Assessment of Environmental and Resource Costs in the Water Framework Directive

Information sheet prepared by Drafting Group ECO2
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Preface

The Wateco guidance on the economic analysis for the Water Framework Directive (WFD), officially published in 2002, identified environmental and resource costs as one of the issues requiring further investigation in order to make direct use of them for developing river basin management plans. In order to further clarify the concept of environmental and resource costs, a European drafting group (ECO2) was set up in September 2003 under the Common Implementation Strategy (CIS) Working Group 'Integrated River Basin Management' (WG2B). WG2B asked the drafting group to prepare a non-binding information sheet on the definition and assessment of environmental and resource costs in the context of the implementation of the WFD.

The fourteen ECO2 group members - official EU member state representatives and interested stakeholder representatives - have met three times since September 2003. The results of these three meetings are presented in this information sheet. In addition to the information sheet presented here, ECO2 also organised an international workshop on environmental and resource costs in Amsterdam in March 2004 in which 50 experts participated. At the workshop an overview was presented of the way environmental and resource costs are dealt with in practice in different EU member states in the context of the WFD. The workshop proceedings have been published separately (RIZA Working Paper 2004.112x) and are available from www.riza.nl.

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1. Main objective and set-up of this information sheet

Environmental and resource costs are identified in the economic guidance document developed by the European Water Economics Working Group (Wateco) in 2002 for the Water Framework Directive (WFD) as one of the issues requiring further investigation (Wateco, 2002; p.6):

> '*how to operationalise methods for assessing environmental costs that would be of direct use for developing river basin management plans?*'

According to Paragraph 1 in Article 9 in the WFD, *member states shall take account of the principle of recovery of the costs of water services*, *<u>including environmental and resource costs</u>, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle*. The main objective of this information sheet is to further clarify the concept of environmental and resource costs and their role in the context of the implementation of the WFD.

The information sheet is structured according to the following three main questions, which the European drafting group ECO2 aimed to answer:
1) What are environmental and resource costs?
2) Which role do environmental and resource costs play in the WFD?
3) How can environmental and resource costs be measured in practice?

Closely related to the first question, two additional sub-questions can be identified:
- 1a) When can we speak of environmental damage?
- 1b) What are internal and external environmental and resource costs?

The first question will be addressed in the next section (Section 2). Special attention will be paid to the distinction between environmental and resource costs. An important conclusion in this information sheet is that they are closely related and cannot therefore simply be added.

Section 3 focuses on the first sub-question (1a) and concludes that environmental and resource costs are based upon available knowledge and information about the physical status of water bodies, including their points of reference (existing status) and target points (desired status). Their assessment is therefore closely linked to the work carried out by the WFD working group IMPRESS.

In section 4, we discuss the second sub-question (1b) and the importance of distinguishing - in the context of cost recovery - between environmental and resource costs, which have already been accounted for in economic activities or through existing price and finance mechanisms and environmental and resource costs which have not.

Section 5 addresses the second question. An overview is given of the role and possible uses of environmental and resource costs in the WFD and an attempt is made to answer the question why we wish to estimate environmental and resource costs. In view of the fact that environmental and resource costs may serve multiple purposes in the WFD, an important conclusion of the drafting group is that no one single method can be prescribed to measure them in practice. Depending on the purpose for which they are used and the specific context in which they arise, different existing methods and approaches may be more or less applicable and suitable.

Section 6 addresses the third question how environmental and resource costs can be assessed in practice. This section also presents some practical examples from a number of European member states. Finally, section 7 summarises and provides some final notes regarding the role and assessment of environmental and resource costs in the context of the implementation of the WFD.

2. What are environmental and resource costs? [1]

In the Wateco guidance's glossary of terms, **environmental costs** are defined as representing *the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils)*. **Resource costs** are defined as *the costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater).*

These definitions also provide the basis for the definitions proposed in this information sheet. However, the distinction in the Wateco guidance between environmental and resource costs is not clear-cut. The difference between these two cost items will be further clarified below.

Resource costs are defined in this information sheet as the opportunity costs of using water as a scarce resource in a particular way (e.g. through abstraction or wastewater discharge) in time and space. They equal the difference between the economic value in terms of net benefits of present or future water use (e.g. allocation of emission or water abstraction permits) and the economic value in terms of net benefits of the best alternative water use (now or in the future). Resource costs only arise if alternative water use generates a higher economic value than present or foreseen future water use (i.e. the difference between net benefits is negative). There may be a variety of reasons why this is the case, including institutional ones (e.g. historical water abstraction rights or the current or future distribution of pollution permits). Contrary to the definition in the Wateco guidance document, resource costs are therefore not necessarily confined to water resource depletion only (in terms of water quantity or water quality). They arise as a result of an inefficient allocation (in economic terms) of water and/or pollution over time and across different water users, because an alternative water use generates a higher net economic value.

Environmental costs consist of the environmental damage costs of aquatic ecosystem degradation and depletion caused by a particular water use (e.g. water abstraction or the emission of pollutants). Following the definition in the Wateco guidance, a distinction can be made between damage costs to the water environment and to those who use the water environment. Interpreted in terms of the concept of total economic value, one could argue that the environmental damage costs refer to non-use values attached to a healthy functioning aquatic ecosystem, while the costs to those who use the water environment refer to the corresponding use values[2]. Use values are associated with the actual or potential future use of a natural resource (e.g. drinking water, fish consumption, irrigation water). Non-use values are not related to any actual or potential future use, but refer to values attached to the environment and natural resource conservation based on considerations that, for example, the environment should be preserved for future generations or because plants and animals also have rights. In both cases, however, it is humans who hold the values for the different possible states.

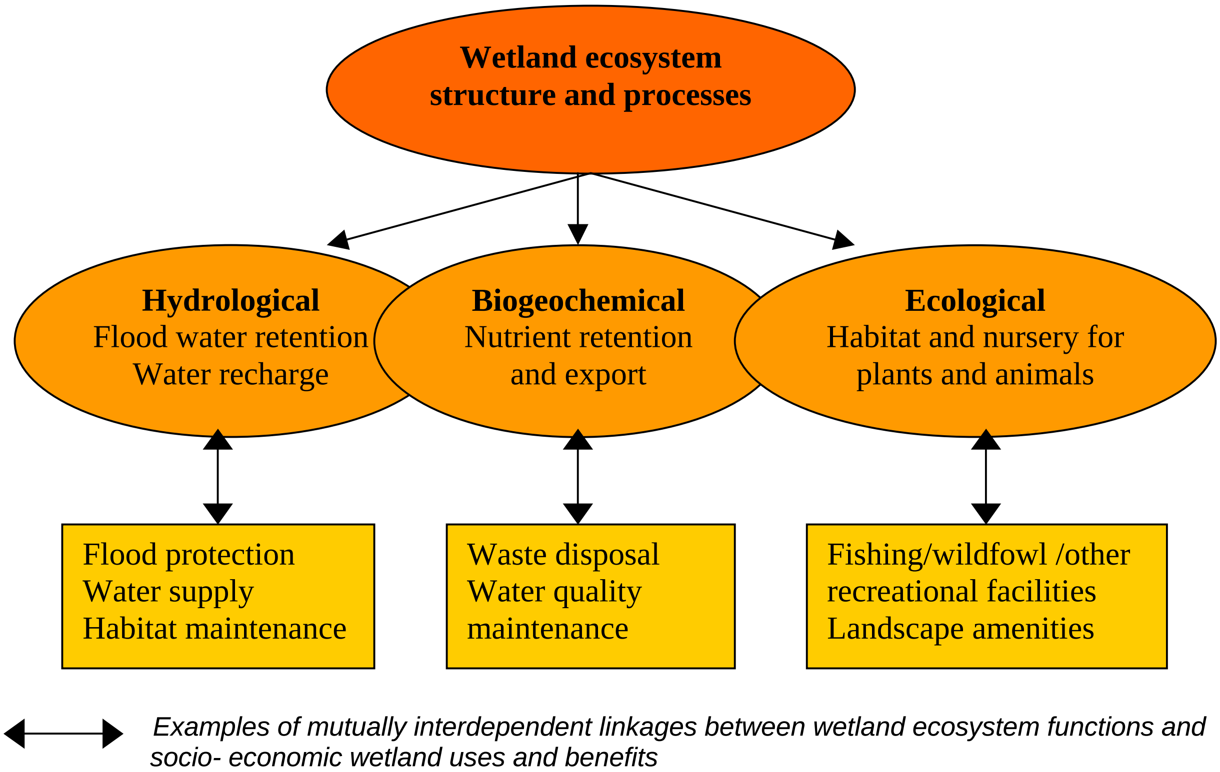
The estimation of these use and non-use values as a result of alternative and competing water use provides the basis for the subsequent assessment of resource costs. For instance, resource costs arise if ecosystem restoration and conservation - measured through the use and non-use values attached to the water environment by the general public (households) and/or recreation - generate a higher economic value than for example current or future water abstraction by agriculture or water pollution by industry. Hence, environmental and resource costs cannot simply be added in view of the fact that environmental costs may be part of the net benefits with which the resource costs are calculated and there is hence a real risk of double counting. On the other hand, there may be resource costs even if there are no environmental costs such as a degraded aquatic ecosystem.

[1] The definition and measurement of environmental and resource costs is based on neo-classical economic welfare theory, the theoretical foundations of which are briefly presented in the annex.

[2] In environmental economics, the concept of total economic value has been broken down into various use and non-use related reasons and motives for people to value a specific environmental change (e.g. Pearce and Turner, 1990).

Water bodies provide socially beneficial goods and services, which when impaired by (excessive) water use, result in environmental and resource costs

In the economic analysis of the WFD, environmental and resource costs arise if and only if a specific change in a water body results in a welfare loss to human beings, who depend on water and use water in some form. Environmental and resource costs are therefore estimated in the economic analysis from the point of view of human beings (society) and the way they make use of the various functions provided by water systems. Environmental and resource costs therefore arise if a change in a water body affects one (or more) of these functions from which we, human beings, benefit. This can be visualized, for example for wetlands, as shown below.



Source: Brouwer et al. (1999).

Environmental and resource costs furthermore play at different **scales**. A welfare loss may occur to an individual person or household (micro level), a sector (meso level) or society as a whole (macro level). Obviously, the scale of a welfare loss is determined by the scale of the physical ecosystem damage (e.g. local, regional, national, global).

In practice, the actual costs and expenditures of measures, which primarily aim to protect the environment, including the water environment, are also often referred to as ‘environmental costs’ or ‘environmental expenditures’[3]. In order to avoid confusion over the definition of environmental costs, we will refer to the costs and expenditures of measures to protect the water environment (e.g. prevent, avoid, abate or mitigate

[3] See, for example, OECD (2001) or Eurostat (2002). In the Wateco guidance document, these actual ‘costs’ are referred to as ‘financial costs’. However, costs are usually not restricted to actual financial (monetary) expenditures only and may include non-monetary costs as well, such as depreciation costs. Environmental damage is another example of a cost item, which is often not monetised and can therefore not be related to an expenditure. Here, we interpret ‘costs’ (including actual environmental protection costs) in a broader economic sense, while environmental expenditures are strictly considered financial costs involving a cash flow.

environmental pollution and/or damage) as ‘environmental protection costs’, following the OECD and EUROSTAT Classification of Environmental Protection Activities (CEPA)[4].

In summary, environmental costs are defined in this information sheet as the environmental damage costs to the water environment and its users as a result of alternative competing water use, while resource costs are defined as the costs of an economically inefficient allocation of water, either in terms of water quantity or water quality, over time and across different water use(r)s. The calculation of resource costs can be based upon the estimation of environmental costs, but there may also be resource costs in the absence of environmental damage costs. Environmental protection costs refer to the costs and expenditures of activities and measures, whose primary aim is to protect the water environment, including water services such as wastewater collection and wastewater treatment.

