

Practical Working Definition Environmental and Resource Costs and Benefits (Deliverable D12)

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1. Introduction

This paper aims to provide a practical working definition for the concept of environmental and resource costs and benefits in the Water Framework Directive (WFD). Despite their description in the 2002 Wateco guidelines and the 2004 ECO2 information sheet¹, their definition, estimation and use are still surrounded by a lot of discussion.

It's not so much the general idea that water use imposes a cost on the water environment and those who use this environment, which often remains unaccounted for in policy and decision-making, that is disputed. Cause for debate is primarily (1) the explicit distinction between environmental costs and resource costs, (2) their practical measurement, either through cost or benefit based approaches, and (3) the extent to which these costs have already been accounted for in existing pricing and financing mechanisms. The focus of this paper is on the first two points, with an emphasis on the distinction between environmental and resource costs. We furthermore look at environmental and resource costs and benefits in view of the fact that the two are closely related. However, their assessment may serve different purposes in the WFD. The extent to which environmental and resource costs have already been accounted for through existing financial and economic instruments is beyond the scope of this writing.

The theoretical basis of the concept of environmental and resource costs and benefits will be briefly addressed in this paper, followed by a proposal for their working definition and a brief, preliminary discussion of their practical estimation. A short introduction to the relevant policy context of environmental and resource costs and benefits in the WFD is presented in the next section first. A more detailed discussion of the relevant policy context of environmental and resource costs and benefits is found in AquaMoney deliverable D14 due during the first half of 2007, which presents the results of the AquaMoney inventory of policymaker demand for information about environmental and resource costs and benefits across Europe.

¹ ECO2 was a drafting group established in 2003 under Working Group B Integrated River Basin Management in the WFD Common Implementation Strategy to address and advise the Working Group B on the specific issue of environmental and resource costs, resulting in an information sheet.

2. Role of environmental and resource costs and benefits in the WFD

Environmental and resource costs are introduced (but not defined) for the first time ever in environmental EU legislation in paragraph 1 in article 9 in the WFD, which states that ‘*member states shall take account of the principle of recovery of the costs of water services, including environmental and resource costs,... , and in accordance in particular with the polluter pays principle*’. Water services are defined in paragraph 38, article 2 in the WFD: ‘*Water services means all services which provide, for households, public institutions or any economic activity: (a) abstraction, impoundment, storage, treatment and distribution of surface water or groundwater; (b) waste water collection and treatment facilities which subsequently discharge into surface water.*’ Cost recovery is a well-known economic pricing principle, implying that the total private and social production costs of a good or service are fully recovered. In order to assess the level of cost recovery, one has to know the total production costs and the way these costs are paid for by the different users of the water service through existing pricing and financing mechanisms. Article 9 in the WFD also specifies that water users provide an ‘adequate’ contribution to the level of cost recovery. However, what exactly constitutes an adequate contribution is not defined.

Although article 9 is the only place in the WFD, where environmental and resource costs are mentioned explicitly, they are closely related to the economic analysis underlying articles 4 and 11. If the environmental water quality objectives defined in article 4 are not met, article 11 asks water managers to identify a cost-effective program of measures to reach them. If the costs of these measures are considered disproportional, paragraphs 3-7 in article 4 provide water managers with a legal instrument to lower their environmental objectives or delay their achievement in time. Disproportionate costs are not defined in the WFD either and clear international benchmarks, for instance from other European Directives such as the IPPC or Habitat Directive, are lacking and hence also this concept gives rise to a lot of discussion. However, most economists will argue that a comparison with the economic benefits of reaching the environmental WFD objectives is an important and necessary first step in order to be able to assess disproportionate costs from an economic point of view, even though the WFD does not explicitly ask for a cost-benefit analysis (CBA). This is also the reason why AquaMoney refers to both environmental and resource costs and benefits, where the role of environmental and resource costs and benefits in relation to article 4 can be to show whether the costs outweigh the benefits in a CBA, including the environmental and resource costs avoided (=benefits) by specific pollution control measures and/or the environmental and resource benefits involved. In the cost-effectiveness analysis (CEA) underlying article 11 it is important to highlight any environmental damage cost or other cost arising as a result of an inefficient allocation of water and pollution rights associated with specific alternative programs of measures.

3. