

# ESManage Project: Freshwater Ecosystem Services - An Introduction for Stakeholders

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## ENVIRONMENTAL PROTECTION AGENCY

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**Regulation:** *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

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We regulate the following activities so that they do not endanger human health or harm the environment:

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- large scale industrial activities (e.g. pharmaceutical, cement manufacturing, power plants);
- intensive agriculture (e.g. pigs, poultry);
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- sources of ionising radiation (e.g. x-ray and radiotherapy equipment, industrial sources);
- large petrol storage facilities;
- waste water discharges;
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- Supervising the supply of drinking water by public water suppliers.
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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

**EPA RESEARCH PROGRAMME 2014–2020**

# **ESManage Project: Freshwater Ecosystem Services**

## **An Introduction for Stakeholders**

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Prepared for the Environmental Protection Agency

by

University College Dublin

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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# Contents

<b>Acknowledgements</b>	<b>ii</b>
<b>Disclaimer</b>	<b>ii</b>
<b>Project Partners</b>	<b>iii</b>
<b>List of Figures</b>	<b>vi</b>
<b>List of Tables</b>	<b>vii</b>
<b>List of Boxes</b>	<b>viii</b>
<b>Executive Summary</b>	<b>ix</b>
<b>1 What Are Ecosystems, Ecosystem Services and the Ecosystem Services Framework?</b>	<b>1</b>
<b>2 Understanding Ecosystem Services</b>	<b>3</b>
<b>3 Freshwater Ecosystems and Ecosystem Services</b>	<b>5</b>
<b>4 Role of Biodiversity in Ecosystem Service Delivery</b>	<b>7</b>
<b>5 Valuation of Freshwater Ecosystem Services and Benefits</b>	<b>8</b>
<b>6 Stakeholder Importance, Involvement and Perceptions</b>	<b>10</b>
<b>7 How Can Ecosystem Services Be Used in Management and Policy?</b>	<b>11</b>
<b>8 Conclusion and Further Reading</b>	<b>12</b>
<b>References</b>	<b>13</b>
<b>Abbreviations</b>	<b>14</b>
<b>Glossary of Ecosystem Services Terminology</b>	<b>15</b>
<b>Appendix 1</b>	<b>17</b>

## List of Figures

Figure 1.1.	Schematic diagram of the different types of services provided to humans within catchments, as proposed by Donal Daly (EPA), which encompasses services from the living, non-living and human/social elements and shows how natural capital, consisting of ecosystem and geosystem services, links with human/social system services to give holistic catchment services	2
Figure 2.1.	Conceptual relationship between supporting processes and intermediate and final services for fresh water in providing human goods and benefits. Also showing how joint goods and benefits can stem from individual final services	3
Figure 2.2.	The chain of knowledge required to get from basic science to policy application in the ecosystem services framework	4
Figure 3.1.	A selection of freshwater ecosystems found in Ireland: top left, canalised section of River Barrow; top middle, pool in a mountain blanket bog, Co. Wicklow; top right, a drying turlough, Lough Gowra, Co. Sligo; bottom left, Bullala River (foreground) and Gartan Lough (background), Co. Donegal; bottom middle, upper River Liffey, Co. Wicklow; bottom right, a heavily vegetated constructed wetland, Co. Waterford	6
Figure 4.1.	Examples of biota found in Irish freshwaters: top left, a mayfly nymph <i>Ecdyonurus venosus</i> Fabricius; top middle, a white-clawed crayfish, <i>Austropotamobius pallipes</i> (Lereboullet); bottom left, an adult male damselfly, the beautiful demoiselle, <i>Calopteryx virgo</i> (Linnaeus); bottom middle, freshwater pearl mussel, <i>Margaritifera margaritifera</i> (Linnaeus); right, leaping Atlantic salmon, <i>Salmo salar</i> Linnaeus	7



## List of Tables

Table 2.1.	Names and description of three main final ecosystem services categories, with examples focused on freshwater ecosystems	4
Table 3.1.	Definition of ecosystem service trade-offs and synergies, with examples from freshwater ecosystems	6
Table 5.1.	Applicability of valuation methods to value freshwater ecosystem services	9

## **List of Boxes**

Box 2.1.	Ecosystem service classification	4
Box 5.1.	The ESManage project approach	9

# Executive Summary

In the simplest of terms, ecosystem services are defined as “the contributions that ecosystems make to human well-being”. Ecosystem services and the ecosystem services framework are considered a means of embedding biological and ecological thinking into policy and practice. The framework is seen as an effective means of communicating to all stakeholders, including the general public, the value of protecting our environment and its ecosystems, in order to maintain the flow of benefits (i.e. goods and services) that they provide to human societies. In fact, stakeholder engagement is an essential component of the ecosystem services framework, ensuring that a wide range of views are considered when planning future options for the sustainable management of our ecosystems.

The adoption of ecosystem services in the management and protection of our freshwater ecosystems allows the quantitative valuation (both monetary and non-monetary) of changes in specific ecosystem services and their flows, the protection of their biodiversity and the integration of the formerly separate disciplines

of economics and ecology, in order to better represent and investigate the relationships between human economies and natural environments. Therefore, there are many benefits of incorporating the ecosystem services framework into the implementation of both the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC), in addition to providing a unifying basis for various other policy strategies, e.g. the EU Biodiversity Strategy.

Ultimately the ecosystem services framework can be used as a means to better communicate and take account of nature's importance in policymaking and decision making, with particular emphasis on human well-being and the conservation of the natural environment for reasons of inter- and intra-generational equity and legacy. A more detailed and comprehensive review of ecosystem services in freshwaters can be found online at: [http://www.epa.ie/pubs/reports/research/water/EPA\\_187\\_wrapped.pdf](http://www.epa.ie/pubs/reports/research/water/EPA_187_wrapped.pdf) (accessed 22 September 2016).



