Environmental Liability, Resource Equivalency and the Valuation of Ecosystem Services

Report Summary:

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The valuation of impacts on protected species and natural habitats for the purposes of liability assessment and remediation under the Environmental Liability Directive

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The valuation of impacts on protected species and natural habitats for the purposes of liability assessment and remediation under the Environmental Liability Directive

Report Summary

Introduction

The Environmental Liability Directive (2004/35/EC) applies a common liability approach to instances of environmental damage throughout the European Union. It aims to prevent and remedy environmental damage by holding those responsible financially liable for remediation. The objective of ECORISK has been to explore methods whereby the valuation of ecosystem services can be used to supplement established methods of environmental damage assessment. This document summarises the main output from the project beginning with a summary of the document structure and the principal findings.

The full report can be found on the EPA website or the project website www.ecorisk.ie. Chapter 1 of the report contains a description of the Environmental Liability Directive (ELD) beginning with its application in relation to impacts to land, water, protected species and natural habitats. This is followed by an introduction to ecosystem services, a discussion of environmental valuation methods and of the procedures used for biodiversity offsets. The following chapters of the report consider impact cost estimation in relation to water. Water is of the three foci of the ELD and is of evident relevance to protected species and natural habitats. Chapter 2 introduces the relationship between the ELD and the Water Framework Directive. Chapter 3 discusses impact cost estimation for freshwater environments and Chapter 4 discusses the same for estuarine and inshore coastal environments. Chapter 5 introduces a case example of the River Suir and Waterford Harbour. Chapter 6 summarises the study and findings. A database of environmental valuation studies has been added to the EPA "SAFER" site.

In brief, the main findings for the study are as follows:

Overall findings and recommendations

- Remediation should take account of impacts on ecosystem services of value to human beings. It should aim to restore these ecosystem services or compensate for interim losses.
- In some cases the value of these ecosystem services can be quantified in monetary terms.
- Various economic valuation methods are available including cost-based methods, revealed preference and stated preference techniques. As the last of these can be time-consuming, benefit transfer methods are also recommended if the source study has been applied to a similar Irish or UK environment.
- Many ecological functions are not well understood, but often data on distinct environmental changes in outputs (e.g. in fish stocks, bird populations, etc.) is sufficient for environmental valuation.
- When valuing environmental damage, ecologists, the public and specific stakeholders are most likely to value avoidance of dangerous environmental thresholds or tipping points.
- Where monetary quantification is difficult or data unavailable, the scale of these ecosystem services should still be assessed along with the number and identity of recipients. Where ecosystem service losses have occurred in an interim period but cannot be quantified remediation should aim to exceed a no net loss situation.
- Procedures should be put in place to improve the availability of data for local impact assessment, for example data on public and private water abstraction (location, quantity, recipients), data on water and waste water treatment costs, and data on visitor and tourist numbers. Public bodies should be obliged to collect this data and to make it more freely available.
- More primary economic surveys are needed to establish the value that the public places on the quality of freshwater and coastal water bodies and on wildlife and wildlife habitat.

On freshwater bodies:

- Rivers and lakes supply a key ecosystem service in the form of waste assimilation and other service benefits in the form of water supply, angling and various types of recreation.
- A water body's capacity to assimilate waste is strongly related to water quality and is best measured through primary stated preference valuation or benefit transfer. Population is a factor, but it is important to define the extent of the spatial catchment in which values are held.
- Angling and recreation values can be measured through a combination of production function methods and revealed preference, i.e. participation, fishing permit sales, boat hire, travel cost and local expenditure.
- Some local authorities have insufficient data - or insufficiently accessible data - on water abstraction, waste water treatment and respective costs.

On estuarine and inshore coastal water bodies

- Estuaries and coastal areas supply key ecosystem service benefits in the form of waste assimilation, fin fish, shellfish, and recreation including wildlife related recreation. However, ecosystem services valuation can be challenging because many of the relevant ecosystem functions are still poorly understood.

The Environmental Liability Directive

The procedures of the ELD apply to the contamination of land presenting a significant risk to human health, to the quality of water bodies o protected species and natural habitats covered by the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC).

Of these, ECORISK has focused on impacts to the natural environment, namely damage to water or to protected species and natural habitats. To quality as a significant impact under the ELD:

- Damage to water must be significant enough to affect the quality status of a water body as defined by the Water Framework Directive (WFD) (2000/60/EC).
- Damage to protected species or natural habitats must be sufficient to undermine the achievement or maintenance of "favourable conservation status" as defined by the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC).

The potential scope of the ELD is wider than for the Habitats Directive (HD) in that it refers to protected species and natural habitats within or outside of Natura 2000 sites and not just within the confines of designated sites.

Where damage has occurred the ELD allows for three types of remediation:

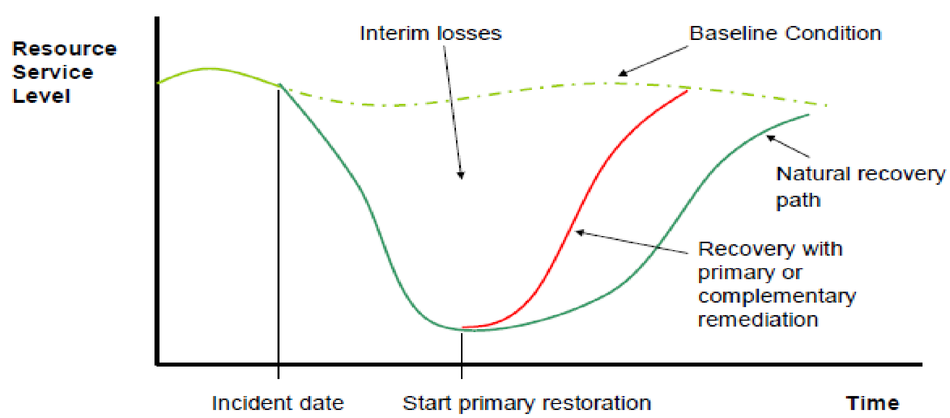
- Primary remediation to restore a damaged resource or impaired service to its baseline condition,
- Complementary remediation in cases where primary remediation would fail to fully restore a site to its baseline conditions using primary remediation alone.
- Compensatory remediation where there are interim losses until primary or complementary measures take effect. This includes temporal loss of ecological functions.

Complementary and compensatory remediation requires an "operator" to scale the level of remediation to compensate for the loss of environmental resources. In practice, where restoration is not feasible, complementary remediation has involved improvement to habitat at another site which is geographically linked in terms of species/habitats or human interactions. Measures have generally been decided on a case by case basis by environmental protection agencies.

The definition of complementary and compensatory measures has been informed by Member States' experience of implementing the HD, often following legal debate on specific cases. The directive is strict in its interpretation of remediation. Priority is firmly placed on the avoidance of impacts. Impacts are only conceded for planned projects of imperative reasons of overriding public interest (IROPI) and then only after an 'appropriate assessment' of the implications for the site's conservation objectives. According to Guidance provided by the Commission on Article 6(4) (EC, 2007) of the HD, compensatory measures are independent and additional to any mitigation required for a project. They are intended to offset certain negative consequences while restoration is undertaken to return a site to the reference biological integrity that justified its designation.

By its nature, a key distinction between the ELD and the HD is that the former deals with unplanned environmental impacts. A further distinction is that it acknowledges both the importance of environmental functions (services between species) *and* services to human beings. The ELD states that where restoration of these services is not possible, "alternative valuation techniques shall be used" to ensure that the environmental resource is remediated to a level equivalent to that which has been lost. This distinction is important in that it permits resource equivalency to be pursued through a hierarchy of resource-to-resource, service-to-service or value-to-value approaches. Emphasis is placed on remediating the ecological resource by means of resource equivalency analysis (REA) expressed in physical units such as bird species or animals. Consideration of ecosystem services is relevant to the service-to-service approach which is addressed by habitat equivalency analysis (HEA) and refers to the ecological functions provided by specific habitat. A value-to-value approach applies a monetary metric to the estimation of the ecosystem service element.

Figure 1 Stylised example of remediation (from REMEDE, 2008)



The case for compensatory remediation emerges for interim losses including where physical remediation is prolonged or not possible within a meaningful timeframe. These situations are likely to occur for many habitats that are complex or which have evolved over very long time periods. Figure 1 helps to demonstrate how interim losses can be relatively significant. Whatever approach is taken, the ELD addresses physical remediation rather than financial compensation, but where interim losses occur, remediation is likely to differ from just the replacement of a damaged resource and is more likely to be quantified in terms of an equivalent level of functions or services.

In principle, calculating resource equivalency in either physical units (REA) or services (HEA) is straightforward. It involves the calculation of resource or service losses (debits) due to the damage, estimating the expected benefits per unit of remediation (credits), and then dividing the debit by the per-unit credit to determine the total amount of remediation required (REMEDE (Lipton et al., 2008)). This analysis proceeds in five steps, i.e.

1. An initial evaluation
2. Determination of the damage (debit)
3. Determination of the gains from remediation (credits)
4. Scaling the complementary or compensatory remediation
5. Monitoring and reporting

Fuller details are provided in the main report.

