ecosystem services.

The issue of doing comprehensive assessments of ecosystem services can be further illustrated by considering an example of valuations of wetlands. The example present a number of pilot evaluations of three wetlands in France based on an assessment of a comprehensive list of ecosystem services. Findings from this study include[76]:

- The higher the number of ecosystem services included, the higher the benefit value (the study finds higher values for recent assessments where several ecosystem services have been included compared to older studies including fewer ecosystems);
- There are large variations in provisions of the individual ecosystem services in each of the three wetland sites;
- Overall, the estimated values varies with a factor of 2 to 5.

[76] COMMISSARIAT GÉNÉRAL AU DÉVELOPPEMENT DURABLE (2013) Avancées et enseignements pour la valorisation des services rendus par les zones humides.

Text box 6-5 Example of valuation of ecosystem service benefits of wetland creation, Seine-Normandy basin, France

Valuation of ecosystem services for three wetland test sites in the Seine-Normandy basin (€/ha/yr)

Services provided by wetlands	Cotentin and Bessin		Bassée		Oise	
	Min.	Max.	Min.	Max.	Min.	Max.
Regulation Services						
Flood Control	Ø	Ø	210	3840	110	370
Recharge of Aquifers	190	370	35	70	35	35
Water Purification	830	890	475	1420	315	560
Climate Regulation	1800	1800	1800	1800	Ø	Ø
Production Services						
Agriculture	585	750	285	305	285	305
Shellfish	120	120	Ø	Ø	Ø	Ø
Forestry	Ø	Ø	75	270	75	270
Cultural Services						
Hunting	170	340	100	155	60	80
Amateur Fishing	165	230	130	160	80	90
Educative and Scientific Value	10	15	490	540	Ø	Ø
Aesthetic Value and Recreation	290	1170	Negligible	Negligible	Negligible	Negligible
Maintaining Biodiversity (non-usage)	225	870	470	2360	440	2230
Total Economic Value*	2400	4400	1300	6700	1200	3400

Source: CGDD

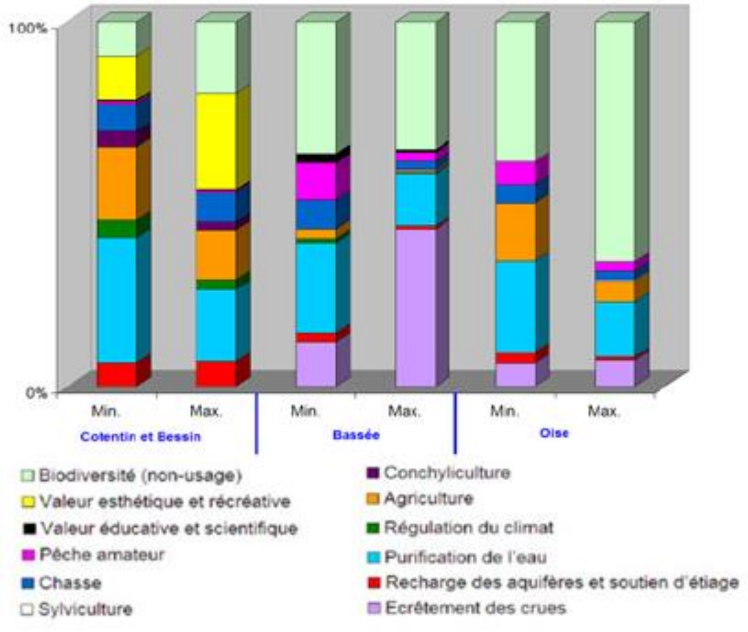
Ø: service not available at this site

(*) It should be noted that values for each ecosystem service in the table does not add to the total value. All values are in (€/ha/yr), but the areas related to each type of ecosystem are different.

Instead, the distribution can be seen in the following figure.

The figure illustrates how the total value is distributed by each ecosystem service category.

Distribution services provided by wetlands for each of the three test sites in the basin (in percentage).



Translations	
biodiversité	biodiversity
valeur esthétique et récréative	aesthetic and recreational value
valeur éducative et scientifique	educational and scientific value
pêche amateur	amateur fishing
chasse	hunting
sylviculture	forestry
conchyliculture	shellfish
agriculture	agriculture
régulation du climat	climate regulation
purification de l'eau	water purification
recharge des aquifères et soutien d'étiage	aquifer recharge and low water support
écrêtement des crues	flood risk reduction

Source: COMMISSARIAT GÉNÉRAL AU DÉVELOPPEMENT DURABLE (2013) Avancées et enseignements pour la valorisation des services rendus par les zones humides. URL: < http://www.developpement-durable.gouv.fr/Avancees-et-enseignements-pour-la.html>.

The example in Text box 6-5 illustrates both the importance of including all benefits (= all ecosystem services) provided by different types of wetlands and the variation in service provision across different locations.

It should be noted that while the three pilot valuations in the above example suggest that the provision of different types of ecosystems vary significantly, the values are in the same order of magnitude.

Text box 6-6 Example of cross-border administrative boundaries, Emilia-Romagna Region, Italy

The Emilia-Romagna case study reveals the limitations in planning and implementing intervention measures due to administrative boundaries. The use of administrative boundaries assumes that water courses do not pass through other regions before crossing Emilia-Romagna. This strict assumption must usually be relaxed, as rivers flow through numerous regions. In this study, the Po River was not included and the impact of low water ecological status on both tourism (bathing water) and the fishing industry (mollusc life) was therefore not considered.

Source: Galioto, F., Marconi, V., Raggi, M., Viaggi, D. (2013) An assessment of Disproportionate Costs in WFD: The Experience of Emilia-Romagna. Water. 1967-1995

The example in text box 6-4 from England presents an approach to the assessment of disproportionate costs, which is based on a comprehensive consideration of ecosystem services. It is also an approach that aims for monetary valuation, but some of elements presented in example can be used even for a more qualitative approach.

Using a table with a gross list of ecosystem services as a simple tool to review the benefits of each measure or package of measures could in most cases be a useful way forward.

6.3. Implementation process of the FD

The key areas where the ecosystem service considerations are relevant in relation to implementation of the FD include:

- Flood risk assessment (Art. 4)
- Developing the FRMPs (Art. 7 and Art. 9).

The use of ecosystem service considerations in these two planning steps are further elaborated on in the next subchapters.

6.3.1. Flood risk and hazard assessment

The possible impacts of future flood events have to be assessed as part of a flood risk assessment. For environmental impacts, the use of ecosystem services could help organise the assessment and ensure that all potential impacts are covered.

It should be noted that the Guidance on reporting under the Floods Directive contains a list of potential categories of consequences of flood events that includes most of the relevant ecosystems services, even though the term ecosystem services is not used. The key consequences include water supply under the heading human health, fisheries under economic effects while most other ecosystem services would fall under the environmental category.

It seems that in most Member States the consideration of the environmental impacts of flood events are less detailed and comprehensive compared with the economic and social impacts[77].

> *As revealed in the Ghent workshop, most MS consider risk of potential contaminated flood waters, potential pollutants and link to WFD objectives as being most important for environmental consequences. Ecological impacts of flooding are not yet taken into account by most MS, environmental impact is often seen in relation to contaminated water[78].*

The current version of the guidance document includes the elements listed in Table 6-2, which are of relevance to environmental effects, even though they do not specifically refer to ecosystem services. To make an assessment of the consequences of a specific flood event, the ecosystem service assessment approach (identification, quantification and valuation) could be used.

[77] See for example: CIS WG presentations at circabc.eu.
[78] Floods Working Group (CIS) Resource document 2012 *Flood Risk Management, Economics and Decision Making Support.*

Table 6-2 Types of consequences (Table 10.2-1 in the guidance document)

Type of Consequence	Sub-Type of Consequence / Description
Environment	*Water body Status:* Adverse permanent or long-term consequences ecological or chemical status of surface water bodies or chemical status of ground water bodies affected, as of concern under the WFD. Such consequences may arise from pollution from various sources (point and diffuse) or due to hydromorphological impacts of flooding.
	Protected Areas: Adverse permanent or long-term consequences to protected areas or water bodies such as those designated under the Birds and Habitats Directives, bathing waters or drinking water abstraction points.
	Pollution Sources: Sources of potential pollution in the event of a flood, such as IPPC and Seveso installations, or point or diffuse sources.
	Other: Other potential permanent or long-term adverse environmental impacts, such as those on soil, biodiversity, flora and fauna, etc.

Source: COM 2013 Guidance for Reporting under the Floods Directive - Guidance Document No. 29

A generic approach will comprise an assessment of the ecosystems and habitants that would be affected by a given flood event. The effects could be negative or positive and based on that an assessment of how the provision of ecosystems services could be made.

The following types of ecosystem services are most likely to be affected by a flood event:

- Fisheries (commercial and leisure)
- Biodiversity protection
- Erosion and Sediment control
- Recreation.

It most cases, an expert assessment is required to decide to which extent these effects are long-term or permanent, adverse effects. Biodiversity and erosion/sediment control are the services for which long-term impacts are most likely.

The impact on for example the provision of clean water for water supply services is more about short-term contamination of the supply rather than an impact on the ecosystem service of clean water as such.

6.3.2. Developing the FRMPs

Development of the FRMPs requires the Member State to consider costs and benefits of alternative flood risk mitigation measures (Art. 7), and many Member States apply cost-benefit analysis (CBA) even though they are only required to consider cost and benefits. As discussed above in the chapter on WFD implementation, this can be done by applying any approach from qualitative to quantitative and monetisation.

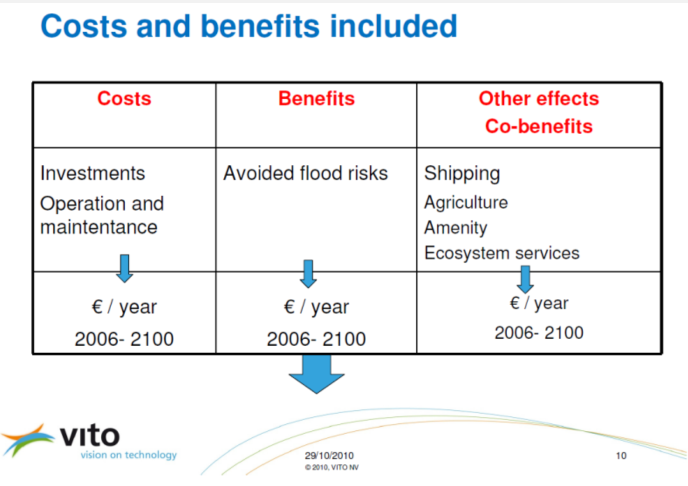
The inclusion of ecosystem service considerations in the selection of flood protection measures is about taking the co-benefits or costs of certain measures into account. Hard structure flood protection measures such as dikes could have negative hydromorphological impacts and hence make compliance with the WFD more difficult. On the other hand, natural flood protection measures might support both the achievement of the WFD objectives and offer other ecosystem service co-benefits.

Member States prone to flooding have typically developed guidance on how to assess alternative flood protection measures and procedures for where and when economic assessments are required. This means that the consideration of ecosystem services could be made by extending the lists of benefits included in the assessment. Instead of only considering the benefit of flood protection measures on potential direct economic assets, it should include changes (both positive and negative) on the full set of ecosystem services. The CIS WG Floods resource document[79] includes many relevant examples, links to Member State approaches and other relevant information. Here, we have chosen to include just one example in Text box 6-7 below, which illustrates how ecosystem service co-benefits can be included in a quantified cost-benefit analysis. Under the term ecosystem service, the Belgian example includes (recreation, regulation and non-use value) while impacts on navigation and agriculture are presented separately.

Text box 6-7 Example of costs-benefits assessment of flood protection measures, Belgium

An example of a cost-benefit assessment of alternative flood protection measures was presented at the WG-F Thematic workshop in October 2010 titled Floods and Economics: valuating, prioritising and financing flood risk management measures and instruments. The example CBA for flood protection in Flanders is included to illustrate how a CBA approach can be used to assess alternative measures where the impacts on ecosystem service provision are included in the assessment.

The findings of the assessment including considerations of ecosystem services were:



FCA means *Flood control area agriculture*

CRT means *Controlled Reduced Tide = floodplain + estuarine nature*

The main elements in the category 'Other effects' comprise several ecosystem services as illustrated below.

The regulating benefits comprise nutrients recycling, carbon fixation and effects on sedimentation. These benefits have been quantified through various ecological models and valued through avoided costs (avoided nutrients treatment at WWTPs, "carbon" shadow price and reduced dredging costs).

[79] Working Group Floods (CIS) resource document "Flood Risk Management, Economics and Decision Making Support" (2012). URL< http://ec.europa.eu/environment/water/flood_risk/pdf/WGF_Resource_doc.pdf>.

2. Results for risk based approach

	Costs	Benefits **	Other	Pay back
Higher Dykes	240	691	-	27
Floodpains (FCA) *	217	731	-23	24
Floodplains (CRT) *	233	733	+ 6	20
Risk based 'optimal' combination with CRT	139	730	+33	13

NPV in million euro, (2006-2100), 60 cmSea level rise, 1.8 % econ.growht, 4 % discounting.
* For fixed safety standard T4000
** Includes impacts in Flanders and Western Scheldt

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The recreation benefits were estimated using a survey addressing the population's willingness to pay for "changed landscape".

Other impacts : FCA and CRT

Impact category	Floodplain + agriculture FCA *	Floodplains + est. Nature CRT *
agriculture	-30	-58
Visual intrusion	-7	-7
Ecosystem benefits		
recreation	13	13
regulation benefits	-	57
non-use value	-	pm
Total	**-23**	**6**

NPV in million euro, (2006-2100), 1.8 % econ.growht, 4 % discounting.
* For fixed safety standard T4000

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Source: L. De Nocker 2010, *CBA for flood protection in Flanders* Workshop presentation, http://ec.europa.eu/environment/water/water-framework/economics/pdf/WGF11-3-BE-Floods_and_economics_workshop.pdf.

The Resource Document on Economics and Floods Directive includes links to more examples and to national guidance documents, etc.

6.4. How to improve the planning process?

The above examples illustrate the differences in specific decision-making framework and how ecosystem service considerations can be introduced in alternative ways.

The overall principle is simple:

1
- **Consider the existing analysis or analytical framework**
  - Assessment for exemptions
  - CEA assessement and development of PoM
  - CBA assessment for FRMPs
  - Multicriteria analysis
  - Apprasial

2
- **Have all potential ecosystem services been identified and assessed?**

3
- **If yes**
  - Assessment is complete
  - Framework is fit for purpose

4
- **If no**
  - Reconsider analytical framework
  - Apply an ecosystem service classification list
  - Review each ecosystem serviece
  - Assess potential impacts on ecosystem service provision and revise the initial assessment

Source: COWI.

The inclusion of ecosystem services in existing water planning practices should abandon existing practice, but rather serve as an extension, which can improve the ecosystem services provision in the river basin. The examples presented in this chapter illustrate how it can be done.

There are a number of general issues to take into consideration:

- Link to other legislation
- Stakeholder involvement
- Uncertainty assessments.

Link to other legislation

The ecosystem services identified might be related to achieving the objectives of other legislation, planning processes, projects or initiatives. One of the important examples is the flood protection service that some of the WFD measures can provide. One of the aims of the WFD (Art. 1- mitigates the impacts of floods and droughts). This means that such measures will contribute to achieving the objectives of both the WFD and the FD. Also, the carbon sequestration effects could be important in achieving the climate change mitigation objectives.

To support the integration and making sure that these links are properly accounted for, it could be relevant to list for each ecosystem service the legislation that it might support. This is illustrated in Table 6-3 below.

Table 6-3 Example: Linking ecosystem services to other policies and directives

Service category	Ecosystem service	Related policies and directives
Provisioning	Water supply	Drinking Water Directive
Regulation and Maintenance	Flood risk reduction	Floods Directive Climate Change policy (Adaptation)
	Carbon sequestration	Climate mitigation policies, EU Emissions Trading System (ETS), 2020 targets
	Filtration of pollutants	Marine Strategy Framework Directive
	Biodiversity protection	Birds and Habitats Directive Bio-diversity policy

Source: COWI.

In the assessment of measures to improve status, be it in the context of considering exemptions or in the process of developing the PoM, the links to other directives and policies are important to consider. It means that for ecosystem services of potential importance to the achievement of non-WFD or FD objectives, the assessment of the "value" should be directed towards assessing how much they contribute to these other objectives.

Stakeholder consultation

Stakeholder involvement is important to the implementation of the WFD and FD, and the introduction of ecosystem service considerations can support the various stakeholder processes.

Many benefits from improved water status can be described by specifying the increased provision of certain ecosystem services. In this way, the ecosystem service considerations can act as a communication tool in the stakeholder process and this is one of the key advantages of introducing ecosystem service considerations into the implementation of the directives.

It is also important to stress that the assessment of ecosystem services will in most cases require involvement of or consultation with stakeholders.

The ESAWADI project has specifically looked into the use of ecosystem service considerations in relation to stakeholder involvement. The experience from their cases examples suggests that ecosystem services considerations and assessments are very useful in communication about water management issues, but also that the concept of ecosystem services is new and therefore some effort is required to introduce the concept[80].

[80] ESAWADI 2013 Utilizing the Ecosystem Services Approach for Water Framework Directive Implementation Policy Report

Stakeholder participation is being successfully used to inform water management in a number of countries. In England, the Government has introduced a policy to allow stakeholder groups to take a leading role in catchment water management planning[81]. Nearly every catchment in England has now been adopted by a stakeholder led group.

Sensitivity analysis

It might be one of the major flaws of the CBA, and a lot of other economic tools, that they give the illusion of certainty, because in the end it will present the planner or analyst with a single number that tells him whether or not to implement a measure. It is important to stress, however, that there is no tool out there that will provide full certainty in decision-making particularly where we take account of social choice. In the end, what we are trying to accomplish is to make a decision that is in the interest of a large group of people that all have different preferences. So the question has to be if the CBA is more or less uncertain than other tools used to inform decision-making. Here there is no clear answer.

This uncertainty should be kept in mind. It is necessary to perform a sensitivity analysis to investigate the robustness of the result. In a sensitivity analysis, the planner or analyst adjusts the different variables (e.g. benefit estimates or timing), and by this the implicit assumptions, and investigates how this changes the result and policy implications obtained. This is done separately for each variable, while keeping all others fixed. This allows the identification of critical variables and gives an idea of how certain results are.

Sensitivity assessments can be done in various ways. The following "test" will in most cases be useful:

- Test whether the conclusions are sensitive to certain values. How much should each value change before the conclusion is changed? E.g. if a benefit estimate increases by 25%, will it cause the conclusion or CBA ratio to tip so that the benefits exceed the costs or is the balance the same?

If for example monetary valuations have provided a range, the sensitivity assessment can be done using the high-low values. In cases where there is no range or limited confidence in the range, the above test can help to identify the importance of each value.

The above approach could also be used when there is no monetary value available. By a "backward" calculation, one can estimate what the value should be of a certain ecosystem service or services in order to the conclusion to change. For example what should the value be for a given measure be become the preferred measure. Then it can be assessed whether this is likely, possible or realistic value and thereby support the decision process.

[81] https://www.gov.uk/government/publications/catchment-based-approach-improving-the-quality-of-our-water-environment.

6.5. Planning tools, literature and links

The general tools that typically are proposed to give structure to decision-making and ensuring transparency includes:

1. Cost-effective analysis (CEA)
2. Cost-benefit analysis (CBA)
3. Multi-criteria analysis (MCA)
4. Extended cost-benefit analysis (combining CBA and MCA).

The last tool which combines CBA or CEA with qualitative and semi quantitative assessments is likely to be the most practical tool by combining aspects of two or all three tools, depending on the available information and preferences of the planning entity[82].

The discussions in the previous chapters have made reference to these tools and the examples includes cover the actual applications of the tools. The Annex Report includes more details on each of the economic assessments tools.

There is already much guidance material available regarding the specific planning tools. Some key documents can be mentioned:

- WATECO guidance
- EU Guidelines for Impact assessments
- Cost-benefit guidance by DG REGIO (for investment projects)
- Flood resource document on economics.

Links the documents and other relevant literature is included in Text box 6-8.

Text box 6-8 Suggestions for literature recommendations

WATECO guidance (https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp).

EU Guidelines for Impact assessments (http://ec.europa.eu/smart-regulation/impact/commission_guidelines/commission_guidelines_en.htm).

Cost-benefit guidance by DG REGIO (for investment projects) (http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf).

Flood resource document on economics. (http://ec.europa.eu/environment/water/flood_risk/pdf/WGF_Resource_doc.pdf).

Aquamoney studies (valuation of WFD benefits) http://www.ivm.vu.nl/en/projects/Projects/economics/aquamoney/project-deliverables/index.asp.

[82] See in particular the A Working Group Floods (CIS) resource document "Flood Risk Management, Economics and Decision Making Support" 2012 for good description of these tools and assessment of their advantages and disadvantages.

Goerlach and Pielen (2007), Disproportionate Costs in the EC Water Framework Directive - The Concept and its Practical Implementation. http://www.ecologic.eu/download/vortrag/2007/goerlach-pielen-envecon-paper.pdf>.

Martin-Ortega (2012), Cost-effectiveness Analysis in the Implementation of the Water Framework Directive: A Comparative Analysis of the United Kingdom and Spain.

In pursuit of optimal measure packages: http://publicaties.minienm.nl/documenten/op-zoek-naar-optimale-maatregelenpakketten-handboek-kosteneffect.

Different cost-benefit analyses in The Netherlands for the European Water Framework Directive http://www.iwaponline.com/wp/01205/wp012050746.htm.

Department for Communities and Local Government: London (2009), Multi-criteria Analysis: a Manual. http://eprints.lse.ac.uk/12761/1/Multi-criteria_Analysis.pdf.

Pearce et al. (2006), OECD, Cost-Benefit Analysis and the Environment –recent developments.

7. LINK TO FINANCING

Financing of measures is one of the constraints on implementation of the WFD and the FD. This chapter provides some links financing: presentation of EU funds and how they can contribute as well as how ecosystem service assessments can support the financing aspect of the directive implementation.

The key question to be addressed in this chapter is:

- In what way can the assessments of ecosystem services support financing of measures to improve WFD and FD compliance?

Payments for Ecosystem Services (PES) schemes have received increased attention in recent years. In order for PES to work, a buyer needs to be identified, which is usually the user of an ecosystem service. The considerations and assessments of ecosystem services can identify potential buyers and sellers and provide the basis for a PES scheme. The EU provides a wide number of funding mechanisms and programmes that can be used to support certain ecosystem services and therefore the assessments of ecosystem services can support funding applications.

Key challenges	Assessment of ecosystem services could support funding applications by providing a detailed account of the benefits generated by investing in WFD and FD measures. Additional funding could be achieved by setting up payment schemes for users of ecosystem services (PES).
Chapter outcome	Presentation of funding sources and examples of the use of payment for ecosystem service schemes.
Approach according to the level of ambition	High: Contact an expert that can help set up a PES or contact authorities in charge of fund allocation and approval. Medium: Get inspiration to explore the possibilities that PES offer and investigate whether these could be applied in the specific case. Low: Learn about Payments for Ecosystem Services (PES) and some of the funding programmes in the EU.

7.1. Financing of measures

Currently, financing of WFD and FD measures originate from different sources:

- Public budgets (general funds):
    - EU funds
    - National funds
- Taxes and user charges (includes PES schemes)
- Operators' and companies' own funds.

This chapter discusses how ecosystem services could improve the provision of funds for financing of measures.

The most direct way is through payment for ecosystem services (PES), which is a way of connecting the provision of an ecosystem service with payment for the service received. Payment for ecosystem service schemes are described in Chapter 7.3.

Article 9 of the WFD specifies requirements for cost recovery and the polluter pays principle. Through the notion of resource and environmental costs there are links to the ecosystem service considerations. These links are discussed below in Chapter 7.2.

Indirectly, ecosystems service considerations can substantiate arguments for allocation of public funds for WFD and FD implementation by making it easier to describe and communicate the benefits of the WFD and FD objectives.

The main EU funding options are briefly described in Chapter 7.4.

7.2. Economic requirements from the WFD

"The use of economic instruments by Member States may be appropriate as part of a programme of measures. The principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter pays principle. An economic analysis based on long-term forecasts of supply and demand for water in the RBD will be necessary for this purpose."[83]

Article 9 of the WFD requires Member States to take account of the cost recovery principle. This means that water services should be chargeable, including environmental and resource costs. This is done with two objectives in mind:

- Water pricing incentives should be used to encourage effective use of water thereby reducing over-exploitation of water resources and contributing to achieving other environmental objectives;
- Water users should pay for the services they receive to make an adequate contribution to the financing of the water services taking the polluter pays principle into consideration.

[83] WFD preamble no 38, http://ec.europa.eu/environment/water/water-framework/index_en.html.

Water pricing requirements include three elements: cost recovery (which is about the amount of costs that should recovered), the polluter pays principle (which is about who should contribute the payment) and incentive pricing (which is about how the payment is designed).

The polluter pays principle means that polluters have to pay for the damage caused by their activities. In WATECO, this is formulated as follows: *"The polluter pays principle (PPP) requires that users pay according to the costs they generate."*[84] This is further discussed in ECO2 (working group to support the implementation in the first cycle) *"Is the principle which states that those who cause industrial pollution should offset its effects by compensating for the damage incurred, or by taking precautionary measures to avoid creating pollution*."[85]

The specific requirements of Article 9 of the WFD have been and are being discussed in CIS, in particular in WG Economics. In the present document, the focus is on the whether the consideration of ecosystem services provides input to the implementation of Article 9.

One link to ecosystem services is in relation to the notion of resource and environmental costs that should be included in the cost-recovery schemes. The environmental costs of a water use could to a large extent be defined as the loss in ecosystem service benefits caused by this water use. It means that the consideration of ecosystem services could support the assessment of the environmental costs through the comprehensive consideration of the loss in ecosystem services from the each water use. Issues in estimation of the environmental costs are therefore similar to the issues discussed in this document on the valuation of ecosystem services. The discussion on valuation has suggested that monetary valuation is generally challenging, but it might be feasible to estimate environmental costs by order of magnitude estimates. Then it will be a political decision how to translate such estimates into a specific cost recovery pricing scheme.

In relation to resource costs, the key issue is to estimate the necessary environmental flow and then determining the opportunity costs of alternative uses of the remaining – sustainable - water resource. This is the same as estimating the value of the ecosystem services of alternative uses of the water. The price would then be determined by the highest value of using the water resource for irrigation, industrial production, drinking water or hydropower. In practice, such assessments are very complex as the natural water flow changes over the seasons as does the irrigation demand. Hence, the "optimal" price should also vary accordingly.

The ecosystem service assessment opens up the scope of charging for water services, as new users that were previously not considered as such are identified. An example could be fishing licenses to charge fishermen for the improvement in fish populations through implementation of a measure. It could also be justified to provide partial funding from taxes, as some benefits are public goods - and it is sometimes difficult to charge users for the service provided (e.g. biodiversity).

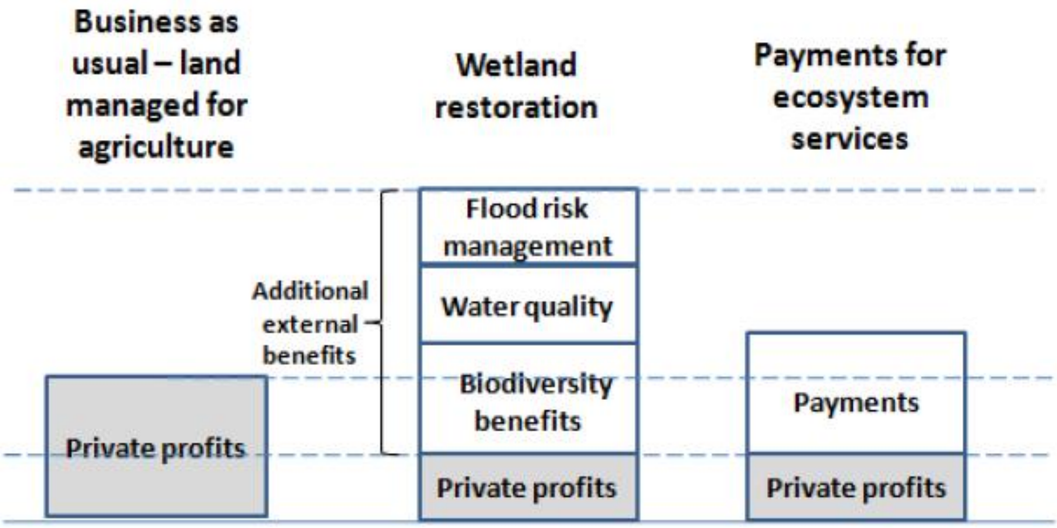
The aspect of incentive pricing is not specifically linked to the ecosystem service considerations. It is about the design of the payment scheme. It should link to the use so that changes in use are reflected in the level of the payment.

[84] WATECO: http://ec.europa.eu/environment/water/water-framework/economics/pdf/Guidance%201%20-%20Economics%20-%20WATECO.pdf, p. 139.
[85] http://www.waterframeworkdirective.wdd.moa.gov.cy/docs/OtherCISDocuments/Economics/ECOResouceCosts.pdf, p. 27.

7.3. Payment for Ecosystem Services (PES)

Payment for Ecosystem Services is a voluntary scheme that aims at securing a certain ecosystem service by paying the provider of the service. The basic idea is to create a win-win situation in which both the buyer and seller of the given ecosystem services are better off with the PES scheme. The idea is illustrated in Figure 7-1. In the figure, the left part exemplifies land managed for agriculture, where all revenues accrue to the farmers in the area in the form of private profits. In the middle part, wetland restoration is introduced. While this reduces farmers' profits, societal benefits are provided by the wetlands in the form of flood risk management, improved water quality and higher biodiversity. As can be seen, the total benefits, which are the sum of private profits accruing to farmers plus benefits to society, are higher if the wetland is restored. In this case, the PES scheme in the right part of the figure offers an acceptable solution to all stakeholders. The farmer receives compensatory payment, which is more than just income lost. It secures a higher income than without the restoration project. Therefore, he has an incentive to accept the offer. The state has an incentive to offer the scheme, because payments to farmers are lower than the sum of the additional benefits provided by the wetland restoration. This will, however, be in conflict with the rules for state aid so the payment should come from another source in society.

Figure 7-1 Incentive structure of PES



Source: Defra 2011, p. 23 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69329/ecosystem-payment-services-pb13658a.pdf).

Often, there is only an indirect link between the demand for ecosystem services and the suppliers of ecosystem services, for example, wildlife-interested people who are members of a nature organisation, which buys ecosystem services from farmers. PES schemes can also be applied to pay farmers to set aside productive acreage for certain WFD measures (e.g. wet buffer strips), because the particular measure not only contributes to meeting WFD objectives, but also provides services to various (other) ecosystem services; e.g. natural river banks providing better water quality (WFD), but also retention (anti-dehydration), flood protection (FD), ecological corridors (N2000), etc.

As can be seen from the example in Text box 7-1 below, in the Netherlands the use of PES dates back to the 12th century. Regional water boards have their own financing structure (earmarked water system levy), which allows them to charge the regional inhabitants and industries (including agriculture) according to the value protected, based on the principle 'interest-payment-say'. In fact, in a democratic process regional inhabitants (industry and agriculture) decide on regional water management measures for which they pay collectively. This is how the PES schemes are financed.

Text box 7-1 Example of PES, Netherlands

A study in the Netherlands was carried out to explore the possibility of implementing a system to pay for water-related ecosystems in the agricultural sector. The ecosystem services included in this context can influence the water quantity, the water quality and the value of the landscape.

The study reviewed 120 initiatives in which different kinds of instruments, mostly subsidy schemes, that had been implemented to improve the management of river basins. Most of the initiatives aimed at disseminating information, carrying out pilots or investigating and implementing specific regulation in a certain area. No cases were identified where the price of an ecosystem service was created in a market involving a transaction between the users of the ecosystem services.

The initiatives were mostly financed by regional water boards, which are in turn financed by regional, earmarked levies, municipalities, regions or specific national funds to support improvement of the water environment. A few initiatives were funded by other parties, such as an initiative funded by Rabobank, an initiative in part funded by a business association and an initiative financed by a fund for cultural history.

An example of a project is the "Actief randenbeheer Brabant" which sought to implement wet buffer zones. The project was financed by various national and European funds. In compensation, farmers were paid a compensation of 0.7 EUR/m of cultivated land and 0.35 EUR/m of grassland for the buffer zones, which are to be 4 m wide. The EUR 10 million project managed to establish 1200 km of buffer zones in the area. The project involved extensive interaction between landowners and authorities to support the optimisation of the process. The landowners joined the project motivated by the wish to have clean water for farming and to promote the image of farmers. The compensation was fair, and participation was voluntary. As a result of the project, many farmers experience additional pressures in their fields in the form of increasing weed growth. Even though extra work is required to maintain the buffer zones to avoid weeds, the farmers chose to stay in the project.

Source: Rijkswaterstaat Waterdienst (2010) Verkenning innovatieve economische instrumenten voor agrarische watermaatregelen overzicht van praktijkstudies. Arcadis. C03031.000231.

The scheme is voluntary to ensure that both sides gain from the arrangement, otherwise they would drop out of it. In this case, the buyer of the ecosystem service provided by wetland restoration was the state and the sellers were farmers in the same region.

There are **two types of PES schemes** – public and private:

Public PES schemes are government-funded and work well when a broad range of services is provided by a measure; especially when a lot of the services provided have public goods characteristics. Public goods are goods to which everybody has access. Furthermore, the use of the goods by one person does not affect the benefits reaped by other persons. One example is clean water, which benefits every water user in the same way. If one person benefits from clean water, it does not prevent another person from benefitting from the same. When the state pays for an ecosystem service, it does so using tax income. In fact, society as a whole pays for the provision of such a service. However, the Dutch example shows that regional funds from regional water boards can also be used to pay for regional ecosystem services which can be considered public goods.

Privately funded PES schemes should usually be preferred to government-funded programmes, but they are not always feasible. The main requirement for a privately funded scheme is that a given ecosystem service benefit can be clearly assigned to a specific user-group since it will be motivated to pay for the provision of the ecosystem service. This view might be controversial in some Member States where it is expected that such services are provided by the state, i.e. certain environmental services. The advantage of making private initiatives/interest groups pay for the ecosystem service provision is that users can check that the service is delivered. If the state paid, it would have to set up a monitoring system. An example is the landscape fund in the Netherlands, where home owners pay to a fund for improved nature views and sceneries in a rural area (see chapter 6.3 in Annex report I).

Text box 7-2 Example of PES, Sweden

Blue mussel farming to improve water quality in Lysekil, Sweden

The small Swedish town of Lysekil on the county's western coast, one of the first examples of trade in nutrient discharge was initiated in 2003.[86] In a trial period from 2005-2011, the local sewage treatment plant was allowed to continue emitting nitrogen, as long as the same amount of nitrogen was "harvested" in the form of blue mussels. The municipality (which owns the sewage treatment plant) bought this ecosystem service from a mussel farming enterprise, which was responsible for the full removal of the 39 tons of nitrogen emitted by the plant. By farming 3,500 tons of blue mussels 100% of the nitrogen would be removed, and as an added bonus 3 tons of phosphorus would also be recycled back to land. [87]

The requirement for a sewage plant the size of the one in Lysekil is to remove 70% of the nitrogen, the scheme thus performs in excess of the minimum requirement. The waste associated with the mussel farming (small and crushed mussels not suitable for human consumption) can be used for animal feed, fertilizer or for liming.[88]

The scheme cost the municipality approximately EUR 150 000[89] a year, which is much lower than the cost of traditional nitrogen removal. [90] It has been estimated that the savings amount to EUR 100,000 a year. [91]

Sources:

Lindahl, Odd, and Sven Kollberg. "How mussels can improve coastal water quality." Bioscience Explained 5.1 (2008): 1-14. http://www.bioscience-explained.org/ENvol5_1/pdf/musseleng.pdf

Zandersen, Marianne, Kirsten Grønvik Bråten, and Henrik Lindhjem. Payment for and Management of Ecosystem Services. Nordic Council of Ministers, 2009

Miljömusslor.se: Blåmusslor som miljöförbättrare, retrieved November 2013 from:

http://www.miljomusslor.loven.gu.se/index3.html

[86] Miljömusslor.se.
[87] Lindahl and Lovén 2008, p. 5.
[88] Lindahl and Lovén 2008, p. 8.
[89] 200,000 USD.
[90] Lindahl and Lovén 2008, p. 5.
[91] Zandersen et al 2009, p. 65.

Text box 7-3 Example of PES, UK

Wessex in South England had trouble preserving the quality of their surface water, as groundwater extracted by farmers was showing increasing pollution levels from pesticides. In 2008, they started an active catchment management approach, which was initiated by the water services company Wessex Water. The aim of the programme was to invest in catchment management to improve raw water quality. In the case Wessex Water represented both the buyer and intermediary of this PES-like approach. While there was a fund available to invest in better management practice, which would represent the payment part of PES, this was not the only mechanism at work. Equally important was the Wessex Water's role as knowledge provider sharing information about best practice and providing external advice.

The programme was effective in reducing the frequency of events where pollution thresholds were exceeded and therefore managed to secure a wide range of ecosystem services. Additional funding was also achieved were appropriate, effectively increasing the funds available for protecting the natural environment in the area.

Source: Defra, 2013, Payments for Ecosystem Services: A Best Practice Guide – Annex Case Studies

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/200920/pb13932-pes-bestpractice-20130522.pdf

The fact that PES schemes try to achieve win-win situations makes it necessary to ensure that some sort of valuation has been made. This can however also be largely intuitive; regional water managers responsible for both water quality and water quality management will always look for cost-effective win-win options, where they can improve the water quality and e.g. increase water retention at the same time. For this, they do not always need quantitative/monetary valuation. Additionally, identifying the winners and losers of a specific measure requires knowledge of how **benefits and costs** are distributed. With this knowledge, it is possible to explore the possibilities of a government-funded PES scheme or to facilitate a privately funded PES scheme. For privately funded schemes, the planner should facilitate communication between the buyer and the seller to start a bargaining process. The planner does not necessarily have to know the exact benefits and costs of the potential parties to the scheme as only agreements that can be accepted by both parties will be made.

Two important requirements of any PES scheme are additionality and conditionality.

Additionality means that the ecosystem service provision is higher than it would have been in the absence of the scheme. This also means that PES schemes always operate in excess of legal requirements, because these will have to be fulfilled either way. In other words, PES schemes are a way to ensure environmental protection beyond regulatory requirements, where this is beneficial to the parties involved.

Conditionality means that a payment is conditional on the delivery of the contracted ecosystem service. This means that it is also necessary to have a clear definition of the ecosystem services under consideration and the means to monitor them.

Text box 7-4 Stakeholder consultation

Stakeholder involvement is a very important part of setting up a PES as stakeholders can be the buyers and sellers of environmental services, possibly both. Possible third parties should also be considered. It should be noted that stakeholder consultation has to be more comprehensive in the case of a privately funded PES scheme as full clarity is required of the parties to a potential deal. A government-funded PES scheme mainly needs to involve the seller of the environmental services, as long as it is certain that the project provides enough benefits to justify the transaction.

Source: COWI.

7.4. EU funding instruments

There are a number of EU funding possibilities to support projects aimed at improving the provision of ecosystem services. Within this document, it is not possible to give a comprehensive list of funding opportunities, but the ones described here are among the most relevant and can serve as inspiration for further investigation into the topic. For EU funding instruments the access to the specific funding go through Member State managing authorities which define the specific national application procedure and hence, no specific guidance on funding can be provided. However, we will outline different funding mechanisms that aim at supporting the provision of ecosystem services, and which may be used as funding sources.

There are ongoing reforms within the EU where PES can play an important role, in particular, agri-environmental schemes in the Common Agricultural Policy (CAP)[92] reform and similar support payments in the proposed European Maritime and Fisheries Fund. The establishment of Green Infrastructure is another area where PES could potentially play a role.[93]

The following four funding sources are the most relevant to approach:

- European Structural and Investment Funds (ESIF; note that it comprises CAP Pillar II);
- CAP Pillar I;
- LIFE;
- Horizon 2020.

Below, these funding sources are briefly presented. Links are provided to useful websites for further reading.

Text Box 7-5 Example of financing of a PoM, Norway

Management of the water areas is divided into 11 water regions, yet the financing of measures in these regions comes from the sectoral public budgets (e.g. sectors for transport, energy, agriculture, infrastructure etc.)

The judicial system establishes that the polluter pays, yet political implementation of the most expensive projects is sometimes difficult, as they imply a trade-off between environmental goals and other important objectives, such as renewable energy.

The PoM for the most prioritized areas (hydropower especially) has been approved by the government on the basis of a cost estimate, i.e. without knowing the true price of the measures.

The polluter pays principle has been used in relation to the building of dams and power stations, where the operating company must pay environmental fees to the government, as well as to a specific fund intended to improve the environment in the area.

In many ways, the implementation of the WFD in Norway is about coordinating its goals with existing environmental policies, rather than introducing something completely new. However, the implementation of the WFD has contributed to a change of focus in some parts of the established policies (e.g. within agriculture and infrastructure) towards water quality.

Source: COWI, Interviews

[92] http://ec.europa.eu/agriculture/cap-funding/funding-opportunities/index_en.htm
[93] http://ec.europa.eu/environment/integration/research/newsalert/pdf/30si.pdf

7.4.1. European Structural and Investment Funds (ESIF)

The **European Structural and Investment Funds (ESIF)** comprise the following funds:

- The Cohesion Fund;
- The European Regional Development Fund (ERDF);
- The European Agricultural Fund for Rural Development (EAFRD; this is, in fact, CAP Pillar II);
- The European Maritime and Fisheries Fund (EMFF);
- The European Social Fund (ESF).

The overall objective of the ESIF for the current funding period 2014-2020 is to support the Europe 2020 strategy which is about delivering growth that is:

- smart, through more effective investments in education, research and innovation;
- sustainable, thanks to a decisive move towards a low-carbon economy;
- and inclusive, with a strong emphasis on job creation and poverty reduction.

The funding is focused through 11 thematic objectives. Of those, two are very relevant in the context of possible funding for measures that increase the provision of ecosystem services.