3. When can we speak of environmental damage?

An important question when estimating environmental costs is what exactly constitutes damage, to the water environment and those who use the water environment. In theory, damage arises when there is a discrepancy between some reference and target point or situation. The latter can be measured, for instance, through existing environmental norms or standards or the right people attach to a clean environment and the provision of sufficient and clean water. In practice, sometimes also a point in the past, when pollution levels and corresponding damage costs were lower, is taken to represent the target situation.

An example is the discharge of waste water into a water course at a rate (e.g. tons of N per year), which exceeds some permitted rate (in tons per year) and hence results in a eutrophic water system with negative consequences, for example, for both the biological diversity of the water system and recreational amenities provided by the water course, including the possible negative effects on human health if the specific water body is also used for recreational swimming. It is important to point out that this permitted discharge rate is usually not some constant and can be determined in a variety of ways, including through expert judgement of good ecological status, public participation or taking into account the incremental costs of reducing damage just below or above the rate[5].

In the context of the WFD, it seems logical to use the expected water status in 2015 as the reference situation, but other reference situations may also be appropriate. The same applies to the target situation. It seems logic to relate the target situation to the environmental objectives of the WFD, i.e. good ecological water status in 2015. However, again other target situations may also apply (e.g. high ecological water status).

Hence, there is a strong dependence of environmental costs on the physical status of the water system and knowledge and information about this physical status. This includes the damage caused to the water system as a result of pressures exerted on the water system, such as the extent to which the system’s natural rate of recharge or recovery has been impaired by a specific water use. Other damage categories include, in general, eutrophication, salinisation, dessication, loss of biological diversity and morphological changes to a water system. This type of information is crucial to the subsequent estimation of environmental costs. The physical status of a water body or water system provides the basis for the estimation of the environmental costs in economic terms. If this information is not available, environmental costs (and subsequently possible resource costs) cannot be assessed.

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[4] Wastewater management is such an environmental protection activity in CEPA, comprising activities and measures aimed at the prevention of pollution of surface water through the reduction of the release of wastewater into inland surface water and seawater. It includes the collection and treatment of wastewater including monitoring and regulation activities (OECD, 2003, p.17).

[5] Another important point is that even if a target situation is met, this does not necessarily mean that there are no more environmental damage costs. There may still be residual environmental damage, for example, because the target situation is based on a politically and/or socially acceptable level of water use (e.g. abstraction or pollution), which does not necessarily correspond with a healthy functioning ecosystem. Another reason may be that part of the environmental damage is currently unknown or invisible and only manifests itself years later, because of fundamental uncertainties surrounding environmental cause-effect relationships. Furthermore, theoretically speaking any residual damage beyond the target situation may still have an economic value as long as there is a positive public willingness to pay to reduce pollution levels even further.

Environmental and resource costs depend on the available knowledge and information about the physical damages caused by (excessive) water use

Physical damage to water systems (depletion and degradation) as a result of (excessive) water use is not always clear-cut as a result of limited ecosystem knowledge and information and hence substantial uncertainties surrounding cause-effect relationships. Examples of important environmental damage categories related to water use include:

- **water pollution**
- **eutrophication**
- **salinisation**
- **dessication**
- **loss of biological diversity**
- **morphological change**

However, in practice the extent or size of these damages is not easy to measure. Nor can these damages easily be related to specific water use and water users.

In general, the extent of the damage depends upon the difference between some ***reference*** and ***target*** situation. The reference situation may be the current situation or the expected situation, for example in the year 2015. The target situation is usually related to some kind of environmental norm or standard. In the context of the implementation of the WFD, the obvious reference and target points would be the expected (chemical and ecological) status of a water body in the year 2015 and its (to be defined) good ecological status in 2015. Hence, the environmental and resource costs are determined by the difference between this expected and good status.

Important **caveats** include:

- there may not exist any clear-cut environmental norms or standards for specific environmental damages, only for specific substances or pollutants;
- existing norms or standards for specific substances or pollutants may be difficult to relate to specific environmental damages;
- even if existing environmental norms or standards are met, there may still be substantial physical environmental damage, e.g. as a result of the fundamental uncertainties surrounding certain forms of environmental damage, temporal delays in cause-effect chains or the geographical distribution of environmental problems.

4. What are internal and external environmental and resource costs?

Another important point is the distinction between internal and external environmental and resource costs. Internal costs refer in this context to costs, which are part of the economic system related to specific water use, whereas external costs remain outside the economic system. According to Pearce and Turner (1990):

'An external cost exists when the following two conditions prevail:

- *An activity by one agent causes a loss of welfare to another agent.*
- *The loss of welfare is uncompensated.'*

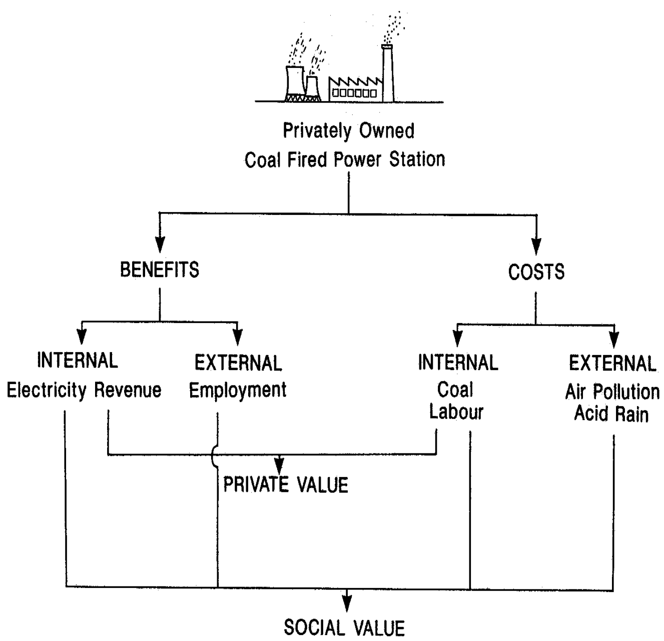
(see also the Glossary of Terms in the Wateco guidance).

Hence, if economic costs as a result of specific water use are compensated, financially or otherwise, we speak of internal or internalised environmental and resource costs. If, on the other hand, these economic costs remain uncompensated, we speak of external environmental and resource costs.

For example, a company located upstream along a river produces marketable output (e.g. food products or chemical products) and at the same time wastewater, which is treated before it is discharged into the river. Although the wastewater is treated before it is discharged in accordance with existing legislation, the discharge still pollutes the water. The polluted water results, for example, in higher purification costs for drinking water companies located downstream and loss of recreational fish stock. The higher (monetary) purification costs of the drinking water companies and the (non-monetary) damage caused to the recreational anglers downstream, who experience a real loss of recreational fishing opportunities, are not compensated by the polluter or through some other mechanism, and are therefore external costs.

On the other hand, potential damage is prevented or mitigated by the wastewater treatment measures taken by the polluting company. The costs and expenditures of these pollution abatement measures are referred to as environmental protection costs in view of the fact that their primary aim is to protect the water environment. They prevent potential damage and as a result reduce the welfare loss and hence the need for compensation of the drinking water companies and recreational anglers. In other words, part of the potential economic damage costs are taken into account in the company's own operations and passed on to its customers and can therefore be considered as part of the economic system. There would have been a bigger welfare loss without these protection activities or measures and one could argue that they (partly) compensate this bigger welfare loss to other water users. The associated costs are borne by the polluter and can therefore from this point of view be interpreted as internal environmental protection costs.

Illustration internal (private) and external (social) costs and benefits



Source: Bateman (2003)

In summary, it is important to know the extent of the damage caused and by whom, but also to what extent the damage is compensated (or not) by the polluter or beneficiary of a particular water use or water service. The fact that the polluter or beneficiary pays for the damage caused is a necessary, but insufficient condition to assess the extent to which environmental and resource costs are internal or external costs. Information is also needed about the extent to which stakeholders negatively affected by water pollution or abstraction are compensated, financially or otherwise, directly by the polluter or through some other compensating mechanism. In the specific context of cost recovery, we suggest that the actual costs of activities and measures, which prevent and mitigate potential damage to the water environment and other water users, are interpreted as internal environmental protection costs.

Internal and external costs related to water in England and Wales

1. External environmental costs
External environmental costs are the damage costs (or loss of welfare) from current abstraction and discharges (after current controls).

England and Wales have a long tradition in the assessment of environmental and resource costs and will apply and develop this knowledge base to help implement the WFD. Previous research shows that these costs are highly significant, although their exact estimation is subject to a high degree of uncertainty on both scientific and economic grounds. Current information on the level of these damages is set out in the Regulatory Impact Assessment prepared for the WFD. These costs need to be properly assessed and quantified in order to develop the right set of measures for the WFD.

2. Internal financial costs of current control measures
Considerable financial costs have already been incurred to control discharges, releases and abstractions affecting the water environment. For instance, water companies in England and Wales in the years 2000 to 2005 alone will have invested between £4.5 to £5.5 billion in order to address environmental impacts related to the discharge of pollutants and water abstractions. Similar capital costs were incurred in each of the two prior quinquennia since the 1989 privatisation of the water companies. Other bodies also bear financial costs in meeting existing standards.

3. External financial costs of control/abatement measures
However, the water companies' expenditures on water treatment include about £313m per annum on removing nitrates and pesticides and reducing risks associated with *cryptosporidium* along with a number of other parameters. This represents about 10% of the total public water supply costs in England and Wales. About £240m of these costs are attributable to external sources such as agriculture. These represent external financial costs incurred by the water companies to treat pollutants originating from other sectors, most notably agriculture and other diffuse sources of pollutants, who do not pay for these costs.

Estimated annual costs in 2002-03 associated with external impacts on raw water quality

£m 2002-03 prices		Annual costs borne by water company customers	% Contribution due to external sources	Total annual remediation costs attributable to external sources
Capital Costs				
	Nitrates	47.7	80%	38.20
	Pesticides	78.3	89%	69.69
	Other parameters	108.6	50%	54.32
	Cryptosproridium	23.3	90%	20.97
	Total	234.7		162.2
Opex				
	Deteriorating raw water quality	70.4	69%	71.1
	Cryptosproridium	8.3	90%	7.5
	Total	78.7		78.6
Total		**313.4**		**240.8**

Source: ERM (2004) and Pretty (2000).

Disentangling these costs per type of pollutant and per source sector and identifying them is a first step to establish the link between pressures and impacts, which will help to devise more coherent policies.

However, care should be taken as these three distinctly different types of costs above can not be added since they are not comparable.

- Cost 2 (already internalised financial control costs) represents the costs already incurred recently or in the past on treatment and control measures to reduce discharges or abstractions to their current levels.
- Cost 3 (external financial control costs) represents the portion of these water treatment costs paid by water companies that are to treat pollutants coming from other sectors (e.g. agriculture) who are not paying for these costs.
- Cost 1 (environmental damage costs) are the external **residual** environmental damage costs arising from current discharges, releases and abstractions (after the current controls which are included in the financial cost in 2 above).

References:
ERM, Stone & Webster. Assessing current levels of cost-recovery and incentive pricing, DEFRA, May 2004
Pretty, J.N. et al. (2000). An assessment of the total external costs of UK agriculture. Agricultural Systems, 65, pp 113-136.
The Final Regulatory Impact Assessment of the Water Framework Directive can be found at:
http://www.defra.gov.uk/corporate/ria/2004/wfd.pdf.

5. Which role do environmental and resource costs play in the WFD?

There are four different places in the WFD where environmental and resource costs come into play:

1) Article 9: take account of the cost recovery of water services, including environmental and resource costs.

2) Article 9: Member States shall ensure by 2010 that water pricing policies provide adequate incentives for water users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive.

3) Annex III and Article 11: make judgements about the most cost-effective combination of measures in respect of water uses to be included in the programme of measures.

4) Article 4: possible economic justification for derogation (including designation of water body status):

   - Objectives derogation if the achievement of these objectives would be disproportionately expensive.
   - Derogation for new modification or sustainable economic activity, if benefits of this activity outweigh benefits from good water status.