# 1 What Are Ecosystems, Ecosystem Services and the Ecosystem Services Framework?

Ecosystems are defined as “a dynamic complex of plant, animal and microorganism communities, and the non-living environment interacting as a functional unit” in the Millennium Ecosystem Assessment (MEA, 2005). In contrast, a plethora of terminology relating to ecosystem services has evolved in recent years and has complicated efforts to communicate both the concept and its benefits to a wide and varied range of stakeholders. Ecosystem services are most commonly defined as “the benefits people obtain from ecosystems” or “the contributions that ecosystems make to human well-being” in the MEA and the Common International Classification of Ecosystem Services<sup>1</sup> (CICES), respectively. They include the components and products of ecosystems that are consumed, used or enjoyed by society.

Ecosystem services are “the contributions that ecosystems make to human well-being”.

The “ecosystem services framework” (also referred to as the “ecosystem services approach”<sup>2</sup>) focuses on understanding how biodiversity, natural systems and the linkages between ecosystem components and processes lead directly or indirectly to human welfare benefits. It is different from the more “traditional” way of describing natural systems in terms of biodiversity and ecological functions. The MEA popularised the ecosystem services framework and the way society understands the connections between natural systems and human well-being.

## 1.1 Similarities with Other Concepts and Approaches

The “ecosystem services framework” is very similar to the “ecosystem approach”, with both attempting to highlight the “ecosystem” as the basis for conservation, decision making and policy; interestingly, both terms have often been used interchangeably. Nevertheless, it is important that the two concepts are not confused, as, although they can be mutually supportive, they differ in their outlook. For example, the ecosystem approach focuses only on natural processes and is the basis for modern nature conservation in many parts of the world, whereas, in its simplest terms, the ecosystem services framework is a way of understanding and illustrating how nature delivers benefits and services for human well-being. Similarly, the ecosystem services framework has much in common with both integrated water resource management<sup>3</sup> and the water–energy–food nexus<sup>4</sup> in relation to their genesis, underpinning assumptions, objectives and approaches, especially with respect to the sustainable use of natural capital and ecosystems.

In Ireland, the Environmental Protection Agency (EPA) recently proposed an overarching “catchment services” approach (Daly, 2015a,b). Catchment services underlie the benefits that the people living in and/or using the catchment derive from the components of natural capital (ecosystems, geosystems and human/social capital) present in the catchment (Figure 1.1). In this approach, ecosystem services, which are derived from biological components and processes, are one of the three service pillars, along with geosystem services (from the physical component) and social system services (from the human component).

1 See <http://cices.eu/> for details (accessed 1 July 2016).

2 Not to be confused with the “Ecosystem Approach” as endorsed by the Convention on Biological Diversity (<https://www.cbd.int/>). For a comprehensive explanation of the differences between the “ecosystem service framework” and “ecosystem approach”, see <http://escom.scot/sites/default/files/resources/eco-communication2pager1.pdf> (accessed 1 July 2016).