- Promoting climate change adaptation, risk prevention and management (Thematic objective 5)
- Protecting the environmental and promoting resource efficiency (Thematic objective 6).

The funding is organised through a national Partnership Agreement that defined the overall national priorities for each fund and then there are operational programmes for each fund. The operational programmes can be thematic and/or regional. The operational programmes define mores specifically the type of actions that can be supported the selection criteria for getting a project funded.

The objective of the **Cohesion Fund**[94] is to strengthen economic and social cohesion in the EU. Supporting sustainable development, it has two focus areas: trans-European transport networks and the environment. Given its objective, the Cohesion Fund only addresses MS with a Gross National Income (GNI) of less than 90% of the Community average.

However, projects in other Member States may be eligible for co-financing through the **European Regional Development Fund (ERDF)**[95], which aims at promoting public and private investments that help reduce regional disparities in the EU.

The **European Agricultural Fund for Rural Development (EAFRD)**[96] provides funding for the CAP Pillar II. It targets rural development. One of the main differences compared with the Pillar 1 is the absence of a direct payment mechanism. Instead, Pillar 2 aims to encourage Member States to draw up multi-year programmes to address six priorities, of which one is the

[94] http://ec.europa.eu/regional_policy/thefunds/cohesion/index_en.cfm.
[95] http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm.
[96]http://www.rural-energy.eu/funding/8/367/EUROPEAN-AGRICULTURAL-FUND-FOR-RURAL-DEVELOPMENT-EAFRD/#.U_Md7fl_t1Y.

restoration, preservation and enhancement of ecosystems that depend on agriculture and forestry. Member States are required to co-finance these projects. Since the Pillar 2 is more flexible concerning the distribution of budgets, it could be used to seek co-financing of measures that support the provision ecosystem services or to set up PES schemes by conducting research for privately funded schemes or by entering into government-funded schemes.

These three funds are the most relevant for funding measures that can improve ecosystems and thereby increase the provision of ecosystem services. The significant amounts that are available make these funds very interesting for financing measures such as NWRMs and other examples of green infrastructure. These measures provide multiple benefits for example on water quality and flood risk protection and therefore fits very well the Europe 2020 strategy and hence they should be relevant for co-financing through the ESIFs.

Applicants should address the relevant national managing authority to investigate the specific national application procedure. The DG REGIO website includes instructions, links to national Member State managing authorities and other relevant information for potential applicants[97].

A specific guidance "*The Guide to Multi-Benefit Cohesion Policy Investments in Nature and Green Infrastructure"* has been prepared by DG REGIO[98]. It includes three main chapters which are useful in relation to financing of measures that provide multiple ecosystem service benefits. Part 1 of the guidance discusses the rationale for investing in green infrastructure and it outlines the importance of multiple benefits, synergies and coordination across different legislation and polity objectives. Part 2 is more aimed at describing the specific benefits of green infrastructure investments. Finally, part 3 includes guidance on how to plan and implement nature projects and achieve synergy with Cohesion Policy. Part 3 also presents the details of the different Cohesion Policy tools and instruments and explains how they can be used to finance investments in nature. The guidance also includes an Annex with examples of nature and green infrastructure projects that have been co-financed by the European funds.

7.4.2. CAP Pillar I

Overall, the Rural Development Priorities of the Common Agricultural Policy in the context of ecosystem services are to "restore, preserve and enhance ecosystems related to agriculture and forestry"[99]

The CAP of the EU is responsible for a significant part of the direct payments to farmers through, among others, the CAP Pillar I (see also above regarding the CAP Pillar II). Making a part of these direct payments conditional on certain environmental-friendly agricultural practices is referred to as the greening of the CAP. The basic idea is that farmers have to adhere to certain standards to receive payments. Part of the greening of the CAP has characteristics similar to a PES scheme, as it is a voluntary arrangement with a well-defined land use to ensure that environmental services, which are bought by the EU from EU farmers conditional on the employment of certain practices. Land-use practices eligible for conditional direct payment are ecological focus areas, crop diversification and permanent grassland.

[97] http://ec.europa.eu/regional_policy/thefunds/access/index_en.cfm.
[98] IEEP and Milieu (2013) http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/guide_multi_benefit_nature.pdf.
[99] http://ec.europa.eu/agriculture/policy-perspectives/policy-briefs/05_en.pdf

Text box 7-6 Examples of PES in UK

In the UK, there are a number of examples of PES. **SCaMP** (Sustainable Catchment Management Programme) aims to develop an integrated approach to catchment management in the North West, England. The SCaMP project is being undertaken by United Utilities in partnership with the RSPB and is a good example of a partnership approach with private, public and non-governmental organisations managing the land for a wider range of ecosystem services and benefits. Among other things, the scheme helps "ensure a sustainable future for the company's agricultural tenants".

Examples of government financed-PES include **Environmental Stewardship**, a key mechanism for rewarding those who deliver a wide range of environmental outcomes from the farmed environment in England. As part of their agreements, many farmers have put in place measures that will benefit bees, including planting pollen and nectar rich flower margins and carrying out rotational grazing on their land. Of examples can be mentioned that Over 85% of all sugar beet in the UK are grown with the support of the scheme.

Upstream thinking is co-developed between South West Water and a broker (the Westcountry Rivers Trust) to encourage and/or incentivise farmers to implement land management actions to improve raw water quality, with many management measures locked into 10 or 25 year covenants.

Yet another example the **English Woodland Grant Scheme - EWGS** which ais to sustain and increase public benefits through maintaining existing woodlands and investing in woodland creation. Six distinct grants are available to woodland owners.

And finally the **Pumlumon Project** which is a scheme taking an economic-based approach to ecosystem management with landowners in the Cambrian Mountain range and addressing multiple ecosystem services. Scientifically validated monitoring ensures improvements to ecosystem service delivery are demonstrated to funders. Beneficiaries include residents downstream (water quality and supply), tourists and visitors, and the general public (carbon storage and sequestration).

Source:http://archive.defra.gov.uk/environment/policy/natural-environ/documents/payments-ecosystem.pdf and DEFRA (May 2013) Payments for Ecosystem Services: A Best Practice Guide.

7.4.3. LIFE

Yet another co-financing mechanism offered by the EU is the **LIFE Programme**[100]. The purpose of the programme is to fund projects that take a new approach to environmental issues which can serve as an example of implementation elsewhere. The scope of the programme is quite wide, but a large fraction of the projects includes water issues, making the programme potentially relevant to WFD/FD implementation. One of the priority areas in the call for project proposals is integrated river basin management, which makes it an ideal way of securing additional funding for a specific ecosystem service project. Furthermore, the LIFE programme contains practical elements that require stakeholder involvement. As the programme is also aiming at cross-compliance, it has good potential in connection with WFD and other directive implementation efforts. It makes sense to look into other projects that have been co-financed in the past to identify potential projects in a river basin. It should be noted, however, that approval of a project and project implementation under the LIFE programme may take some time, which can make it unsuitable for immediate issues.

7.4.4. Horizon 2020

Horizon 2020 is a financial instrument aimed at supporting research and innovation in the European Union, thereby promoting economic growth and job creation. It may support research and innovation projects a aimed at improving the provision of ecosystem services.

[100] http://ec.europa.eu/environment/life/.