Article 9 says that environmental and resource costs should be taken into account in the costs of providing water services such as for example wastewater collection and treatment. In order to be able to assess the level of cost recovery, one therefore has to know the total costs, including environmental and resource costs, and the way these costs are paid for by the different users of the water service through existing price and finance mechanisms. This allows us to assess the extent to which the Polluter Pays Principle applies. Including in this assessment an analysis of the level of compensation received by different water users for any damage caused by a specific water use gives us an idea to what extent environmental and resource costs are internalised. Hence, the role of environmental and resource costs in the context of water pricing policies is to signal to what extent they are internalised through existing pricing mechanisms in society.

Although article 9 is the only article in the WFD, where environmental and resource costs are mentioned explicitly, environmental and resource costs are closely related to the issues raised in articles 4 and 11. The role of environmental and resource costs in the context of selecting a cost-effective programme of measures (Article 11 and Annex III) is to signal to what extent existing or new environmental standards are met or not and what the associated costs are, including (residual) environmental damage costs and any costs arising as a result of an inefficient allocation of water and pollution rights.

In addition to the cost-effectiveness analysis (i.e. estimating the least cost way to achieve the environmental objectives), the benefits of reaching these environmental objectives can be estimated in a cost-benefit analysis (CBA) in order to support the process of establishing environmental objectives from an economic point of view. CBA allows policy makers to include economic efficiency criteria besides ecological criteria in their decision-making process. In the domain of water pollution, this basically means comparing the costs of pollution control measures (including water services such as wastewater collection and wastewater treatment) and the damage costs avoided. These damage costs include the damage to the water environment and other water users. Hence, the role of environmental and resource costs in the context of Article 4 can be to show whether the costs outweigh the benefits, including the environmental and resource costs avoided by, for example, specific pollution control measures.

Assessment of environmental costs in the Netherlands

The practical estimation and application of environmental costs in the context of the implementation of the WFD in the Netherlands is based on the principle "different costs for different purposes", and guided by existing official guidelines for environmental cost calculation from the Environment Ministry. Two other important considerations are (1) data availability and (2) the reliability and accuracy of the available data. In the latter case, policy and decision-maker demand for reliable and accurate estimates in different phases of the implementation of the WFD plays an essential role.

For the purpose of cost recovery (Article 9) and the 2004 reporting requirements (Article 5), environmental costs are approximated by looking at the costs of measures whose primary aim is to protect the water environment based on existing legal (environmental) standards. This approach is used to assess the level of cost recovery and design possible future pricing policies to tackle water pollution problems at water body level in river basins as foreseen in Article 9 based on the cost-effectiveness analysis in Annex III. This cost based approach is used as long as the basis for economic valuation of environmental damage costs (e.g. cause-effect relationships between pressures and impacts) and economic valuation procedures based on expressed or stated preference methods (allowing a valid and reliable break-down of economic values to damage categories and damage units) remain surrounded by too many uncertainties. Cost data are readily available (for water projects and related water management activities data bases exist going back 10-20 years) and guidelines for standard cost calculations for water projects were developed more than ten years ago and have been applied ever since, including guidelines related to the assessment of uncertainties in these cost calculations.

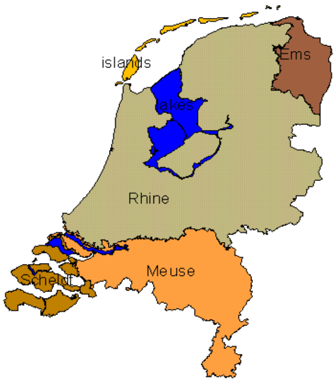
Environmental costs related to water in 2000

Sector	Total environmental costs (million €)
Agriculture	30
Industry	373
Water boards	911
Total	1,314

Source: Statistics Netherlands

The calculation of environmental costs for the 2004 reporting requirements is based on the available data about environmental costs related to water from Statistics Netherlands. Statistics Netherlands calculates these costs annually based on the existing guidelines from the Environment Ministry. These national guidelines correspond with the international environmental cost accounting guidelines provided by the OECD and Eurostat for environmental protection measures. The environmental costs related to water mainly include wastewater treatment costs. The costs are calculated separately for industry, agriculture and the regional water boards. The latter are in charge of public wastewater treatment in the Netherlands.

Available information about the total revenues from existing price and financing mechanisms is used to assess the extent to which the current costs of these measures to prevent, avoid, mitigate or restore environmental damage related to water are recovered within the institutional setting in river basins.



Cost recovery rates of environmental protection activities per basin

River basin	Water service: Wastewater collection (cost recovery %)	Water service: Wastewater treatment (cost recovery %)
Rhine	79	98
Meuse	77	95
Scheldt	73	92
Ems	76	100
Netherlands	78	97

Source: Statistics Netherlands

Environmental costs have been elaborated more specifically for the two water services wastewater collection and treatment. The current costs of these water services are recovered directly from the sources of pollution (households, agriculture and industry) and internalised through existing price mechanisms (sewerage levy and pollution levy).

At the same time, on-going work also focuses on the translation of environmental damages into valid and reliable economic values with the help of economic valuation methods, such as contingent valuation and travel cost studies. For instance, a national contingent valuation study was conducted recently, which investigated public willingness to pay for improved water quality as a result of the implementation of the WFD and in which economic values were broken down by river basin (Brouwer, 2004). Large scale national valuation studies have furthermore been carried out looking at ecological restoration of lakes and lakeshores (Brouwer et al., 2004), bathing water quality improvement in the context of the revision of the European Bathing Water Quality Directive (Brouwer, 2003) and biodiversity and health risks related to the clean-up of contaminated sediments (Brouwer, 2004).

In view of the experiences with these valuation methods in the Netherlands so far in the domain of water, the results are at present only considered suitable for pre-feasibility cost-benefit studies in the explorative phase of the decision-making cycle in the WFD, for example to support the setting of environmental standards. They are considered unsuitable yet to target specific economic sectors and fix price levels for specific water uses and services in possible future pricing policies as foreseen in Article 9 to internalise environmental costs. They are expected to play a more important role in the context of Article 4 (disproportionate costs). As more knowledge, data and information becomes available in time, the accurateness and reliability of the estimates are expected to increase, resulting in a fine tuning of the analysis to support actual decision-making regarding the selection of a cost-effective programme of measures in the river basin management plan by 2009.

Source: Brouwer, R. and van der Veeren, R. (2004). Assessment of environmental and resource costs for the economic analysis in the WFD (in Dutch). RIZA working paper 2004.115x. Lelystad, The Netherlands.

It is important to point out that the target situation may be very different when looking for an economic efficient solution instead of imposing environmental standards based on chemical and/or ecological criteria for good water status. When looking for economic efficiency, the target situation is found, theoretically speaking, at the point where marginal costs equal marginal benefits (or where marginal benefits are equal across the market and non-market goods and services provided by a water system). Environmental objectives should be fixed at this point if and only if economic efficiency is the overriding decision criterion. When using chemical and/or ecological criteria to determine environmental objectives for water bodies, one can still try to assess whether or not the total benefits outweigh the total costs at the predetermined level of pollution or water abstraction and aim for an efficient allocation of clean water across different water users. However, in this latter case only within the constraints imposed by the environmental objectives.

In summary, the assessment of environmental and resource costs serves different objectives depending on where in the WFD they are addressed. This has consequences for the way they are estimated and calculated in practice[6].

6. How can environmental and resource costs be measured in practice?

A number of steps can be distinguished when trying to estimate the environmental and resource costs associated with water use and services. These steps are presented in the flow diagram below. In view of the fact that resource costs are defined as the difference between the net benefits (= total benefits minus total costs) of present or future water resource use and the net benefits of alternative water resource use (including – if relevant and significant - environmental costs) the remainder of this section will concentrate on environmental cost assessment only. An example of the assessment of resource costs is given in the box after the flow diagram.

The flow diagram is an attempt to provide some preliminary guidelines for the assessment of environmental costs. The diagram consists of three parts, which basically reflect the main steps involved in environmental cost assessment in the specific context of cost recovery:

1) **Environmental (impact) assessment** to qualify and quantify the environmental damage involved.

2) **Economic valuation** of the environmental damage.

3) **Institutional and financial assessment** of the extent to which the estimated environmental costs are internalised or not through existing price and/or finance mechanisms and the application of the polluter and/or beneficiary pays principle.

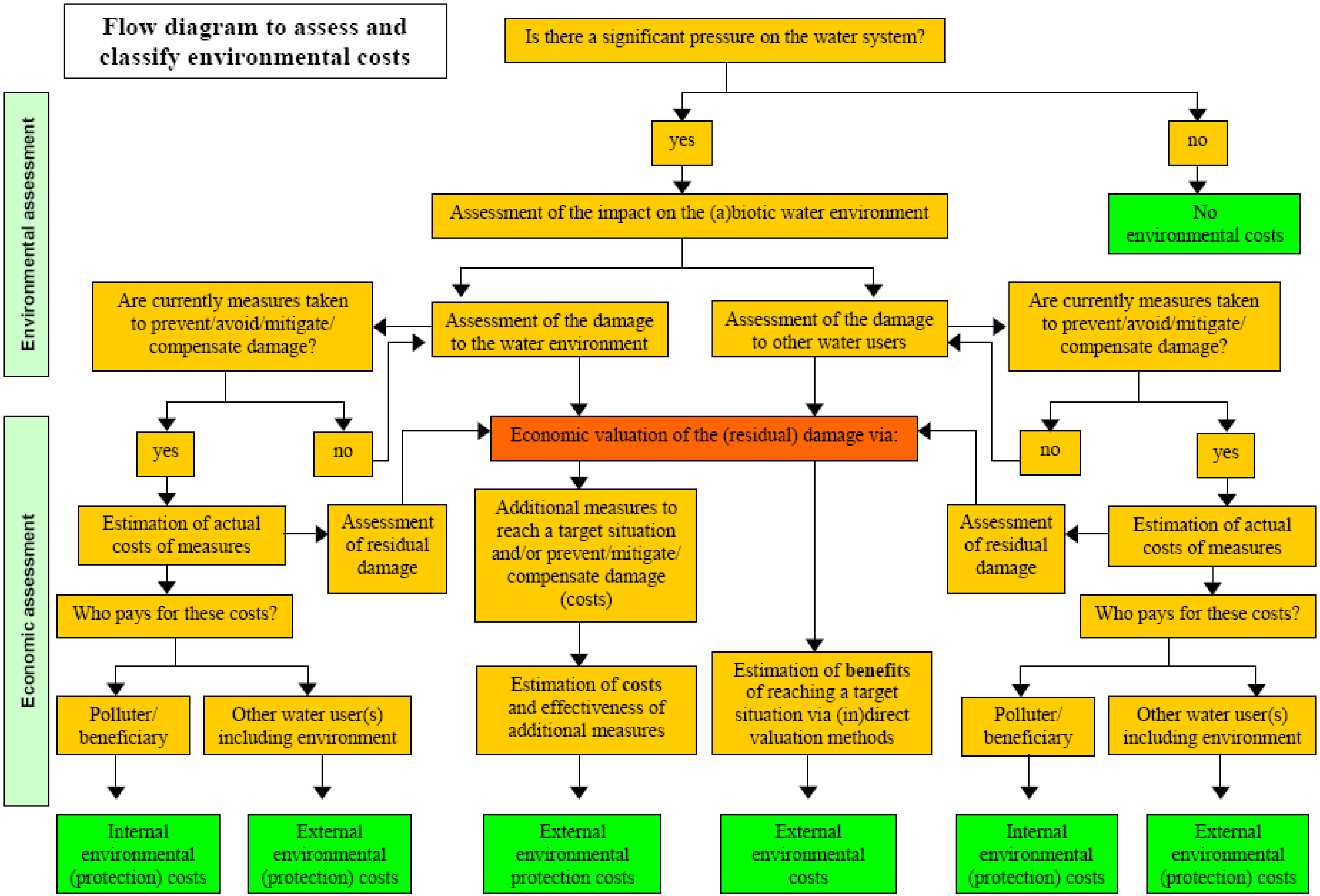
The diagram tries to illustrate that:

- Any assessment of environmental costs starts off with or is based upon an environmental (impact) assessment, hence requiring the input (knowledge, expertise and information) from both economists and environmental experts.