3 See <http://www.un.org/waterforlifedecade/iwrm.shtml> for details (accessed 1 July 2016).

4 See <http://www.unwater.org/topics/water-food-and-energy-nexus/en/> for details (accessed 1 July 2016).

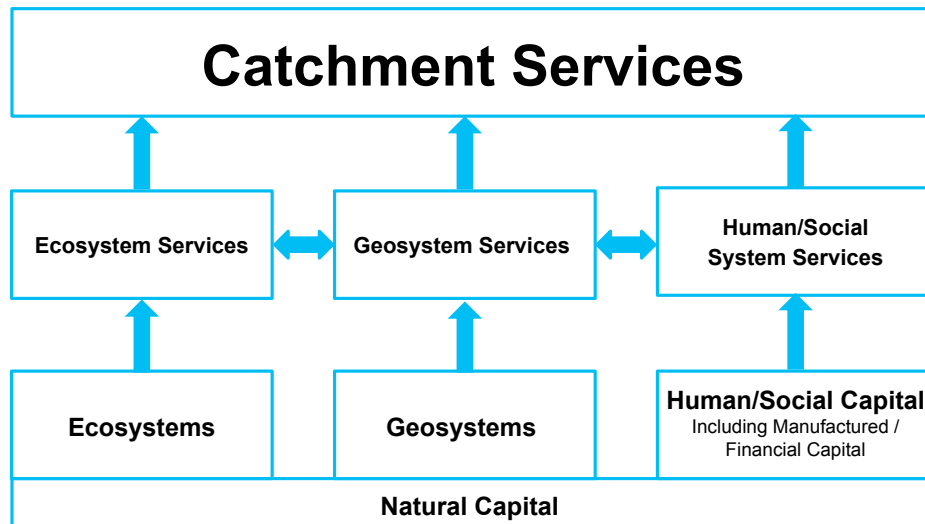


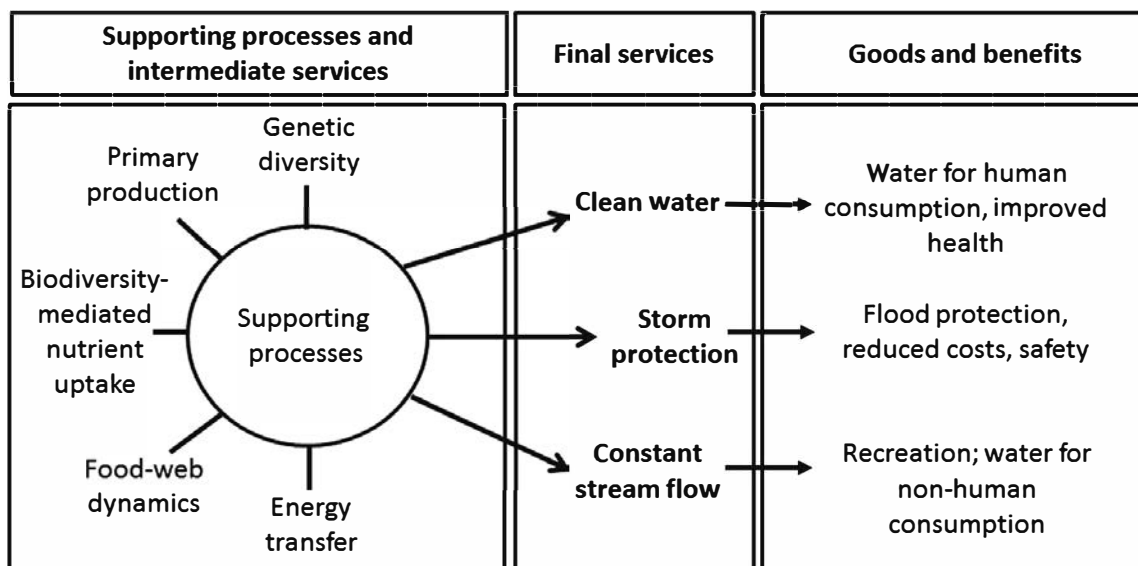
Figure 1.1. Schematic diagram of the different types of services provided to humans within catchments, as proposed by Donal Daly (EPA), which encompasses services from the living, non-living and human/social elements and shows how natural capital, consisting of ecosystem and geosystem services, links with human/social system services to give holistic catchment services (Daly 2015a). Note: Human/social system services are typically derived from combinations of natural, financial, manufactured, intellectual, human and social capital. Furthermore, financial, manufactured, human and social capital may be derived from outside the catchment boundaries and therefore this exact relationship may not hold true at catchment scale.

## 2 Understanding Ecosystem Services

There are two types of ecosystem services: “final” and “intermediate” services. The separation is required to avoid double counting in valuation exercises (see Chapter 5). Final ecosystem services (whether natural, semi-natural or highly modified) either directly underpin or deliver a benefit or good to humanity and improve well-being. A fundamental characteristic of ecosystem services is that they retain a connection to the underlying biological and ecological functions, processes and structures of the ecosystem that generated them. Intermediate services are not directly consumed by people but support the production of the final ecosystem services (Figure 2.1). However, it is important to note that the distinction between intermediate services and final services is not strict and depends on the beneficiary (i.e. the interests of individuals and organisations). It is also important to realise that a single ecosystem service (e.g. clean water) can be the product of two or

more ecosystem functions and processes (i.e. intermediate services), while a single ecosystem function or process may contribute to two or more ecosystem services. Final ecosystem services can be further subdivided into three main categories: these are provisioning services, regulating and maintenance services, and cultural services (after the MEA; Table 2.1). Box 2.1 also outlines the application of CICES for individual ecosystems services.

A long chain of activities is involved in incorporating ecosystem services into policy and management strategies. The chain begins with the nature of diversity and identifies the steps, needed to achieve the delivery of policy options for optimising ecosystem service delivery (Figure 2.2), including identification, mapping, assessment and valuation. Many of the steps require information and co-operation from the environmental and socio-economic sciences.



**Figure 2.1. Conceptual relationship between supporting processes and intermediate and final services for fresh water in providing human goods and benefits. Also showing how joint goods and benefits can stem from individual final services.**

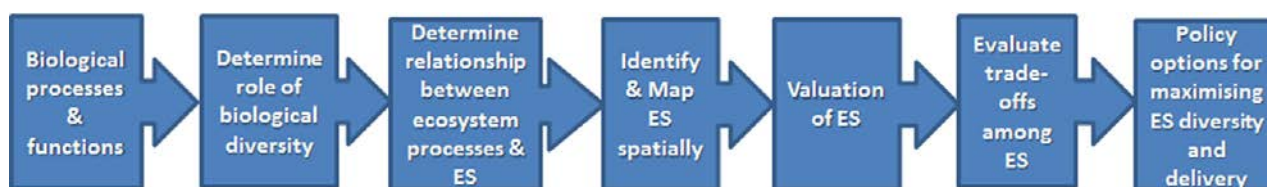
**Table 2.1. Names and description of three main final ecosystem services categories, with examples focused on freshwater ecosystems**

Types of service	
<i>Final services</i>	
Provisioning services	Readily understandable as the material or energy outputs from ecosystems, including the supply of fish, food, fibre or other renewable materials. For example, the supply of water for consumption, agriculture and industry
Regulating and maintenance services	Incorporating the various ways in which living organisms can mediate or moderate the ambient environment that affects humankind. For example, they improve water quality by removing excess nutrients and degrading waste and toxic substances through living processes
Cultural services	Proposed to include the non-material benefits people obtain from contact with ecosystems, such as direct or indirect benefits in the form of amenity and recreation and also certain non-use goods that are valued for their existence or are perceived to contribute to quality of life
<i>Intermediate services</i>	
Supporting processes <sup>a</sup>	Underpinning almost all other services. In fresh waters they relate to all levels of aquatic biodiversity from genetic make-up to community diversity, primary production and other ecosystem processes and functions that occur in well-functioning ecosystems and support their resilience to internal and external pressures

<sup>a</sup>Also known as supporting services and habitat services.