Ecosystem services

Ecosystem services are ecological outputs that contribute to human wellbeing. Economic valuation methods can measure wellbeing through estimates of utility (or the satisfaction of individual preferences). Therefore, ecosystem service benefits (and losses) can potentially be valued in monetary terms too. They can be measured in physical flows too, but monetary estimation provides for units common to debits and credits and facilitates trade-offs where these are realised at different times (as with interim losses) or by various stakeholders.

A conceptual framework was introduced by the Millennium Ecosystem Assessment (MA, 2005) which categorised these flows into supporting, regulating, provisioning and cultural services.

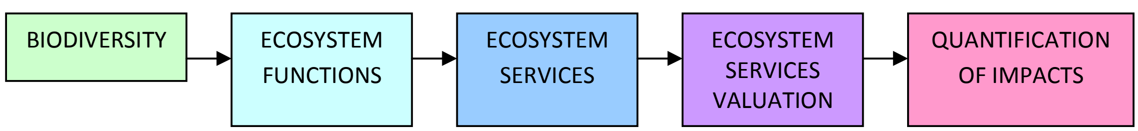
- **Supporting services** underpin other ecosystem service and include such primary production or soil formation,
- **Regulating services** are those which maintain the quality of the environment and include such services as the carbon cycle, waste assimilation or protection against erosion,

- **Provisioning services** provide materials and goods consumed by human beings, e.g. fish, timber, etc.,
- **Cultural services** include such benefits as recreation as well as certain non-use goods that are valued for their existence or because they are perceived to contribute to quality of life.

Recent definitions (TEEB, 2010; CICES, 2013) have concentrated on the final products or benefits provided by the regulating, provisioning and cultural ecosystem services. These definitions will inform the environmental accounting required by the EU Biodiversity Strategy.

Ecosystem services are linked to biodiversity through ecological functions. High levels of biodiversity may indeed be associated with high levels of ecosystem processes or functions, but the relationship is not inevitable due in part to the presence of species redundancy (where a species provides the same functions as another), or conversely, keystone species which are critical to certain functions or habitats (Naeem et al., 2002). Ecological functions provide for ecosystem services, but not all ecological functions are valuable to ecosystem services. On the other hand, some functions may contribute to more than one ecosystem service.

Figure 2. The relationship between biodiversity, ecosystem services and quantification of impacts.



Biodiversity offsets and banking

Resource equivalency can be realised through a process of biodiversity offsetting. Offsets provide for a formalised process of like-for-like complementary remediation and aim to achieve *no net loss* of biodiversity. Conservation banking is an extension to offsetting that allows for more flexibility than the bespoke exchange of habitats. Banking involves the purchase of credits in exchange for environmental damage. These credits are then matched against one or more receptor sites or consolidated with others to achieve an equivalent level of remediation. The Environment Bank being supported under the pilot offsetting scheme[1]in the UK has emphasised the role of ecosystem services. Biodiversity banking has the potential to “mainstream biodiversity” (Crowe and ten Kate, 2010) and deliver new habitats additional to those protected by designation (McManus and Duggan,

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[1] Piloted by the Department for Environment, Food and Rural Affairs,

2011). This does not have to be limited to remediation after damage to protected species or natural habitats, although remediation under the ELD could be a component.

Valuing ecosystem services

Economic valuation can be applied to environmental goods and ecosystem services. However, many of these are public goods that are not priced by the market. As a consequence their value may not be appreciated and there is the prospect that they will be mismanaged or adversely impacted in a manner addressed by the ELD. The directive acknowledges the relationship between human wellbeing and the natural environment. The overt acknowledgement of this relationship by the ELD strengthens the incentive for good environmental management.

The following are the main non-market valuation methods:

- Cost-based approaches. Useful where some market data is available, for example for production function methods that price an ecosystem service input in terms of its contribution to a marketed output.
- Replacement costs or avertive expenditure. The cost of replacing an ecosystem service with an artificial alternative or of supplementing or strengthening the capacity of the ecosystem to provide a service.
- Revealed preference methods. Based on observation of behaviour associated with the environmental good, e.g. travel costs or property prices.
- Stated preference. Establishing willingness to pay directly by through the use of surveys, e.g. contingent valuation or discrete choice experiments.