- There are two main, mutually non-exclusive approaches to the estimation of environmental costs, a ‘cost based’ approach and a ‘benefit based’ approach.

- The cost approach is based on the calculation of the costs of measures, which aim to protect the water environment against environmental damage. These environmental protection costs are used under certain circumstances as a proxy for the environmental damage costs.

[6] However, consistency in some elements between Member States may be necessary, particularly where different approaches to measuring environmental and resource costs lead to different results with impacts on the competitive situation faced by industries in different Member States.


Flow diagram to assess and classify environmental costs
Environmental assessment
Economic assessment
Is there a significant pressure on the water system?
yes
no
Assessment of the impact on the (a)biotic water environment
No environmental costs
Are currently measures taken to prevent/avoid/mitigate/ compensate damage?
Assessment of the damage to the water environment
Assessment of the damage to other water users
Are currently measures taken to prevent/avoid/mitigate/ compensate damage?
yes
no
Economic valuation of the (residual) damage via:
no
yes
Estimation of actual costs of measures
Assessment of residual damage
Additional measures to reach a target situation and/or prevent/mitigate/ compensate damage (costs)
Assessment of residual damage
Estimation of actual costs of measures
Who pays for these costs?
Who pays for these costs?
Polluter/ beneficiary
Other water user(s) including environment
Estimation of costs and effectiveness of additional measures
Estimation of benefits of reaching a target situation via (in)direct valuation methods
Polluter/ beneficiary
Other water user(s) including environment
Internal environmental (protection) costs
External environmental (protection) costs
External environmental protection costs
External environmental costs
Internal environmental (protection) costs
External environmental (protection) costs

- The benefit approach is based on the estimation of the loss of welfare due to environmental damage or the increase in welfare if environmental damage is avoided through Willingness to Pay (WTP) and Willingness to Accept Compensation (WTAC) measures[7].

- Irrespective of the selected approach, in the context of cost recovery an assessment is needed of the extent to which activities and measures - including technical measures as well as administrative measures (e.g. regulation) and economic instruments like environmental taxes related to water - are already in place to protect the water environment (and those who use the water environment) and to which extent the associated costs – related to measures or damage - have already been internalised.

- In the cost based approach, the costs of existing measures are referred to as internal or external 'environmental protection costs', depending on whether or not they prevent, mitigate or compensate any potential or actual damage (see the green boxes at the left and right lower end of the flow diagram).

- They are labelled internal or external 'environmental costs' if the actual costs incurred are based on WTP or WTAC measures of welfare losses or gains associated with potential or actual environmental damage (see the green boxes at the left and right lower end of the flow diagram).

- In the cost based approach, a distinction is furthermore made between actual and potential future costs of additional measures needed to protect the water environment (and reach some target situation). The analysis of the additional measures needed to protect the water environment corresponds with the cost-effectiveness analysis, which has to be carried out in order to be able to select a cost-effect programme of measures in river basin management plans.

The first steps are clearly related to the work by experts working on the identification of pressures and impacts on water bodies. As mentioned, the physical characterisation of environmental damage provides the basis for the subsequent economic assessment and valuation of this damage. Environmental damage can basically be valued from an economic point of view in two different, but mutually non-exclusive ways, i.e. either through the estimation of the costs of measures to reach a (predefined) target situation or the estimation of the benefits of reaching the target situation. The target situation in the flow diagram refers, for example, to a situation with an acceptable level of damage from a societal point of view to the water environment and other water users, or to a situation with no damage at all[8].

A first step is to identify the significant pressure, which causes a water body to change. In principle, if there is no significant pressure, there will also be no environmental costs. A second step is to assess the impact of this pressure on the water environment, in chemical or ecological terms. A third step is to identify and, if possible, quantify the nature and extent of the damage involved, both on the water environment and other water users. Damage is defined here as the difference between some reference and target situation (see section 3).

The assessment of the extent to which some (predefined) target situation (e.g. environmental objective or standard) is met (and hence the environmental damage involved) shows strong resemblance with the *risk* or *gap analysis* carried out by the WFD working groups Impress. On the basis of this step, it is decided to what

[7] In environmental economics, various models and techniques have been developed to measure the value people attach to natural resources and the goods and services these resources provide. Environmental values are measured in money terms through the concept of individual willingness to pay (WTP) or willingness to accept compensation (WTAC) in order to make them commensurable with other market values. Of these two, the WTP approach has become the most frequently applied and has been given peer review endorsement through a variety of studies (e.g. Arrow et al., 1993).

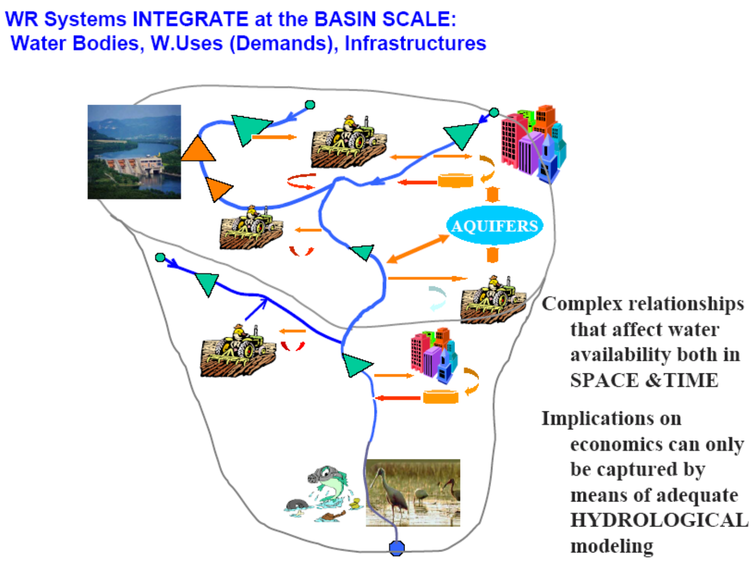
[8] The choice between the cost or benefit based approach depends partly also on the strength of the environmental standards imposed in the target situation. If these standards are fixed and non-negociable (e.g. hands-off policy regarding a particular natural area) and based on the concept of 'strong sustainability', one could argue that monetary valuation of the target situation is methodologically speaking pointless for the provision level of the associated (non-market) environmental goods and services is at that point not 'for sale'. Monetisation through WTP or WTAC measures assumes *a priori* inter-changeability (also referred to as 'weak sustainability') of non-market (e.g. environmental goods and services such as biodiversity or landscape amenities) and market goods and services (e.g. the amount of income people are willing to accept as compensation if the natural area is given up).

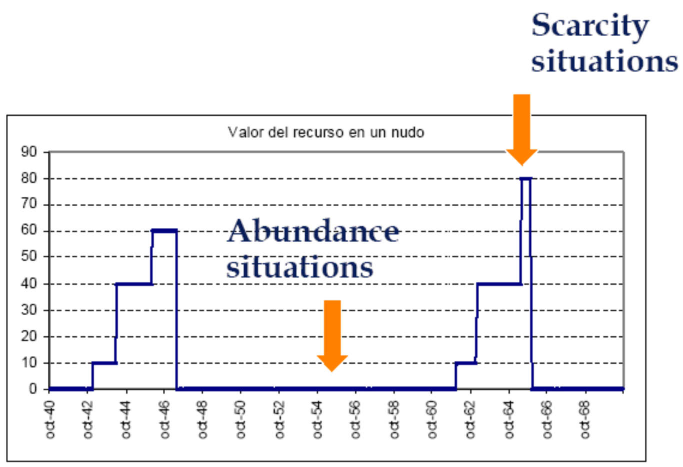
Approach used to assess resource costs in Spain

A pilot methodology and tools for the assessment of resource cost have been developed in the Jucar pilot river basin (Jucar PRB) and has produced some preliminary results. The following two aspects are considered for inclusion in the analysis:

- *Conjunctive modelling of surface and groundwater.* In systems in which the groundwater component is important, the model should be able to simulate both surface and groundwater systems and their interaction. Otherwise, externalities due to separate actions would be ignored. For example, the isolated analysis of an aquifer does not allow the assessment of how pumping influences the ecological status of downstream locations.

- *Incorporation of water productivity functions in the water uses and marginal unit costs of the water supply system.* The demand of the different types of users are represented by "economic value functions", which express the relation between water supply and its marginal value for the different types of users in a specific year. The integration of the economic demand function for a certain level of supply provides the economic benefit at this supply level. The accuracy in the definition of these demand curves, assumed as exogenous information in these models, is fundamental for the reliability of the results. The supply costs considered include annual infrastructure costs and variable cost of intake, distribution and treatment of the resource for both surface and groundwater supply.





The calculation of resource costs is based on simulation and optimisation models. The use of an *optimisation approach* allows us to calculate an upper bound of the economic value of water at a certain location with the system being operated in an economically optimal way. The *simulation approach* allows us to determine the economic value resulting from a set of a priori established operating and allocating rules. These rules can correspond to the priorities and historical rights, reproducing the current *modus operandi* of the system.

Comparison of the optimisation and simulation results provides insight in the resource cost. The gap between the economic value of an economically optimal water use and the current water allocation system allows us to assess the "distance" between the optimum and any management regime analysed. The results of the optimisation model provides insight in possible operating rules or strategies with which to improve the economic results in the system, whereas the benefits of any modification in the management criteria, such as modifications to achieve the quality standards required by the WFD, can be assessed by the simulation model.

Results obtained so far are showing consistency with expected economic behaviour. For instance, opportunity cost of the resource in a point is higher in scarcity situations and lower in abundance situations and opportunity costs are modified in time if there is the possibility of storing water in a reservoir.

Source: Methodology developed for the Jucar PRB and the Environment Ministry by Joaquin Andreu, Manuel Pulido, Guillermo Collazos, and Miguel A. Perez from the Institute for Water and Environmental Engineering (IIAMA), Universidad Politecnica de Valencia, Spain.

extent there is a need for additional measures to reach some target situation, for example good ecological water status in 2015.

In the next steps, the extent of the environmental damage and the damage to other water use(r)s is measured in economic terms. This can be done in various ways, based on the identification of the goods and services (functions) impaired by the pressure involved (e.g. water used for drinking water production, irrigation, food processing, recreation, wildlife habitat etc.). For the purpose of assessing the current level of cost recovery, it is important in these subsequent steps to also assess the extent to which environmental (protection) costs are already internalised through existing price and financing mechanisms. Therefore, in a separate step, measures already taken to reduce, eliminate or mitigate (potential) damage caused by a specific pressure are identified. These measures include economic instruments as well as traditional technical measures. In the latter case, input is usually also required from technical engineers and other experts in the field of pollution abatement and mitigation technologies.

If existing measures suffice to meet the target situation, only the costs of existing measures are calculated - in accordance with the economic analysis advocated in the Wateco guidance document - and an assessment is made of the extent to which the polluter pays principle applies. If the polluter or beneficiary pays, either directly or indirectly through existing price or financing mechanisms to prevent, mitigate or compensate potential or actual damage to the water environment and other water users, the current costs are referred to as internal 'environmental costs' or 'environmental protection costs'. Environmental costs are directly related on the actual or potential welfare losses associated with environmental change, while environmental protection costs are not directly related to any welfare loss (gain) as a result of environmental damage (avoided), but simply relate to existing environmental protection activities and measures.

If no measures are taken to prevent, mitigate or compensate environmental damage or damage to other water users, or current measures are insufficient to reach a target situation (e.g. good ecological status in 2015), additional measures can be taken. The costs and effectiveness of these additional measures can be estimated with the help of other experts: technical engineers who have knowledge and information about best available techniques (BAT) and scientists who are able to assess the environmental impact(s) of these additional measures. For the purpose of cost recovery, the costs of these additional measures can be used under certain circumstances as a proxy for the *external* environmental costs, i.e. costs which remain uncompensated without additional measures and which have to be internalised somehow in order to reach the desired target situation.