Text Box 7-7 Recommended literature

Defra (2013), Payments for Ecosystem Services: A Best Practice Guide

Engel et al. (2008), Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues

IEEP and Milieu (2013) The Guide to Multi-Benefit Cohesion Policy Investments in Nature and Green Infrastructure

8. CONCLUDING REMARKS

This study consists of three parts: the present resource document, a literature review and a number of consultations, including interviews and an expert workshop. The literature review and consultations are reported in a separate Annex Report.

This resource document informs the discussion on why and how the assessment of ecosystem services can support the implementation of the WFD and the FD.

Several ongoing EU initiatives produce relevant material in relation to ecosystem service assessments. The EU initiative "Mapping and Assessment of Ecosystems and their Services" (MAES)[101], which supports the Member States in their ecosystem service assessments as part of the EU Strategy on Biodiversity, is one example of review of relevant data and tools. Also the initiatives on Green Infrastructure and Natural Water Retention Measures (NWRM) are closely linked to ecosystem service assessments. It is recommended to consult the output from this initiatives as they are likely to publish new and relevant material for ecosystem service assessments.

The study has found that knowledge of ecosystem services facilitates an improved understanding of the benefits generated when implementing the WFD and the FD. The understanding of the benefits obtained will allow for a more informed decision-making process in the Member States, where all benefits will be taken into account.

There are a number of articles in the WFD and FD where a systematic assessment of the benefits will improve the decision-making process. When choosing between measures, knowledge can indicate that the cheapest measures may have limited positive influence on the ecosystem services, whereas other services may have considerably more positive impacts on the ecosystem services. This knowledge will inform the decision-making process and allow for smarter decision-making.

It will be possible to apply a more strategic approach to establish the coordination between the different directives and to ensure optimization of the results.

The approach to ecosystem service assessments will depend on the specific case. Ecosystem service assessments do not have to be very quantitative and include monetary valuations in order to produce useful knowledge. Also qualitative assessments can provide valuable support to the implementation. More quantitative assessments are only relevant when they match the appraisal approach and when data are available. In some cases quantitative assessments may be required.

The approach to ecosystem service assessments should be tailored to the national context in relation to institutional set-up and the appraisal procedures. If there is a need to develop operational guidance, this is to be done at the national level, possibly based on EU level recommendations. While it may be relevant for the Member States to consider their appraisal processes in order to improve the implementation of the directives, such changes to the appraisal processes would probably need to be integrated in the EU requirements for reporting.

[101] European Commission, 2013; European Commission, 2014.

The major part of the information and data necessary will already be gathered and analysed during the first stages of the implementation of the WFD and FD. When assessing ecosystem services such existing information, approaches and methodologies should be used, to the extent possible. Many data have been collected and are being collected also as part of implementing other policies; for example, in relation to the biodiversity strategy where mapping and assessment of ecosystem services are ongoing.

As the concept of ecosystem services is relatively new, much research and development is ongoing, which will very likely result in better data and improved approaches. This calls for an exchange of lessons learnt with regard to ecosystem service assessments throughout the EU.

9. LITERATURE LIST

ACTeon 2011 Research project on the use of the Cost Effectiveness Analysis in regard to the European Water Framework Directive.

Burkhard B., Kroll F., Nedkov S. & Müller F. (2012). Mapping ecosystem services supply, demand and budgets. Ecological Indicators 21(2012) 17-29.

CIS-SPI (2011), Implementation of the Water Framework Directive: When ecosystem services come into play.

COM 2013 Guidance for Reporting under the Floods Directive - Guidance Document No. 29.

Cost-benefit guidance by DG REGIO.

Crossman, N.D. et al (2013). A blueprint for mapping and modelling ecosystem services. Ecosystem Services. http.//dx.doi.org/10.1016/j.ecoser.2013.02.001.

De Groot et al. (2006), Valuing Wetlands: Guidance for valuing the benefits derived from wetland ecosystem services.

Defra (2013), Payments for Ecosystem Services: A Best Practice Guide.

Department for Communities and Local Government: London (2009), Multi-criteria Analysis: a Manual.

EFTEC (2010), Scoping Study on the Economic (or Non-Market) Valuation Issues and the Implementation of the Water Framework Directive.

Egoh, B et al (2012). Indicators for mapping ecosystem services; a review. JRC scientific and policy reports. European Commission.

Engel et al. (2008), Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues.

European Commission (2013), Mapping and Assessment of Ecosystems and their Services – An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Brussels, 2013: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.

European Commission (2014), Mapping and Assessment of Ecosystems and their Services: Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Technical Report. Brussels, 2014: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf.

ESAWADI 2013 Utilizing the Ecosystem Services Approach for Water Framework Directive Implementation Synthesis report.

EU Guidelines for Impact assessments.

Goerlach and Pielen (2007), Disproportionate Costs in the EC Water Framework Directive - The Concept and its Practical Implementation.

Haines-Young and Potschin (2013). Common International Classification of Ecosystem Services (CICES) Consultation version 4.

IEEP and Milieu (2013). The Guide to Multi-Benefit Cohesion Policy Investments in Nature and Green Infrastructure. By Peter Hjerp, Patrick ten Brink, Keti Medarova-Bergstrom, Leonardo Mazza, and Marianne Kettunen of IEEP, together with Jennifer McGuinn, Paola Banfi and Guillermo Hernández of Milieu. A Report for the European Commission. Brussels.

Lindahl, Odd, and Sven Kollberg. "How mussels can improve coastal water quality." Bioscience Explained 5.1 (2008): 1-14.

Maes et al. (2013). Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union, Luxembourg.

Maes, J Paracchini M.L. & Zulian G. (2011) A European assessment of the provision of ecosystem services. Towards an atlas of ecosystem services. JRC Scientific and technical Reports. Eur 24750 En – 2011.

Martin-Ortega (2012), Cost-effectiveness Analysis in the Implementation of the Water Framework Directive: A Comparative Analysis of the United Kingdom and Spain.

Millenium Ecosystem Assessment (2005). Ecosystems and human well-being: Synthesis. Island Press, Washington DC.

NAVRUD, S (2009), Value Transfer Techniques and Expected Uncertainties; Part of the NEEDS project (New Energy Externalities Developments for Sustainability).

ONEMA (2011). Amigues J.P. and Chevassus-au-Louis B.: Assessing the ecological services of aquatic environments. Scientific, political and operational issues. The French National Agency for water and aquatic environments (ONEMA).

Pearce et al. (2006), Cost-Benefit Analysis and the Environment.

R.S. de Groot et al. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7 (2010) 260–272.

TEEB (2010). The Economics of Ecosystems and Biodiversity – Ecological and Economic Foundations.

TEEB (2013) The Economics of Ecosystems and Biodiversity for Water and Wetlands. IEEP, London and Brussels; Ramsar Secretariat.

UK National Ecosystem Assessment (2011), Ch. 22.

WATECO guidance.

Weber J-L. (2011): An experimental framework for ecosystem capital accounting in Europe. European Environmental Agency. EEA Technical Report No 13/2011.

Working Group Floods (CIS) resource document “Flood Risk Management, Economics and Decision Making Support”, 2012.

Zandersen, Marianne, Kirsten Grønvik Bråten, and Henrik Lindhjem. Payment for and Management of Ecosystem Services. Nordic Council of Ministers, 2009.