Production function methods are useful where an ecosystem provides a provisioning service to a market good, e.g. timber. Replacement cost or avertive expenditure could relate to investments in flood or storm defences that were previously supplied by the regulating services of wetlands or dunes. Travel costs to a natural destination provide evidence of revealed preference for the cultural service of recreation and can be complemented with data on local expenditure. Of all the methods, only stated preference can capture non-use values and a proportion of total consumer surplus value. Stated preference has typically been used for cultural services, but sometimes for regulating services too. However, they are time consuming to apply, need to undertaken with thoroughness, and are vulnerable to potential biases or various limitations of scope.

Sometimes local data is available for ecosystem services valuation as illustrated by the project's case study of the River Suir. However, in other cases, it can be challenging to obtain such data. These challenges may be of a temporal or spatial nature such as when ecosystem damage may not be realised in the short term or where the benefits of ecosystem services supplied at one location are realised at another.

Fundamentally, the study finds that, for some freshwater, estuarine and coastal environments, there is often limited ecological evidence of how environmental conditions contribute to ecological functions and how these in turn contribute to ecosystem services. This lack of knowledge applies especially to the role of invertebrates and microbes. Ideally, economic analysis requires information of marginal changes to construct a demand or supply function. In practice, this information is not always available for ecological functions and economists have to settle for more discrete data. On the demand side too, various stated preference surveys referenced in the report demonstrate that the public can be rather insensitive to marginal ecological changes where these are subtle or gradual rather than sudden or visual. For these purposes, it is often sufficient to present information on ecosystem services outputs rather than on underlying ecological processes.

Although valuation methods most readily capture utility values (willingness to pay) at the level of the individual, the environment may also have cultural or ethical value to people or be of communal value. In addition, people tend to value losses more than gains, i.e. they are more averse to losses (Kahneman and Tversky, 1979; 1984). The ELD addresses environmental losses, but stated preference valuation studies have often estimated willingness to pay for environmental protection or enhancements. Willingness-to-*accept* is more appropriate to an environmental loss, so environmental valuation estimates may need to be elevated for the purpose of the ELD with a safety margin that exceeds no net loss.

Despite these challenges or reservations, environmental valuation has the potential to demonstrate the impact of adverse environmental impacts on human wellbeing. This at least ensures that the social value of the environment is not ignored and can be accommodated by remediation. A key requirement is to avoid damage in the vicinity of environmental tipping points. Although we may indeed have a sparse knowledge of ecological functions, ecology and economics share an interest in identifying the location of critical thresholds at which impacts to the ecosystem and its social value would present serious consequences. Identifying these thresholds is of much relevance to the ELD. Some of our most valued species and habitats, e.g. high quality rivers, are very sensitive to anthropocentric impacts. Once pollution rises above a certain thresholds, the associated ecosystem services may be lost or otherwise provided by socially less desirable ecology (e.g. algal growth).

Key points - Remediation and ecosystem services

- The ELD allows for primary, complementary and compensatory remediation.
- Remediation must restore the lost resource or provide an equivalent nature, degree, area or extent of remediation to the resource lost.
- Compensatory remediation is especially relevant to interim losses of ecosystem functions and ecosystem services.
- There can be considerable uncertainty attached to the relationship between ecosystem functions and ecosystem services. Conventional ecological research has tended to address impacts on biodiversity rather than of ecosystem functions or especially ecosystem services.
- Uncertainty also attaches to temporal and spatial discrepancies in the supply and demand of ecosystem services.
- People tend to value losses more than gains, but much valuation addresses protection of the status-quo or gains. Coupled with our limited understanding of ecosystem functions, this observation strengthens the case for remediation that delivers no net loss as a minimum.

Water

To examine the practicality of ecosystem services valuation, Chapters 2, 3, 4 and 5 of ECORISK focus on water. Tables 3.2 and 4.2 in the main report [*these could be useful to include at the end of this summary*?] present some of the key habitats and species to be found in fresh and coastal waters along with the ecosystem services they support. The project is also accompanied by a database of environment values for these environments or activities associated with them.

Most studies listed in the database are stated preference surveys. As ecosystem services have only been formally conceptualised in recent years, most of these studies address elements of Total Economic Value (TEV), a tool used by environmental economists to categorise different value types. In the TEV, "use values" relate to provisioning and some cultural services, but "indirect use" and "non-use" values are variously relevant to the valuation of supporting, regulating or cultural services.

For water, ECORISK examined the potential for the use of alternative valuation methods. However, although clean water is presumed to be highly valued, evidence of this value can be difficult to quantify for Irish rivers as levels of abstraction or recreational use are often low. Data on abstraction omits many industrial and small scale private schemes. In principle, the assimilative and cleaning capacity of the aquatic ecosystem should reduce expenditure on water treatment at source, but routine treatment must be carried out for reasons for public health and costs are typically modest.