Besides informing policy and decision-makers about the costs of bridging the gap between the current (or expected future) situation and the target situation, assessing the least cost way to reach some predefined environmental objective in a cost-effectiveness analysis (as requested by the WFD in Annex III and Article 11) may also provide the basis for future water pricing policies (see, for example, Baumol and Oates, 1971). Fixing environmental taxes or charges at individual company or sector level at a level sufficiently above the least costs of implementing BAT should induce companies or a sector to implement the BAT instead of paying the imposed environmental tax or charge. Hence, carrying out a cost-effectiveness analysis may support both the assessment of cost recovery and incentive water pricing policies.

As demonstrated by Baumol and Oates (1971), fixing price levels on the basis of a cost-effectiveness analysis is theoretically speaking a second best solution (because it is not based on economic welfare), but nevertheless in practical terms it is possibly a very effective one in achieving some predetermined target situation (e.g. emission of tons of nutrients or kilograms of trace metals annually) in view of the sometimes fundamental uncertainties surrounding environmental change and the corresponding damage costs.

Alternatively, the economic value of the environmental damage (avoided with the help of existing pollution abatement and mitigation measures) can be estimated with the help of *direct* and *indirect* economic valuation methods (e.g. Johansson, 1987; Mitchell and Carson, 1989; Freeman, 1993). Direct methods (also called stated preference methods) refer to contingent valuation (CV) and contingent ranking (CR) techniques, with which individuals are asked directly, in a social survey format, for their WTP for a pre-specified environmental change.

Assessment of environmental and resource costs incurred by water services in France

The valuation of environmental and resource costs involves valuing the loss of welfare of people using water in a specific environment. This approach, in line with the economic valuation of the environmental costs as defined by the WFD, nevertheless gives rise to a number of practical questions in its application at river basin district scale. Accordingly, it appears preferable to develop it for application on smaller scale (water bodies) to clear up any local uncertainties and anticipate future needs for costs–benefits analysis of measures to achieve good ecological status. Therefore, for the economic analysis at the district scale a more approximate alternative approach appears to be easier to set up. Its purpose is to produce the first elements of discussion and decision at district scale. It makes it possible to compare relative shares of cost categories between sub-basins.

The concept is quite simple: environmental and resource costs of a water service are estimated through the cost of necessary investments and operations, beyond those currently granted, to minimise the impact of services related to the use of water on the environment and users of the environment. By transposing this thinking into terms of the DPSIR (Driving forces – Pressures – States – Impacts - Responses) scheme, it means that an extra expense is done to reduce the impact of pressures on the environment. This method can be applied to the pressure (avoidance) or to the environment itself (restoration). Therefore, environmental and resource costs can be assimilated to these following costs, ranked according to three categories of pressures:

- Avoidance costs of pressures affecting water quality: cost of treatment by the technical resources currently used in treatment plants for the residual dumping of services.
- Cost of avoidance of water user pressure on watercourse hydrology (withdrawals with or without restoration), which can be assimilated to “resource costs”: pressure avoidance cost (refurbishing of drinking water supply networks, better efficiency of irrigation infrastructures, water recycling processes in industry or investments in water retention). Moreover, for withdrawals without restoration it appears justifiable to consider only withdrawals during low water periods.
- Cost of avoiding watercourse continuity and morphology impact: the avoidance cost of impacts appears to be more suitable than thinking in terms of pressure avoidance. It can be the cost of installing fish locks, the cost relative to creating - at regular distances (for instance every kilometer) - areas for the revitalization of watercourses (wet areas propitious to spawning with nurseries), or the cost of creating "buffer" areas (strips of grass or other wet areas).

The “target situations” in these three examples can be the “almost pristine” state for the first category of costs and good ecological water status for the two last categories.

Source: French Water Ministry.

Overview of German water valuation studies

Study	Object	Methodology	Result (examples)
Holm-Müller (1991)	Environmental quality (e.g. drinking water, surface water)	Contingent valuation	Improvement of 1 quality class (€/household*a): 48 (surface water) 24 (drinking water)
Hampicke, Schäfer (1994)	Isar estuary floodplains	Market prices (timber), contingent valuation	500 to 650 €/ha*a
Jung (1996)	Environmental quality (e.g. drinking water)	Contingent valuation	
Schönbäck (1997)	Danube floodplains, national park	Travel costs, Contingent valuation	Value of national park (11.500 ha): 8,3 billion €
Waibel, Fleischer (1999)	Costs and benefits of agricultural pesticides	Market prices (drinking water), Contingent valuation (biodiversity)	Drinking water supply: 65,9 Mio € p.a. for Germany (51% of total external cost)
Muthke (2001)	Quality of water bodies for recreation	Contingent valuation	Improvement of 1 class: 30 – 43 €, 2 classes: 34 – 53 € / household*a
Wronka (to be published)	Biodiversity, drinking water	Contingent valuation	Improvement of drinking water quality: 22 - 75 €/household*a
Meyerhoff, Dehnhardt (2002)	Elbe floodplains (biodiversity, nutrient retention)	Contingent valuation, market prices (nutrients)	Area of 10.000 to 15.000 ha: net present value 850 - 1.080 Mio € (details see below)

Source: German Ministry for the Environment

WTP can also be measured indirectly by assuming that this value is reflected in the costs incurred to travel to specific sites (travel cost studies) or prices paid to live in specific neighbourhoods (hedonic pricing studies). The latter two approaches measure environmental use values through revealed preferences, while CV is believed to be able also to measure non-use or passive use values through stated preferences. An overview of existing monetary environmental valuation methods is given in Annex 2.

Based on the estimation of the environmental damage costs (avoided), through direct or indirect valuation methods, existing pricing and financing mechanisms can be reviewed to assess to what extent the estimated damage costs are internalised. Estimation of the total economic benefits of reaching the target situation (i.e. damage costs avoided) also allows assessment of the economic efficiency of existing pollution abatement measures through CBA or assessment of the most efficient level (and corresponding prices) of pollution control and water abstraction and the economic justification for derogation.

7. Summary and final notes

Environmental costs are defined in this information sheet as the economic damage costs to the water environment and other water use(r)s caused by alternative competing water use (e.g. water abstraction or wastewater discharge). Resource costs are defined as the opportunity costs of using water as a scarce resource in a particular way (e.g. through abstraction or wastewater discharge) in time and space. They only arise, however, as a result of an inefficient allocation (in economic terms) of water and/or pollution over time and across different water users, i.e. if alternative water use generates a higher net economic value. The calculation of resource costs are based upon the estimation of environmental costs if the latter are relevant and significant, but there may also be resource costs in the absence of environmental damage costs. In any case, they cannot and should not be automatically added in view of the fact that environmental costs may be part of the net benefits with which the resource costs are calculated.

Environmental and resource costs can only be estimated if the underlying reference and target situations can be reliably established. The physical characterisation of these two situations, for instance in terms of current annual emission levels of polluting substances (e.g. nutrients or trace metals) and their maximum acceptable levels (e.g. based on existing environmental standards or the water resource’s natural absorption rate), provides the basis for the subsequent economic valuation of the discrepancy between the appropriate reference and target situation. In other words, the economic valuation procedure is based on the gap analysis carried out by Impress. In the context of the WFD, it seems logic to use the expected water status in 2015 as the reference situation and to relate the target situation to the environmental objectives of the WFD, i.e. good ecological water status in 2015. However, other reference and target situations may also apply.

Economic costs can be estimated with the help of (1) available information about the costs of measures needed to prevent, avoid, repair or mitigate the damage or (2) available economic valuation methods assessing public willingness to pay (the costs of measures) to prevent, avoid, repair or mitigate the damage. The choice of a specific economic valuation method depends, first of all, upon the main objective when assessing environmental and resource costs. Different methods simply measure different things and may therefore be more or less appropriate in view of the purpose for which the results are to be used. Second, the available information will also play an important role. In general, cost data are usually more readily available than benefit data. Third, the degree of uncertainty surrounding the outcomes of different methods also differs significantly and may be decisive when choosing a specific method for a specific purpose. For instance, the acceptable level of uncertainty is much higher in a pre-feasibility cost-benefit study than when establishing ‘correct’ or ‘right’ water price levels based on current levels of cost recovery.

Finally, there exists an important relationship between environmental and resource costs and the assessment of what has been labelled ‘financial costs’ in the Wateco guidance for the purpose of cost recovery. In some cases, these financial costs include (part of) the environmental and resource costs, namely when they have actually been internalised through existing price or financing mechanisms. For the purpose of cost recovery, another important challenge is to identify and quantify the extent to which environmental and resource costs are internal or external costs, i.e. actually being paid and compensated for or not by those who have caused the environmental and resource costs involved.

Assessment of changes in the value of environmental capital in the Rába RBMP in Hungary

In an extended cost-benefit analysis four possible intervention scenarios were investigated in the Sárvár-Nick section of the Rába River, aiming to determine which status the water body in this section should be given. The approach used is based on a recent publication by van Beukering et al. (2003) and the so-called “effect route” approach. Benefits transfer was used to express changes in natural capital in monetary terms. Benefits transfer is used as a proxy to substitute the usually unknown market prices for values obtained through a method based on people’s willingness to pay. The following changes were considered in the study: change in water quantity, change in erosion, changes in flora and fauna, change in forest stocks. The effects of the following factors were put in concrete numbers: water supply, fishing/fisheries, flood and drought prevention, agriculture, horticulture, water power, tourism, biodiversity and entrapment of CO_2.

The following four scenarios were analysed:

- Scenario A: current flood protection structures will be dismantled, the Nick dam remains;
- Scenario B: both current structures and the Nick dam remain;
- Scenario C: both current structures and the Nick dam will be dismantled;
- Scenario D: current structures remain and the Nick dam will be dismantled.

The basic difference between the scenarios is that some solutions aim to restore the natural state of the specific section of the Rába River, while others imply preserving the strongly altered water body status. The respective scenarios cause different changes in natural capital, and this is taken into account in our calculations. Effects of captions of the intervention list were considered in detail, based on which calculations were made for the following solutions (adjusted, of course, for the individual scenarios): (1) keeping the Nick dam, (2) dismantling the Nick dam, (3) building a flood reducing furrow/gorge, (4) construction of a power station, (5) construction of fish passages, (6) rehabilitation of/restoring backwaters and meanders, (7) building of ports, (8) building circular dikes, (9) wastewater management, (10) construction of a pumping station, (11) re-evaluate area statuses, (12) reinforcement of dikes, (13) removing dikes and (14) water extraction possibilities.

Overall it can be said that all scenarios result in very similar net present values. However, scenarios A and B are more favorable when the heavily modified water body status is preserved, i.e. the Nick dam is not removed. As either removing the dikes or preserving them does not generate significant differences, it is proposed that other criteria also have to be taken into consideration when looking at future modifications to the dikes – for example, which solution is preferred by the population in the area (reinforcing or removing dikes). Scenarios C and D constitute a much smaller overall social benefit than the previous two, especially in the longer run. So, removing the Nick dam is not advisable in any case. The effects of removing dikes and replacing them with circular dikes, or reinforcing them, does not substantially change the result in net present value.

Source: Department of Environmental Economics and Technology of the Budapest University of Economic Sciences and Public Administration

Economic valuation of the environmental services provided by the river Elbe in Germany

One of the most comprehensive and influential work on the valuation of water resources in the recent past has been carried out by Meyerhoff and Dehnhardt (2002), who have estimated the value of the proposed restoration of 10,000 ha of floodplains along the river Elbe. The creation of floodplains involves substantial environmental benefits. Besides their role in curtailing damages from floods, floodplains contribute in particular to the conservation of biological diversity and to nutrient retention. Against this background, the German Ministry for Education and Research commissioned a project on the monetary valuation of the sustainable development of the River Elbe. At the centre of the project was a cost-benefit analysis for the proposed restoration of 15,000 ha of floodplains.