### Box 2.1. Ecosystem service classification

CICES is a widely adopted hierarchical classification system that organises ecosystem services in a way that is non-overlapping and without redundancy. CICES used the typology of ecosystem services (provisioning, regulating and maintenance, and cultural) suggested in the MEA (2005) as its starting point and refined it to incorporate many of the key criticisms discussed in the literature. At the highest level are the three familiar categories used in the MEA: provisioning, regulating and maintenance, and cultural ecosystem services. Below these major “Sections” are nested a series of “Divisions”, “Groups” and “Classes”. The Divisions give the main types of outputs or processes, which are then subdivided into biological, physical or cultural types or processes within the Group division. At Class level, further divisions identify the specific outputs or processes. This classification methodology reduces the potential for double counting in valuation exercises and clearly distinguishes the multiple benefits to human well-being. More information can be found at <http://cices.eu/> and see Appendix 1 for an expanded table on freshwater ecosystem services and their classification.



**Figure 2.2. The chain of knowledge required to get from basic science to policy application in the ecosystem services framework.<sup>1</sup>**

<sup>1</sup> Mapping of ecosystem services in Ireland is being led by the National Parks and Wildlife Service; see <http://www.npws.ie/research-projects/ecosystems-services-mapping-and-assessment> for more details (accessed 1 July 2016).



### 3 Freshwater Ecosystems and Ecosystem Services

In Ireland, freshwater ecosystems comprise a combination of rivers, lakes, wetlands and other freshwater habitats (e.g. canals and reservoirs) (Figure 3.1) that constitute a large part of the natural infrastructure or “natural capital” that underpins human well-being and economic growth. Fresh waters deliver an extensive range of ecosystem services. The provisioning services delivered include water for drinking and non-drinking purposes (e.g. irrigation, cleaning, industrial use) and provision of food (e.g. fish). Regulating and maintenance services incorporate those that both directly (e.g. waste assimilation, pathogen control) and indirectly (e.g. regulation of decomposition, climate and flows) sustain environmental quality. Regulating and maintenance services provide for water quality and quantity by removing excess nutrients or moderating water flow. Climate regulation, through carbon-cycling processes, maintains air quality, which influences the greenhouse effect and thereby climate regulation at both local and global scales. Cultural services include tangible recreational uses (e.g. kayaking, fishing and riverside walks) and contribute to less tangible benefits, such as aesthetic or spiritual benefits, as well as educational value. Tangible freshwater cultural services in Ireland, for example recreational freshwater fisheries (game, pike and coarse angling), depend on less obvious aspects, such as suitable habitat and visual appearance (Tourism Development International, 2013). However, not all freshwater habitats have the ability to support all processes and functions, and, therefore, they cannot deliver all ecosystem services and goods equally. The delivery of freshwater ecosystem services and related goods and benefits is highly dependent on the location of the service within the catchment and the service in question. For example, the supply of water in Ireland at present is principally associated with rivers

and lakes (71%), and to a lesser extent groundwater (29%). In contrast, wetlands play little or no role in the direct supply of water for consumption in Ireland, but do offer a wide range of services, such as flood protection.

#### 3.1 Ecosystem Service Trade-offs, Synergies and Disservices

The multiple services provided by ecosystems will have varying relationships with each other, some linear, some non-linear, and will interact on various levels. These relationships, however, are not well understood to date, including where ecosystem service trade-offs and synergies may arise (see Table 3.1). The management of ecosystem services and associated trade-offs (and synergies) can change the type, magnitude and relative mix of services provided by ecosystems, and in some instances a trade-off may be an explicit choice in the management of an ecosystem. However, in other instances, trade-offs may arise as unintended consequences of management decisions and possibly even without an awareness that they are occurring. Regardless, identification and analysis of trade-offs are among the key steps required to incorporate basic ecosystem services science into policy and management decision making.

The concept of trade-offs leads to the notion of ecosystem disservices. Ecosystem disservices are described as “functions of ecosystems that are perceived as negative for human well-being” (Lyytimäki and Sipilä, 2009). In the case of water, disservices can result from natural phenomena (e.g. damage caused by flooding) and consequences of anthropogenic activities (e.g. side-effects of deliberate manipulation of a freshwater ecosystem).



**Figure 3.1. A selection of freshwater ecosystems found in Ireland: top left, canalised section of River Barrow [photograph: Fiona Kelly, Inland Fisheries Ireland (IFI)]; top middle, pool in a mountain blanket bog, Co. Wicklow [photograph: Edel Hannigan, University College Dublin (UCD)]; top right, a drying turlough, Lough Gowra, Co. Sligo [photograph: Áine O'Connor, National Parks and Wildlife Service (NPWS) Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (DAHRRGA)]; bottom left, Bullala River (foreground) and Gartan Lough (background), Co. Donegal (photograph: Martin O'Grady, IFI); bottom middle, upper River Liffey, Co. Wicklow (Hugh Feeley, UCD); bottom right, a heavily vegetated constructed wetland, Co. Waterford (photograph: Gustavo Becerra Jurado, UCD).**

**Table 3.1. Definition of ecosystem service trade-offs and synergies, with examples from freshwater ecosystems**

Interaction	Definition	Example(s)
Trade-off	Situation in which one service increases and another one decreases. This may be due to simultaneous response to the same driver or due to true interactions between services	<p>A trade-off occurs between water quality and agricultural intensification due to differing responses to the addition of nutrients to the agricultural landscape</p> <p>Water abstraction for drinking water will affect water level and thus the water body's fish-holding capacity, which may be used as a food source or for angling</p> <p>Sediment and nutrients from the surrounding landscape provide essential in-stream habitats for some invertebrate and vertebrate species, but can also increase toxicity and physical stress on other biota</p>
Synergy	Situation in which both services either increase or decrease. This may be due to simultaneous response to the same driver or due to true interactions between services	<p>A synergistic relationship exists between catchment sedimentation and recreation opportunities in lakes and rivers. A reduction in sediment entering water bodies reduces stress on many aquatic biota and also increase the aesthetics and quality of the water body, thereby enhancing the opportunities for recreation</p>

Source: adapted from Bennett *et al.* (2009).