Regulating services are also relevant to recreational uses, but this is often restricted to angling. Public access to river banks is rather restricted, but rivers do contribute cultural services through the value the public attaches to wildlife and landscape. Lakes are of more significant value for amenity and tourism. More significant use values are associated with coastal waters. However, local data is rather limited. Furthermore, while coastal waters are of provisioning value for fish and shellfish, our understanding of the value of estuaries and bays as fish nursery areas is minimal. We also have only a limited understanding of the value of coastal regulating services for waste assimilation, nutrient cycling and carbon sequestration.

A rather roundabout measure of the value that we attach to the environment is represented by the considerable sums now being invested in wastewater plant and treatment. Where the assimilative capacity of the receiving environment has been diminished by environmental impacts, there is a need for avertive expenditure on treatment to protect water quality. The standards are set by the WFD, but stated preference can provide us with a handle on the value that the public attaches to 'good' water quality status. Only one primary survey has so far been undertaken in Ireland, namely Stithou et al (2011), although Norton et al (2012) demonstrate how these values can potentially be transferred to other rivers. More primary studies are needed including of rivers of varying quality and remoteness as well as of the coastal environment.

Some key findings on ecosystem services and water

- Some data is available on which to base economic estimates of the value of ecosystem services, but only for provisioning and cultural services associated with a handful of direct use activities.
- Ecosystem functions and values are often spatially distinct. For example, the upper stretches of rivers provide spawning habitat for salmon, but the value is realised downstream in terms of angling numbers, capital values, permit revenue and local expenditure.
- Some ecosystem services vary from one location to another and for reasons that may be poorly understood. This means that value estimates can be location specific and not easily transferrable.
- Estuaries provide nursery habitat for fish, but little information is available on this function and mature fish may be caught in a different location. Even shellfish are mobile at the larvae stage.
- Two locations may provide similar cultural types of ecosystem service, but this benefit may be more developed and valuable at one location than another.

The Beneficial Use Index and its relevance to estimates of environmental liability

The EPA is developing a Beneficial Use Index by which water bodies can be scored to prioritise where resources need to be invested for the WFD. Data is available on abstraction points, designated areas (SACs and SPAs), bathing areas and shellfish waters. This can be assembled into a spatial database.

Potentially, data on economic welfare values could be added to this information. Population data could be combined with transfer values from stated preference surveys to estimate the welfare value of rivers and lakes using distance decay factors as demonstrated by Norton et al (2012), Bateman et al (2006) and Hanley et al (2003). However, without more primary surveys it is difficult to predict how these values relate to existing water quality, how closely use values relate to the number of places where riverbanks can be accessed, and importantly, the significance of non-use values (values not associated with use).

The value of many regulating ecosystem services could be captured by related provisioning services (water consumption, abstraction by farms) and cultural services. Spatial considerations are a challenge though in that the value of a particular stretch of river may depend on regulating services upstream and the avoidance of impacts both to the river and the wider catchment.

While ecosystem services are extremely relevant to a Beneficial Use Index, in the short term it could be difficult to incorporate much quantified economic data from national data sources. Over time, though, the index could inform environmental liability estimation and provide the basis for local data collection in the event of an incident. For the purpose of remediation, this economic data can be included within estimates of species or ecological function credits .

Summary

The ECORISK study has demonstrated the extent to which ecosystem services of social and economic value can be identified to inform remediation. Consideration of ecosystem services should always apply to interim losses addressed by compensatory remediation, but should be accounted for in the restoration of ecological functions for both primary and complementary remediation too. This process would also support a programme of biodiversity offsetting that could deliver conservation gains in return for losses addressed by the ELD. The quantification of ecosystem service values in monetary terms is feasible in many cases, but will often require on-the-ground data collection in areas where environmental impacts have occurred. Until more detailed environmental use data is collated and more primary valuation studies are undertaken, approaches such as the proposed Beneficial Use Index can provide broad estimates of the significance of impacts.

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The full project report

The main project report can be viewed on the EPA website and for a finite period on www.ecorisk.ie

The project database of water valuation studies can be located on the EPA SAFER site.

Report Chapters

Chapter 1

The Environmental Liability Directive, its application in Ireland and a general introduction to the valuation of ecosystem services.

Chapter 2

Water Policy, water quality and valuation methods

Chapter 3

Freshwater ecosystem services

Chapter 4

Transitional and inshore coastal ecosystem services

Chapter 5

Ecosystem service values for the River Suir and Waterford Harbour

Chapter 6

Report Summary: Ecosystem services, impacts and synergies