Two distinct methodologies of analysis were used in the study. A contingent valuation study was conducted to evaluate the willingness to pay for the protection of biodiversity and endangered species in the Elbe floodplains through a set of measures. The interviews included both people living nearby as well as people living in other river basins, and users as well as non-users. In addition, the ecosystem services of floodplains in improving water quality were assessed using the replacement cost method, whereby services provided by ecosystems are priced on the basis of technical substitutes. To this end, the floodplains’ capacity for nutrient retention was valued based on the costs of otherwise needed investments for water treatment plants, as well as policy measures to reduce agricultural fertiliser input.

The results of the contingent valuation study demonstrated that 22,5 percent of the people interviewed were willing to financially support the creation of floodplains. An average willingness to pay of € 11,90 per household per annum yielded a total contribution of € 153 million in the first year and € 108 million in the second year, as some of the interviewed people were only willing to pay once. While the willingness to pay was significantly higher for users than it was for non-users, there was no significant difference between people living close to the Elbe and respondents living in other river basins. With respect to the beneficial effects of floodplains on water quality, it emerged that the effects strongly depended upon the local conditions. In general, it was calculated that all planned measures for floodplain restoration would reduce the total nitrogen load of the Elbe by 4%, resulting in annual savings of € 8,8 million. This equals a value of approximately 585 € per hectare and year. In comparison to the costs of floodplain creation, the estimated benefits exceeded the costs. Under different scenarios (sensitivity analysis), the benefit-cost-ration ranged from 2,5:1 to 4,2:1.

Although the study was not carried out in the direct context of the WFD implementation, it does provide a good example of how to approach some of the relevant economic aspects in the WFD. Apart from demonstrating how environmental costs can be included in the selection and design of measures, it also provides evidence of the benefits in terms of environmental damage avoided that users and non-users of the river would derive from a more sustainable development of the river Elbe.

Source: The project was carried out by the Technical University of Berlin and the Institute for Ecological Economic Research, Berlin. See also: Dehnhardt, Alexandra & Jürgen Meyerhoff (eds.), 2002. “Nachhaltige Entwicklung der Stromlandschaft Elbe”, Kiel: Wissenschaftsverlag Vauk Kiel KG.

Assessment of environmental benefits for all water bodies in England and Wales

Type of benefit	£m/year
Informal recreation	6-12
Angling	26-27
Amenity	19
Bathing	20
Groundwater	13
Ecosystems and natural habitats – rivers, lakes	189-405
Ecosystems and natural habitats – wetlands	16-38
Total	289-535
Present value	**4.1-7.6 billion**

Source: Environment Agency England and Wales

Overview French water valuation studies

Water use	Number of studies
Water supply	2
Production	2
Wastewater treatment, transport and storage	3
Inland navigation networks	1
Recreation	17
Ecological use and protection	15
Valuation method	
Contingent valuation	19
Travel cost	7
Hedonic pricing	3
Other (market prices etc.)	11

Source: Amigues et al. (2003)

Economic valuation of the environmental values associated with water use in the River Emå in Sweden

The following study is an example of how economic values provided by the environment can be elicited. It was carried out within the Swedish Water Management Research Programme (VASTRA) and does not represent an official/national approach to valuing environmental and resource costs in relation to the Water Framework Directive.

The River Emå is one of the largest and most valuable water courses in South Sweden. Flora and fauna are very rich with many rare species and unique populations of sea trout and salmon. There is also a varied cultural heritage from the pre-industrial era. Today water is needed for many purposes: human and industrial consumption, power generation, irrigation, recreation, fisheries and as a recipient for wastewater.

The different water uses in the Emå River Basin were studied in order to test and develop methods to assess monetary values for water related goods and services within a catchment area. The benefits originate both from use values (direct and indirect) and non-use values (e.g. existence and option values). Non-use values were not treated in the study. For uses of direct economic importance it was possible to calculate monetary values from market prices, as in the case of hydropower generation (total annual production * price = €3.2 million) and fish production (total annual catch * price/kg = €4.4 million). The value of water for human consumption and irrigation was estimated through extraction cost (total household consumption * cost of extraction/m^3 = €6.9 million, and total agricultural consumption * cost of extraction/m^3 = €0.4 million). In principle, the same method should be applicable to industrial uses, but data were not available. Mitigation costs were used to estimate the value of the river's recipient capacity for emissions from households (total household consumption * cost of WWT/m^3 = €7.3 million) and industry (local emissions from sectors$_{ij}$ as % of sectors$_{ij}$ total emissions = % sectors$_{ij}$ total EPE = €1.3 million), i.e. through costs for wastewater treatment. Shadow prices, including the costs for the restoration of some abandoned but heavily polluted old industrial sites (€1.7 million), the liming of acid lakes (€0.2 million), and nature conservation costs (€0,1 million) were calculated to mirror some recreation values and the maintenance of biodiversity. In all, annual monetary values amounted to €25-26 million. However, care should be taken when interpreting the aggregate value. For the next two decades there are plans to restore fish habitats and to remediate more industrially contaminated areas which would cost €2.2-3.3 million annually.

Source: Summary adapted from M. Löwgren (2001), *Uses of the River Emå – A study of monetary values*, Swedish Water Management Research Programme, funded by the Swedish Foundation for Strategic Environmental Research (MISTRA) and the Swedish Environmental Protection Agency (SEPA).

Overview recent Dutch water valuation studies (in 2002/2003 prices)

Study	Focus	Method	Economic value (average WTP)	Protest bidders (%)	Respondent assessment difficulty answering the WTP question (% not difficult)	Respondent assessment information provided to answer WTP question (% information is sufficient)
Brouwer (2003)	Water quality improvements EU BWQ Directive	CV	€35-45/hh/year	8	62	93
Brouwer et al. (2004)	Ecological restoration of lakes and lakeshores	TC	€50-185/visit	-	-	-
		CV	€58-93/hh/year	14	35	69
Brouwer (2004)	Good ecological status water bodies as foreseen in WFD	CV	€103-108/hh/year	16	65	92

Annex 1: Theoretical foundations

The definition and measurement of environmental and resource costs as presented here in this short paper are based on neo-classical economic welfare theory (e.g. Willig, 1976; Freeman, 1979; Deaton and Muelbauer, 1980; Just et al., 1982; Boadway and Bruce, 1984; Varian, 1984; 1990; Johansson, 1987; 1991). The basic economics of water pollution control can be displayed with the help of the following diagram (see, for example, Tietenberg, 1992).