## 4 Role of Biodiversity in Ecosystem Service Delivery

Biodiversity is a term that incorporates the vast array of species, their diversity (Figure 4.1) and also their genetic variability within an ecosystem. Biodiversity can be considered the natural building blocks that provide renewable services, goods and benefits through various ecosystem processes. The role of biodiversity ranges from supporting ecosystem processes (e.g. primary productivity), through regulating services (e.g. water purification and disease regulation), to cultural services (e.g. education and a sense of place). However, the specific details of the link between biodiversity and ecosystem services are largely unknown. Much of the evidence has come from both empirical and theoretical studies investigating the relationship between biodiversity and ecosystem functioning

or processes. These studies have established that decreasing biodiversity (and its attributes) is, by extension, also likely to affect ecosystem services and vice versa. These processes, along with the physical and chemical characteristics of ecosystems, and the complex and diverse species interactions that occur within them, are the basis of ecosystem services, and the goods and benefits that society derives from ecosystems. Similarly, the consensus in the literature is that loss of biodiversity compromises ecosystem resilience (i.e. capacity of an ecosystem to recover from and to tolerate a disturbance to its structure and function without collapsing or changing status) and, therefore, the capacity to sustainably deliver ecosystem services.



Figure 4.1. Examples of biota found in Irish freshwaters: top left, a mayfly nymph *Ecdyonurus venosus* Fabricius (photograph: Siobhan Atkinson, UCD); top middle, a white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet) (photograph: Jan-Robert Baars, UCD); bottom left, an adult male damselfly, the beautiful demoiselle, *Calopteryx virgo* (Linnaeus) (photograph: Jan-Robert Baars, UCD); bottom middle, freshwater pearl mussel, *Margaritifera margaritifera* (Linnaeus) (photograph: Áine O'Connor, NPWS, DAHRRGA); right, leaping Atlantic salmon, *Salmo salar* Linnaeus (photograph: Fiona Kelly, IFI).

## 5 Valuation of Freshwater Ecosystem Services and Benefits

There are significant challenges to undertaking valuation of ecosystem services. Specifically, the researcher will need (1) to understand the complex ecological linkages between biodiversity and ecosystem processes (the ecosystem) and ecosystem service provision, (2) to convert this understanding into projections of changes in ecosystem services provision that can be understood by the wider public and (3) to identify the means by which this public can value the changes to ecosystem service provision. Key to this framework is the need to present ecosystem services in terms of “final products” that can be consumed/valued by people.

Economic markets often fail to emerge for many ecosystem services, and alternative valuation methods are usually required to capture these values (see Table 5.1). The various valuation approaches have different merits and are applicable to different services, with no approach being universally suited to valuing the full range of ecosystem services. *Production function methods* can be used to indirectly link ecosystem service values to a market value where the environment forms an input into some final good. *Cost-based methods* are useful where damage is averted or where an artificial input is used to replace the ecosystem service. These methods do not require steps (2) and (3) above, but will not be applicable in many circumstances and may not accurately represent the true value of the environmental input. *Revealed preference* (e.g. hedonic pricing or travel cost) is an alternative valuation method that examines human behaviour in a related market; for example, travel costs to a site can be used to value recreational benefits. *Survey-based stated preference methods* (e.g. contingent valuation and choice experiments) are

among the most versatile valuation methods, as they are capable of capturing a range of values (including non-use values), as well as providing the flexibility to assess the benefits of future scenarios, which may be beyond current levels of service provision. Although empirical valuation is preferred, it may also be possible to undertake “value transfer”, in which existing value data are used to infer values in the new policy context. Value transfer tends to save time and costs, but should be undertaken with caution given the innate differences and objectives between different studies .

There are a number of issues that need to be considered when undertaking valuation of ecosystem services.

- To be transparent and comprehensive, an ecosystem assessment needs to start from a position where the full range of services is considered. The CICES classification provides a useful starting point to identify the possible range of services.
- The assessment of ecosystem services may be new and complex to many people and therefore it may be necessary to implement valuation studies in a format (such as a workshop) that provides respondents with the information and the time to understand the concepts.
- Values may vary both spatially and temporally. For example, different ecosystem services will have different spatial impacts; the recreational benefits from fishing may be limited to a particular stretch of river, while carbon sequestration may have global benefits. It will therefore be important to account for the spatial variation in the impact of the values of ecosystem services when assessing the aggregate benefits.

**Table 5.1. Applicability of valuation methods to value freshwater ecosystem services**

Water use being valued	Valuation methods						
	Market analysis	Production function	Replacement cost/cost saving	Avoidance cost/averting behaviour	Travel cost method	Hedonic pricing	Contingent valuation/choice experiments
Potable water for residential use	●	●	●	●		○	●
Water for irrigation	○	●	●				○
Water for livestock watering	○	●	●	○			
Water for food products and other manufacturing	●	●	●	○			
Cooling water for power plants	○	●	●	○			○
Commercial fishing	●	●	●	●			
Transport, treatment and medium for waste	○	●	●	○			
Natural erosion, flood and storm protection		○	●	●		○	○
Sediment removal	○	●	●	●			
Biological diversity provision			●	○	●	○	●
Climate regulation (micro and macro)			●	●		●	●
Recreation (bathing, fishing, etc.)	●	●	●	●	●	●	●
Cultural, historical and aesthetic values					●	●	●

● **Methods that are very suited to valuing the water services.**

○ **Methods that may be used to value the service.**

Source: adapted from Brouwer and Balabanis (2007).

### Box 5.1. The ESManage project approach

Based on the factors discussed in the current section, the EPA-funded ESManage (Incorporation of **E**cosystem **S**ervices Values in the Integrated **M**anagement of Irish Freshwater Resources<sup>1</sup>) project has explored the ecosystem services provided by Irish freshwaters using the CICES classification (see Feeley *et al.* (2017) for more details). This list of ecosystem services was assessed to identify which services could be impacted by future catchment management scenarios and which services could impact on people. This exercise, in combination with stakeholder workshops, will identify key services to be valued. A range of valuation methods will then be considered for implementation, where values will be considered in the context of changes in space and time. Cost-based methods will be applied to the water and wastewater treatment costs given the need to preserve water quality and the capacity of aquatic ecosystems to contribute to this water quality. Survey-based valuation exercises will also be applied and will need to ensure that the public has sufficient knowledge of the ecosystem services to ensure robust valuation.

<sup>1</sup> See [www.ucd.ie/esmanage](http://www.ucd.ie/esmanage) for more details (accessed 1 July 2016).

## 6 Stakeholder Importance, Involvement and Perceptions

Stakeholder engagement is an essential component of the ecosystem services framework, as it helps to ensure that a wide range of views are considered when planning future options for the sustainable management of ecosystems. Similarly, embedding participatory and deliberative approaches into the valuation framework may be a useful way to enhance respondent engagement with the valuation process. The scale at which humans as organisms perceive landscapes, what we

term the perceptible realm, is particularly important in the ecosystem services framework; this is the scale at which humans intentionally change landscapes and these changes affect environmental processes. However, people have a preference for what appears natural to them, which might not always be in accordance with expert opinions on what provides ecological quality.

## 7 How Can Ecosystem Services Be Used in Management and Policy?

The European Commission's Communication on Green Infrastructure<sup>5</sup> emphasises the important role of natural capital and the value of the ecosystems services concept as providing an integrating and balanced perspective in policy making, planning and management of our landscapes and ecosystems. Some of the challenges identified are (1) scale issues and (2) the need for consistent and reliable data on which to base valuations. The specific benefits of incorporating the ecosystem services framework into the implementation of both the Water Framework Directive (WFD, 2000/60/EC) and the Floods Directive (FD, 2007/60/EC) were identified (COWI A/S, 2014; Blackrock *et al.*, 2015) and developed further as:

- Helping the WFD deliver its objectives with wider policy imperatives of sustainability, integration and subsidiarity, and to live up to its original ambition.
- Helping illustrate how human well-being is dependent on ecological health; widening the focus from

good ecological status as an end in itself to showing how it supports societal goals.

- Enabling proper assessment and communication of the benefits and co-benefits of implementing the WFD and FD, and explaining the trade-offs involved in selecting cost-effective measures.
- Enabling a more comprehensive evaluation of the benefits and costs of measures to improve water quality.
- Avoiding unintended impacts of measures on other benefits (not directly associated with the measure); this is facilitated by the broad overview provided by the ecosystem services framework.
- Providing better understanding of who gains and loses from specific measures, as the ecosystem services framework requires the identification of stakeholders, in addition to widening and deepening the engagement of stakeholders.
- Assisting in planning the integrated implementation of multiple directives, as it can describe the impact of each in terms of a single set of descriptors (the ecosystems services). Similarly these descriptors can provide a unifying basis for various strategies, e.g. the EU Biodiversity strategy.

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5 See [http://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817-4c73e6f1b2df.0014.03/DOC\\_1&format=PDF](http://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817-4c73e6f1b2df.0014.03/DOC_1&format=PDF) for more details (accessed 1 July 2016).

## 8 Conclusion and Further Reading

There are still many unknowns within the field of ecosystem service research, and many aspects contain “jargon”, which can be off-putting to stakeholders. Regardless of the terminology and approach used, “the process of identifying nature’s value to humans is not to be taken as an end in itself. It should be treated as a means to better communicate and take account of

nature’s importance in policy- and decision-making, with particular respect to human well-being and to the conservation of natural commons for reasons of inter- and intra-generational equity” (Sukhdev *et al.*, 2014).

For a more comprehensive review of ecosystem services and freshwaters see Feeley *et al.* (2016).



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# Abbreviations

<b>CICES</b>	Common International Classification of Ecosystem Services
<b>DAHRRGA</b>	Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs
<b>EPA</b>	Environmental Protection Agency
<b>ESManage</b>	Incorporation of Ecosystem Services Values in the Integrated Management of Irish Freshwater Resources
<b>EU</b>	European Union
<b>FD</b>	Floods Directive
<b>IFI</b>	Inland Fisheries Ireland
<b>MEA</b>	Millennium Ecosystem Assessment
<b>NPWS</b>	National Parks and Wildlife Service
<b>WFD</b>	Water Framework Directive
<b>UCD</b>	University College Dublin