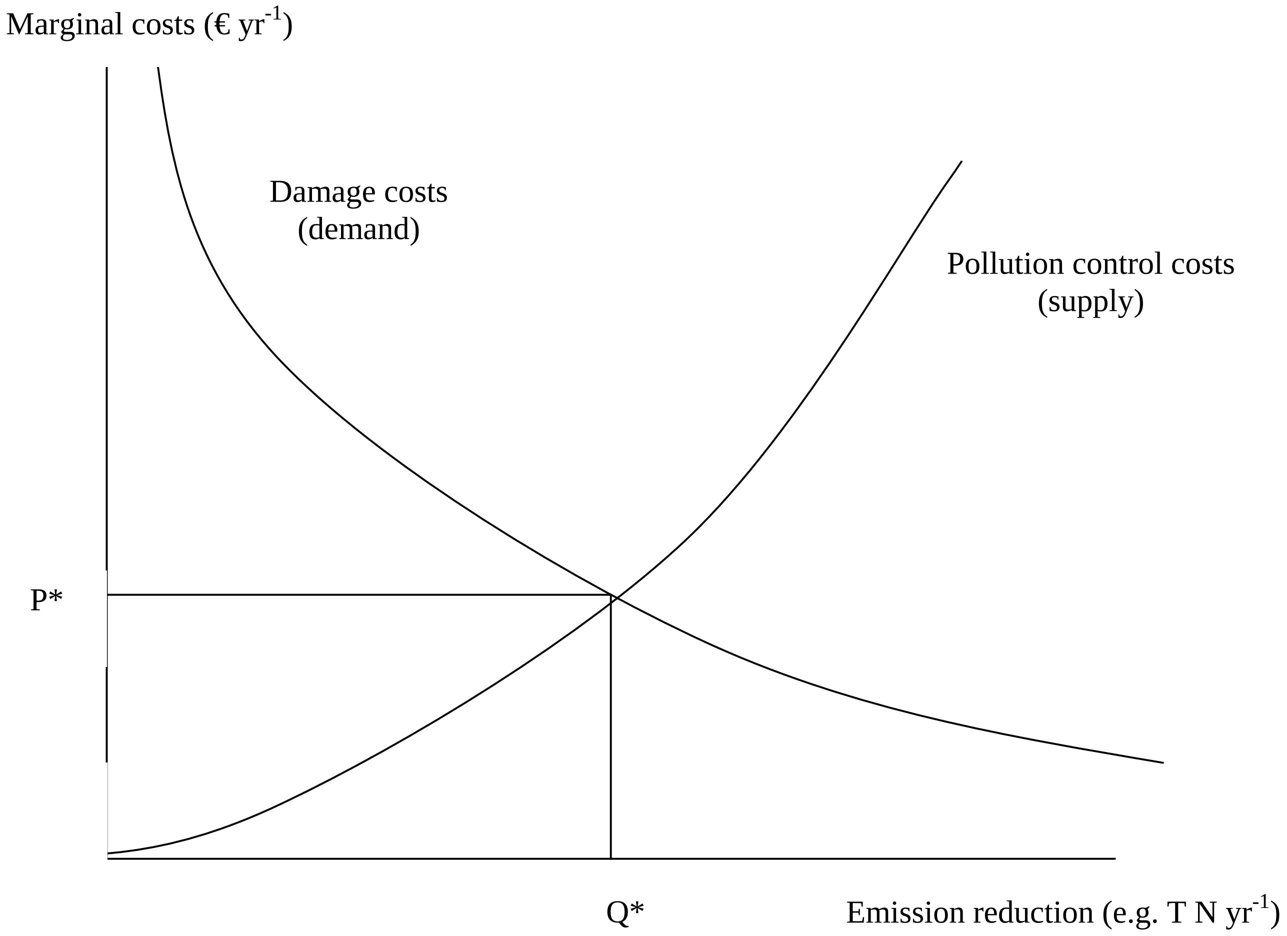


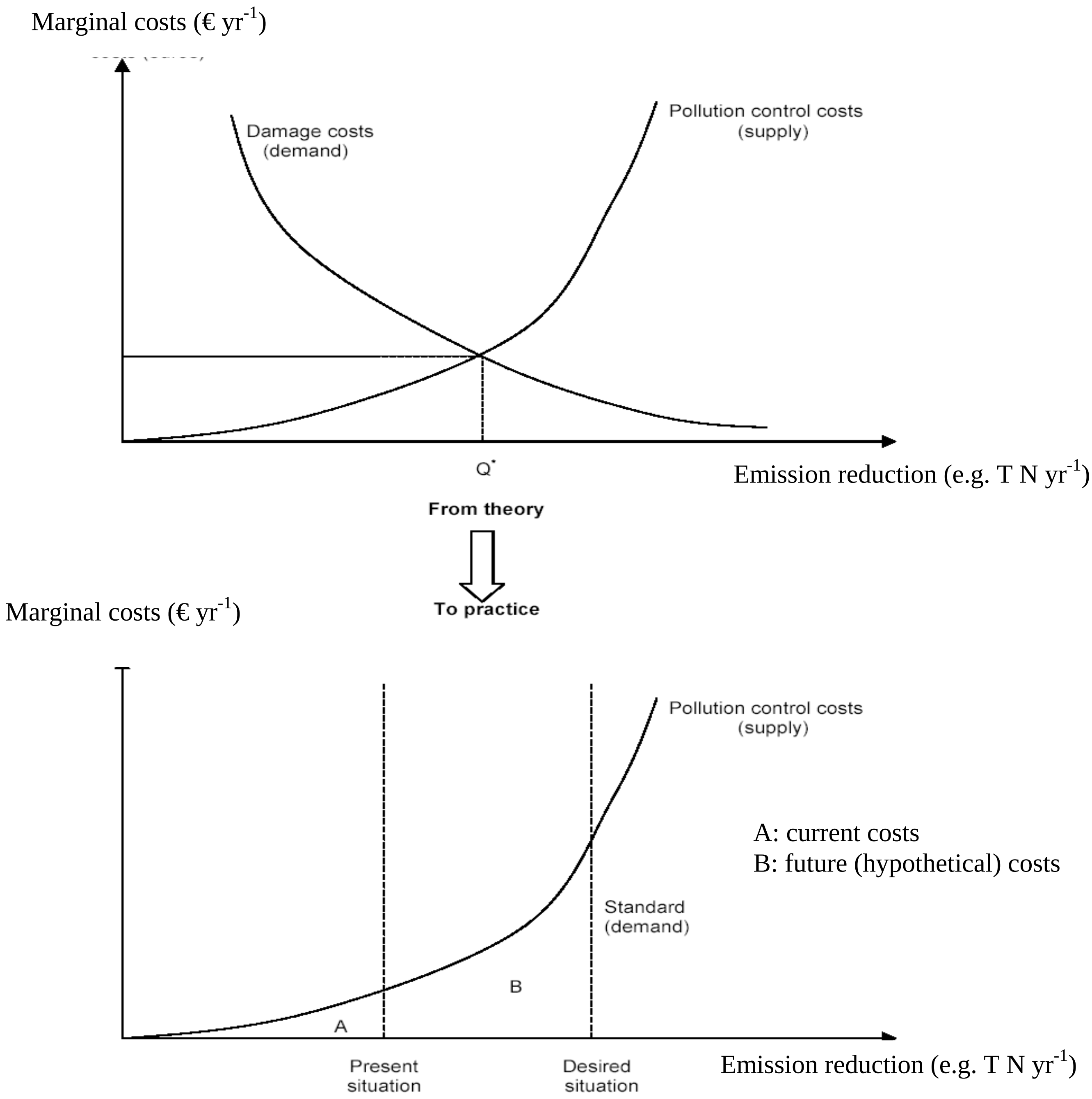
Diagram: Basic economics of pollution control

In the upper part of the diagram, the marginal cost curves are drawn for pollution control and damage costs. The curve for pollution control reflects the cost (supply) side of the story, while the environmental damage curve reflects the benefits (demand) side of the story. Increasing pollution control means that environmental damage costs go down. Low pollution control usually means that damage costs are higher. Ideally, both curves are known and policy responses based on this information result in an economic efficient allocation of pollution control (Q^*)[9].

The pollution control cost curve consists of the various possible (sets of) measures identified to reduce pollution, ranked in increasing order of their costs per unit emission reduction. The damage cost curve should theoretically reflect the monetary value of damage done to society (Pearce and Turner, 1990). However, in practice, physical dose-effect (pressure-state-impact) relationships are often only known partially and usually surrounded by a lot of scientific uncertainty (including damage to ecosystem functioning, species and human beings). Full monetization of these relationships, especially in terms of

[9] Ideally, the so-called Pigovian tax, a pollution charge, is based on this optimal level of pollution, assuming that the pollution control costs are private costs and the environmental damage costs social costs under perfect competition.

(discrete) environmental damage costs, let alone (continuous) marginal damage cost curves, further adds to existing uncertainties and lack of knowledge and information. Damage functions are very difficult to estimate in practice (Pearce and Turner, 1990). In practice, putting the marginal cost curves for pollution control and damage costs together in one and the same diagram, after they have been made comparable and commensurate in one and the same quadrant in terms of time and space, is very difficult and more often than not impossible.



Setting standards which are assumed to reflect demand for environmental quality in the face of these uncertainties and lack of knowledge and empirical data circumvents most if not all of the problems when going for the route of full monetization of environmental damage (see, for example, Faucheux and Froger, 1995). In the lower part of the diagram above, the current (reference) situation and the desired (target) situation (as reflected for example by an environmental standard) are included together with the marginal cost curve for pollution control. The area under the marginal cost curve for pollution control between the present situation and the desired situation (A) reflects the total (environmental protection) costs needed to reach the desired standard for GEQ.

As pointed out in the literature, using the cost-effectiveness of measures to reach an environmental standard as a basis for environmental policy results in a second-best solution from an economic point of view (Baumol and Oates, 1971). However, assuming that the standard reflects society's demand for environmental quality allows one to bring the analysis back in the realm of neo-classic economic welfare theory[10].

[10] Theoretically speaking, demand is inelastic when represented by a standard or norm (and benefits are infinite in that case).

Annex 2: Overview economic valuation methods

Below an overview will be given of existing monetary environmental valuation methods. First, a brief description of selection criteria is given, followed by a brief summary of each method. This annex is based on chapter 4 (Guidelines for Economic Valuation) in: Georgiou, S., Whittington, D., Pearce, D.W. and Moran, D. (1997). Economic values and the environment in the developing world. Edward Elgar, Cheltenham, UK. We are grateful to Stavros Georgiou and his co-authors for allowing us to use this chapter in this information sheet.

Choosing between valuation techniques

All valuation techniques have strengths and weaknesses, and the decision on which to use for a particular application requires experience and judgement on the part of the analyst. Some general points for the analyst to consider when making this choice are set out below.

First, it is often possible to use more than one valuation technique and compare the results. All methods involve some uncertainty; if the analyst has multiple estimates, he or she will have greater confidence in the value of the proposed change.

Several of the valuation techniques typically use data from a household survey (for example contingent valuation, travel cost and hedonic property pricing methods). When a technique requires that primary data be collected with a household survey, it is often possible to design the survey to obtain the data necessary to undertake more than one valuation method. Household surveys are required for contingent valuation, opportunity cost and travel cost studies. Such surveys need to be designed with the goal of producing value estimates using multiple methods.

Second, different valuation techniques may measure different things. In this sense they should be considered as complimentary rather than competing tools. For example, the contingent valuation method is the only available technique for measuring non-use (or passive use) values. Suppose that estimates of use value of a national park and wildlife reserve were obtained using a travel cost model and estimates of non-use value were obtained from a contingent valuation survey. These value estimates are not substitutes for one another; both may be useful for policy makers.
Similarly, revealed preference methods measure the perceived benefits to individuals; they do not capture the value of effects of which people are unaware. For example, if individuals do not know that a cancer-causing substance is in their drinking water, they obviously will not take action to avoid this risk. There will thus be no 'behavioural trail' that an analyst can follow to determine how much they would be willing to pay to avoid such a risk. However, using the damage function approach, an analyst could estimate the reduced cancer deaths that would result if the carcinogenic substance were to be removed from the water supply.

Third, it is important to consider the needs of the user(s) of valuation studies. In some cases clients have preferences for the use of one valuation technique over another. For example, estimates obtained from travel cost or hedonic property pricing methods may be considered too theoretical or too complex. A particular client may feel that contingent valuation estimates are too subjective and unreliable to support policy debate and discussion. The analyst carrying out policy work must be sensitive to such concerns.

Fourth, the analyst should consider not only the client's needs, but also the needs of the public. Information elicited on people's values for environmental improvement is often of great interest to a wide variety of groups in society. In choosing a valuation technique, thought should be given to how the information obtained will be received by the public and interested parties other than the immediate client. Information from valuation studies could be used in a 'top-down' hierarchical planning process or it could contribute to democratic dialogue or a participatory political process. A technique such as contingent valuation bears a resemblance to a referendum or voting process. Whereas the final decision on a policy or project may not be determined by an election, the process of eliciting information on people's preferences involves a certain degree of participation in decision-making. Analysts need to be aware of the consultative nature of the valuation task and sensitive to the political implications. They should choose techniques that inform and facilitate public debate. One useful step is to hold public hearings or meetings with local community leaders to explain the findings of valuation studies.

Fifth, the cost of carrying out a valuation study or set of studies must be weighed against the value of the information in helping to make a better policy or project decision. Clearly more money could be spent on a valuation study than a policy decision warrants. But it is also important to keep in mind that many policies and projects have large-scale environmental implications that extend far into the future. In this case there is a substantial risk that too little money will be spent on the use of valuation techniques.

Summary of valuation techniques

Brief summaries of the main techniques and their relative strengths and weaknesses are presented below.

1. Contingent Valuation Method (CVM)

Range of Applicability	Extensive, since it can be used to derive values for almost any environmental change. This explains its attractiveness to 'valuers'. Only method for eliciting non-use values.
Procedure	Involves administering a carefully worded questionnaire which asks people their WTP and/or WTA compensation for a specified environmental change. Econometric analysis of survey results is generally required to derive mean values of WTP bids and to estimate the determinants of respondents' WTP. Literature tends to suggest that most sensible results come from cases where respondents are familiar with the asset being 'valued'.
Validity	The literature has identified various forms of potential bias. 'Strategic bias' arises if respondents intentionally give responses that do not reflect their 'true' values. They may do this if they think there is potential to 'free ride'. However, there is limited evidence of strategic bias. 'Hypothetical bias' arises because respondents are not making 'real' transactions. Costs of studies usually limits the number of experiments involving real money (criterion validity), but some studies exist. Convergent validity is good. Construct validity – relating value estimates to expectations of values estimated using other measures – is debated, especially the marked divergence in many studies between WTP and WTA compensation.
Reference	Case material is extensively reviewed in Mitchell, R. and Carson, R. (1989).

2. Contingent Ranking Method (CRM)

Range of Applicability	Extensive. Limited number of studies exist and are confined to 'private goods' – that is goods purchased in the market place. It is unclear how extensive the range of application could be for environmental goods.
Procedure	Individuals are asked to rank several alternatives rather than express a WTP. Alternatives tend to differ according to some risk characteristic and price. Method could be extended to a ranking of house characteristics with some 'anchor' such as the house price being used to convert rankings into WTP.
Validity	Not widely discussed in the literature, but is theoretically valid. Too few studies exist to test other validity measures but initial results suggest CRM WTP exceeds CVM WTP.
Reference	Magat, W., Viscusi, W.K. and Huber, J. (1987).

3. Conventional market approaches, incl.dose–reponse, replacement, and opportunity cost approaches

Range of Applicability	Extensively used where 'dose–response' relationships between pollution and output or impact are known. Examples include crop and forest damage from air pollution, materials damage, health impacts of pollution, output losses from soil erosion, sedimentation from soil erosion. Limited to cases where there are markets or where shadow prices can be estimated – that is the method cannot be used to estimate non-use values.
	Replacement cost approaches also widely used because it is often relatively easy to find estimates of such costs. Replacement cost approaches should be confined to situations where the cost relates to achieving some agreed environmental standard, or where there is an overall constraint requiring that a certain level of environmental quality is achieved.
	Opportunity cost approaches are very useful where a policy precludes access to an area – for example estimating forgone money and in-kind incomes from establishment of a protected area.
Procedure	Dose–response: takes physical and ecological links between pollution ('dose') and impact ('response') and values the final impact at a market or shadow price. Most of the effort usually resides in the non-economic exercise of establishing the dose–response links. Multiple regression techniques often used for this.
	Replacement Cost: ascertain environmental damage and then estimate cost of restoring environment to its original state.
	Opportunity Cost: ascertain functions of displaced land use and estimate in-kind and money incomes from those uses. May require detailed household surveys to establish economic and leisure activities in the area in question.
Validity	Dose–response: theoretically a sound approach. Uncertainty resides mainly in the errors in the dose–response relationship for example where, if they exist, are threshold levels before damage occurs? Are there 'jumps' (discontinuities) in the dose–damage relationship? An adequate 'pool' of studies may not be available for cross-reference.
	Criterion validity not relevant since presence of 'real' markets tends to be a test in itself – that is revealed preferences in the market place are being used as the appropriate measure of value.
	Replacement Cost: validity limited to contexts where agreed standards must be met.
	Opportunity Cost: sound measure of damage done by a given land use that precludes other activity. More sophisticated estimates would include lost consumer surplus.
Expense	Dose–response can be costly if large databases need to be assembled and manipulated in order to establish dose–response relationships. If dose–response functions already exist, the method can be very inexpensive and quick. Replacement cost is inexpensive if engineering data exists.
Reference	US Environmental Protection Agency (1985).

4. Surrogate markets: avertive behaviour

Range of Applicability	Limited to cases where households spend money to offset environmental hazards, but these can be important – for example noise insulation expenditures; risk-reducing expenditures such as smoke-detectors, safety belts, water filters, and so on.
	Has not been used to estimate non-use values though arguable that payments to some wildlife societies could be interpreted as insurance payments for conservation.
Procedure	Whilst used comparatively rarely, the approach is potentially important. Expenditures undertaken by households and designed to offset an environmental risk need to be identified. Examples include noise abatement, reactions to radon gas exposure – for example purchase of monitoring equipment, visits to medics, and so on
Validity	Theoretically correct. Insufficient studies to comment on convergent validity. Uses actual expenditures so criterion validity is generally met.
Expense	Econometric analysis on panel and survey data is sometimes needed. Can be fairly expensive.
Reference	Dickie, D., Gerking, S. and Agee, M. (1991).

5. Surrogate markets: travel cost method

Range of Applicability	Generally limited to site characteristics and to valuation of time. Former tends to be recreational sites. Latter often known as discrete choice – for example implicit value of time can be estimated by observing how choice between travel modes is made or how choice of good relates to travel time avoided.
	Cannot be used to estimate non-use values.
Procedure	Detailed sample survey needed of travellers or households, together with their costs of travel to the site. Complications include other possible benefits of the travelling, and presence of competing sites.
Validity	Theoretically correct, but complicated when there are multi-purpose trips and competing sites. Some doubts about 'construct validity' in that number of trips should be inversely correlated with 'price' of trips – that is, distance travelled. Some UK studies do not show this relationship. Convergent validity generally good in US studies. Generally acceptable to official agencies and conservation groups.
Reference	Willis, K. and Benson, J. (1988).

6. Surrogate markets: hedonic property pricing

Range of Applicability	Applicable only to environmental attributes likely to be capitalised into the price of housing and/or land. Most relevant to noise and air pollution and neighbourhood amenity.
	Does not measure non-use value and is confined to cases where property owners are aware of environmental variables and act because of them (as with avertive behaviour).
Procedure	Approach generally involves assembly of cross-sectional data on house sales or house price estimates by estate agents, together with data on factors likely to influence these prices. Multiple regression techniques are then needed to obtain the first estimate of an 'implicit price'. A further stage of analysis is required since the multiple regression approach does not identify the demand curve directly.
Validity	Theoretically sound, though market failures may mean that prices are distorted, that is markets may not behave as required by the approach. Data on prices and factors determining prices often difficult to come by. Limited tests of convergent validity but generally encouraging results.
Reference	Brookshire, D. et al. (1982).

7. Surrogate markets: hedonic wage-risk estimation

Range of Applicability	Limited to valuation of morbidity and mortality risks in occupations. Resulting 'statistical values of life' have been widely used and applied elsewhere, for example in the dose–response approach.
Procedure	As with other hedonic pricing methods, the approach uses multiple regression to relate wages/salaries to factors influencing them. Included in the determining factors is a measure of risk of accident. The resulting 'wage premium' can then be related to risk factors to derive the so-called value of a statistical life.
Validity	Theoretically sound. Convergent validity may be tested against CVM of risk reduction, but wage-risk approach measures WTA compensation not WTP.
Reference	Marin, A. and Psacharopoulos, G. (1982).

Annex 3: Glossary of Terms

Benefits	The benefit of a project, programme or policy is the positive expected aspect of an outcome, including the improvement in environmental protection or environmental quality which will flow from it, but also including other improvements - for example, in cost savings, social benefits such as health, convenience, or general welfare.
Costs	The costs of a project are the opportunity costs -the full value of any resource in its best alternative use. This may be estimated by the financial expenses incurred by an operator or proponent in meeting the requirements placed upon them by the authorising body, or any expenses incurred by a Government body in carrying out its activities; similarly, the cost of a programme or policy is the expected financial expense of implementing the programme or policy by those it will affect. Costs also include any environmental, resource, human health or other social impacts which are detrimental in nature. Costs include any capital (and the opportunity costs of this capital) and recurrent expenditure, administrative costs, monitoring and enforcement costs, and research and development costs. Economic costs include market and non-market costs, private and social ones.
Cost-benefit analysis	Economic analysis of an undertaking, involving the conversion of all positive and negative aspects into common units (e.g. Money) so that the total benefits and the total costs can be compared. It also involves clearly defining the state of affairs which would prevail if the undertaking was not taking place. The costs and benefits of an undertaking reflect the difference between the state of affairs without and with the undertaking. Cost-benefit analysis (CBA) Is based on the principle that an investment project should only be undertaken if all its benefits outweigh all Its costs. If a project has several alternative forms, or there are competing projects, the one with the highest benefit cost ratio should normally be chosen. As costs and benefits (including those of an environmental nature) can only be added and subtracted if expressed In the same units, CBA attempts to place monetary values on them, money being a convenient 'measuring rod of value'. Whilst It can be a useful way of weighing environmental considerations in the balance with economic considerations, there are problems in the use of monetary valuation techniques. CBA provides a conceptual framework which evaluates projects by taking into account all the costs and benefits arising over time and which seeks to quantify in money terms (CBA) as many of the costs and benefits of a proposal as possible, including items for which the market does not provide a satisfactory measure of economic value. Procedure for valuing gains (benefits) and losses (costs) in monetary terms inevitably entails value judgement about certain benefits and costs for which no monetary value exists. These must be made explicitly so that they can be challenged and evaluated, particularly during the WFD Article 14 activities.
Cost-effectiveness analysis	A technique similar to Cost Benefit Analysis, but which seeks to identify how to meet. A particular objective, at least cost. It enables prioritisation between options, but ultimately cannot assess whether an objective is economically worthwhile A method that finds the option that meets a predefined objective at minimum cost
Cost recovery	Extent to which the production or supply costs of a specific good or service are covered by the revenues.
Damage	Physical deterioration or degradation of the physical environment or detrimental impact of human activities on the environment and those who use the environment.
Damage costs	Welfare loss associated with the deterioration or degradation of the physical environment.
Economic value	The monetary measure of the welfare associated with the change in the provision of some good. It is not to be confused with monetary value unless the latter is explicitly designed to measure the change in welfare, nor with financial value which may reflect market value or an accounting convention. As Freeman (1993), notes the terms 'economic value' and 'welfare change' can be used interchangeably.
Effect	Any response by an environmental or social component to an action’s impact. Under the Canadian Environmental Assessment Act, "environmental effect" means, in respect of a project, "(a) any change that the project may cause in the environment, including any effect

	of any such change on health and socio-economic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by aboriginal persons, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance and (b) any change to the project that may be caused by the environment, whether any such change occurs within or outside of Canada".
Environmental costs	
External costs	An externality is said to exist when the actions of one individual affect the well-being of other individuals, without any compensation taking place through the market. For example, the discharge of a CSO will be a negative extemality to informal recreational users to the extent that it will lead to an aesthetic degradation of the river corridor for which they will not receive any compensation which would lead them off as well as if the CSO discharge had not happened.
Internal costs	Welfare loss which has been compensated.
Loss	A negative outcome.
Marginal cost	Of a good or service is how much it costs to produce just one more unit of it. Measurement of marginal cost depends on the time frame considered. Short term marginal cost may often be derived from variable cost -- the extra labour and raw materials, for example. Measuring long term marginal cost may entail modification to relevant assets and costs which are considered fixed over a shorter period, such as the capital cost of a factory. The measurement of marginal cost crucially depends on the unit of production chosen, particularly in a network industry. The marginal cost of an additional unit of water is different from the marginal cost of an additional connection to the network for instance.
Market	Place where goods and services are traded.
Market price	The price at which a commodity is bought or sold.
Market value	Value of a commodity when sold on a market.
Mitigation	The elimination, reduction, or control of the adverse environmental effects of the project, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation, or any other means
Natural resources	Stock of environmental (ecosystem) goods and services.
Net present value	The sum of discounted future costs and benefits
Non-priced good	A resource is non-priced if it is not traded through a well-defined market. Many environmental resources fall into this category. This because it is difficult to define property rights over them, and if something is not owned then it cannot exactly be traded. Since the observation of market prices provides an important basis for the valuation of resources in economics, non-priced goods are somewhat harder to value.
Opportunity costs	Refers to the net benefit forgone because the resources providing the service can no longer be used in their next most beneficial use. It is measured by the value of the resources in their most valuable alternative use.
Polluter Pays Principle	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 Means including environmental costs in the price of products. The public still ultimately bears those costs, but through products and services we choose to buy, rather than through general taxation. The concept of polluter pays includes that of user pays
Present value	The capitalised value of a stream of future costs or benefits. The term Net present value (NPV) is often used to describe the difference between the present value of a stream of costs and a stream of benefits.
Pressure	A threat or pressure which is affecting the state of some aspect of the environment e.g. Traffic levels). Forms part of the state-pressure-response model for environmental indicators.
Price	See market price.
Private good	Effectively a good that can be marketed. (See 'Public Good).
Property right	The right to a particular resource. Property rights over environmental resources are often ill-defined.
Public good	One where the provision of the good for one individual necessarily makes it available for others and which it is not possible to prevent others using. (See Private Good).
Resource	Anything that is used directly by people. A renewable resource can renew itself or be renewed at a constant level. A non-renewable resource is one whose consumption necessarily involves its depletion.
Resource cost/benefit	Cost of marketed goods or services which reflects actual resources used in their production (material, labour), but not taxes, subsidies and other transfers which may affect financial costs.

Revenues	Monetary benefits derived from the sale of a good or service.
Shadow price	A concept which seeks to express the real value of goods, services, etc., It may reflect opportunity costs in some cases, or an aggregated 'willingness to pay' for something in other cases. Estimates of the costs of resources which represent their true opportunity costs, in circumstances when observed market prices do not. In perfect markets, shadow prices will simply be equal to market prices, but distortions in the market, such as the presence of monopoly power or of taxes which do not correct externalities, lead to a divergence between market prices and shadow prices.
Social benefit	The benefit that accrues to individuals from economic activity other than those who are the generators of the benefits. It is the difference between the total and private benefits that arise from a project.
Standard	An accepted or approved example of something against which others are measured. Standards allow meaningful evaluation, negotiation, lawmaking and comparison site to site, country to country and year to year. To be of use, they must be agreed, reliable and measurable (using common units) levels; for example, the level of lead in drinking water that is considered toxic, or the level of ozone in a city street regarded as harmful. For enforcement purposes a 'standard' means a limit, the maximum level permitted. A set of Criteria or requirements that is generally agreed upon. Values of the benefits from improvements in water quality that are obtained by past studies. Environmental, management and performance criteria that may not be exceeded, and that are monitored and controlled on an ongoing basis.
Stock	In the context of environmental capital, 'capital stock' refers to the environmental resource itself, measured as a snapshot at a particular point in time. Measurement would not generally be in monetary terms but in terms of the attributes associated with this resource.
Total economic value	Total economic value of an environmental resource is made up of, i) use values and ii) non-use values. Use values are composed of a) direct use value, b) indirect use values and c) option values, whilst non-use values are made up of a) altruistic, b) existence values and c) bequest values.
Utility	A measure of the satisfaction individuals receive from the consumption of goods and services. Its measurement may be based on observation of market price, willing to pay or behaviour of individuals or populations when choosing between alternatives.
Welfare cost	Any effect on human well-being (or benefit).

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