# Glossary of Ecosystem Services Terminology

<b>Asset(s)</b>	See “Natural capital”
<b>Beneficiaries</b>	The interests of individuals and organisations (e.g. households, associations, societies and companies) that “drive active or passive consumption and/or appreciation of ecosystem services resulting in an impact (positive or negative) on their welfare”
<b>Benefit</b>	In this context, used as a general term to denote the many ways that human well-being is enhanced through the processes and functions of ecosystems via ecosystem services, or something that directly affects the welfare of people, such as more or better-quality drinking water, or a more satisfying fishing trip. Benefits may be economic, social or health benefits. It must be noted that “services” are not “benefits”
<b>Biodiversity</b>	Also described as “biological diversity”: the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and between ecosystems
<b>Driver</b>	Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem
<b>Ecological process</b>	An interaction among organisms; ecological processes frequently regulate the dynamics of ecosystems and the structure and dynamics of biological communities
<b>Ecological stability</b>	An ecosystem is considered ecologically stable if it has the capability to return to its original (and possibly dynamic) state after a disturbance and does not experience a regime shift, or if it exhibits low temporal variability or does not change dramatically as a result of a disturbance. See also “Pressure” and “Regime shift”
<b>Ecosystem</b>	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit
<b>Ecosystem approach</b>	A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way
<b>Ecosystem function</b>	A subset of the interactions between ecosystem structure and processes that underpins the capacity of an ecosystem to provide goods and services
<b>Ecosystem goods</b>	The resources from ecosystems that people value through experience, use or consumption, whether that value is expressed in economic, social or personal terms. Note that the use of this term here goes well beyond a narrow definition of goods simply as physical items bought and sold in markets, and includes objects that have no market price (e.g. outdoor recreation)
<b>Ecosystem process</b>	Changes in the stocks and/or flows of materials in an ecosystem, resulting from interactions among organisms and their physical–chemical environment
<b>Ecosystem service</b>	The benefits people obtain from ecosystems. It can also be defined as an activity or function of an ecosystem that provides benefit (or occasionally disservice) to humanity and its economies
<b>Ecosystem services approach</b>	See “Ecosystem Services Framework”

<b>Ecosystem Services Framework</b>	A way of intervening to manage an ecosystem, based on taking a systemic and participatory approach. Also sometimes referred to as the ecosystem services approach
<b>Evolutionary process</b>	Process leading to changes in gene frequencies in populations and, ultimately, potentially the appearance of new species or intraspecific taxa
<b>Final ecosystem service</b>	An ecosystem service (whether natural, semi-natural or highly modified) that directly underpins or delivers a good to humanity and improves well-being. A fundamental characteristic is that they retain a connection to the underlying ecosystem functions, processes and structures that generate them
<b>Flow</b>	Transfer of materials in an ecosystem from stocks and between pools, forms or states
<b>Human well-being</b>	See “Well-being”
<b>Indicator</b>	Information based on measured data used to represent a particular attribute, characteristic or property of a system
<b>Intermediate service</b>	A service that is not directly consumed by people but supports or underpins the output of other services. See also “Ecosystem function”
<b>Natural capital</b>	The economic metaphor for the limited stocks of physical and biological resources found within an ecosystem and the capacity to provide ecosystem services
<b>Pressure</b>	A stress or negative effect on the environment caused by human activities (e.g. excess organic pollution) or by natural events (e.g. drought)
<b>Regime</b>	The set of system states within a stable landscape/catchment
<b>Regime shift</b>	A change in a system state from one regime or stable state to another
<b>Resilience (of ecosystem)</b>	Capacity of an ecosystem to recover from and tolerate a disturbance to its structure and function without collapsing or changing
<b>Service-providing areas</b>	A catchment or defined area that includes the sum of biodiversity and its traits (i.e. the biotic components of the ecosystem) required to deliver a given ecosystem service, as well as the physical or abiotic ecosystem components
<b>Stakeholder</b>	A person, group or organisation that has a stake in, or is affected by, the outcome of a particular activity or policy
<b>Stock</b>	The amount of a material or component in a given pool, form or state in an ecosystem that provides services
<b>Threshold</b>	Boundaries in space and time in changeable systems that separate alternative stable states (i.e. dynamic regimes), which shift towards different attractors
<b>Trade-offs</b>	Management choices that intentionally or otherwise change the type, magnitude and relative mix of services provided by ecosystems
<b>Value</b>	The size of the well-being improvement delivered to humans through the provision of good(s)
<b>Well-being</b>	The state that arises from adequate access to the basic materials for a good life needed to sustain freedom of choice and action, health, good social relations, security, peace of mind and spiritual experience. The state of well-being is dependent on the aggregated output of ecosystem goods and benefits, the provision of which can change the status of well-being

# Appendix 1 Ecosystem Services Provided by Freshwater Ecosystems

Section	Division	Group	Class	Examples
Provisioning	Nutrition	Biomass	Wild plants and animals and their outputs	Wild fruit/berries, game, freshwater fish (trout, eel, etc.); includes commercial and subsistence fishing and hunting for food
			Plants and animals from <i>in situ</i> aquaculture	<i>In situ</i> farming of freshwater fish (e.g. trout) and other products (e.g. cranberry growing)
		Water	Surface water for drinking	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking
			Groundwater for drinking	Freshwater abstracted from (non-fossil) groundwater layer or via groundwater desalination for drinking
	Material	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	Fibres and other products, which are not further processed; chemicals extracted or synthesised from algae, plants and animals; includes consumptive ornamental uses. Peat/turf for energy use <sup>a</sup>
			Materials from plants, algae and animals for agricultural use	Plant, algae and animal material for fodder and fertiliser in agriculture and aquaculture
			Genetic material from all biota	Genetic material from wild plants, algae and animals for biochemical industrial and pharmaceutical processes (e.g. medicines, fermentation, detoxification), bio-prospecting activities (e.g. wild species used in breeding programmes), etc.
		Water	Surface water for non-drinking purposes	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (e.g. washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (e.g. consumption and cooling), etc.
			Groundwater for non-drinking purposes	Freshwater abstracted from (non-fossil) groundwater layers or via groundwater desalination for domestic non-drinking use (e.g. washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial non-drinking use (e.g. consumption and cooling), etc.
Regulating and maintenance	Mediation of waste, toxins and other nuisances	Mediation by biota	Bioremediation by microorganisms, algae, plants and animals	Biochemical detoxification/decomposition/mineralisation in land/soil, freshwater systems including sediments; decomposition/detoxification of waste and toxic materials (e.g. wastewater cleaning)
			Filtration/sequestration/storage/accumulation by microorganisms, algae, plants and animals	Biological filtration/sequestration/storage/accumulation of pollutants in land/soil, freshwater biota, adsorption and binding of heavy metals and organic compounds in biota
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	Biophysicochemical filtration/sequestration/storage/accumulation of pollutants in land/soil and freshwater ecosystems, including sediments; adsorption and binding of heavy metals and organic compounds in ecosystems
			Dilution by freshwater ecosystems	Biophysicochemical dilution of gases, fluids and solid waste, wastewater in atmosphere, lakes, rivers and sediments

Section	Division	Group	Class	Examples
Regulating and maintenance	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	Erosion/landslide/gravity flow protection; vegetation cover protecting/stabilising terrestrial ecosystems
			Buffering and attenuation of mass flows	Transport and storage of sediment by rivers and lakes
		Liquid flows	Hydrological cycle and water flow maintenance	Capacity to maintain baseline flows for water supply and discharge (e.g. fostering groundwater), recharge by appropriate land coverage that captures effective rainfall, including drought and water scarcity aspects
			Flood protection	Flood protection by appropriate land coverage
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats	Habitats for plant and animal nursery and reproduction (e.g. microstructures of rivers, etc.)
			Pest and disease control	Pest and disease control including invasive alien species
		Disease control	Disease control	Disease control in cultivated and natural ecosystems and human populations
			Water conditions	Maintenance/buffering of chemical composition of freshwater column and sediment to ensure favourable living conditions for biota (e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorus, etc.)
		Atmospheric composition and climate regulation	Global climate regulation by reduction in greenhouse gas concentrations	Global climate regulation by greenhouse gas/carbon sequestration by water columns and sediments and their biota; transport of carbon into oceans (dissolved organic carbon), etc.
			Micro and regional climate regulation	Modifying temperature, humidity, wind fields; maintenance of rural and urban climate and air quality and regional precipitation/temperature patterns
		Energy <sup>b</sup>	Renewables	Various types of energy generated from use of natural water flows and oscillations (e.g. osmotic energy, hydropower)
Cultural	Physical and intellectual interaction with biota, ecosystems and landscapes	Physical	Experiential use of plants, animals and landscapes in different environmental settings	<i>In situ</i> wildlife watching
			Physical and experiential interactions	Walking, hiking, boating and leisure fishing (angling)
		Intellectual and representative interactions	Scientific, educational, heritage, cultural, entertainment, aesthetic	Subject matter for research and education both on location and via other media; historic records, cultural heritage (e.g. preserved in water bodies); <i>ex situ</i> viewing/experience of natural world through different media; sense of place, artistic representations of nature
	Spiritual, symbolic and other interactions with biota, ecosystems, landscapes and seascapes (environmental settings)	Spiritual and/or emblematic	Symbolic	Emblematic plants and animals
			Sacred and/or religious	Spiritual, ritual identity (e.g. holy places); sacred plants and animals and their parts
		Other cultural outputs	Existence	Enjoyment provided by wild species, wilderness, ecosystems
			Bequest	Willingness to preserve plants, animals, ecosystems for the experience and use of future generations; moral/ethical perspective or belief

Source: adapted from CICES. Available online: <http://cices.eu/> (accessed 1 July 2016).

<sup>a</sup>Peat is non-renewable in the short to medium term and therefore it is often not considered an ecosystem service.

<sup>b</sup>Although 'energy' is included in CICES, the authors consider this a geosystem service (see section 1.1) in freshwaters, not an ecosystem service, as it has no biological element.

## AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Gníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

## Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

**Rialú:** Déanaimid córais éifeachtacha rialaithe agus comhlionta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.

**Eolas:** Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

**Tacaíocht:** Bimid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

## Ár bhFreagrachtaí

### Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola*);
- gníomhaíochtaí tionsclaíocha ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géimhódhnaíthe (OGM);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha*);
- áiseanna móra stórála peitрил;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

### Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhírí ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a idíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

### Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuisceí, leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

## Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsiúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

### Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

### Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainathint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

### Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórfheananna forbartha*).

### Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

### Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhail ghuaiseach a chosc agus a bhainistiú.

### Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht comhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

## Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

## ESManage Project: Freshwater Ecosystem Services - An Introduction for Stakeholders



Authors: Hugh B. Feeley, Michael Bruen, Craig Bullock, Mike Christie, Fiona Kelly, Kyriaki Remoundou, Ewa Siwicka and Mary Kelly-Quinn

### Inform policy

The ESManage Literature Review for Stakeholders provides an overview of information on the ecosystem services framework, the role of biodiversity in ecosystem service provision, and how the concept aligns with the objectives of current policy and legislation to inform management of freshwater resources. The Water Framework Directive (WFD) is the key EU driver requiring Member States to improve and sustainably manage water quality. The specific benefits of incorporating the ecosystem services framework into the implementation of the WFD relate to illustrating how human wellbeing is dependent on good ecological health, biodiversity and widening the focus from good ecological status as an end in itself to showing how it supports societal goals. Additionally, it allows for the proper assessment and communication of the benefits and co-benefits of implementing the WFD, highlighting potential trade-offs involved in selecting cost-effective measures but also avoiding unintended impacts of measures on other benefits (not directly associated with the measure). Other relevant policy measures such as the EU Biodiversity Strategy aim to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restore them in so far as feasible.

### Develop solutions

The ESManage Literature Review for Stakeholders highlights the types of ecosystem services, the main ecosystem services classification scheme known as CICES, and identifies the chain of knowledge required to get from basic science to policy application and the management of freshwater resources. This review provides an overview of the ESManage project approach to understanding the complex ecological linkages between the health and resilience of the ecosystem (critically dependent on biodiversity) and the provision of ecosystem services, goods and benefits for human wellbeing. It also highlights the importance of stakeholder involvement, and their perceptions, in incorporating ecosystem services into policy and water management.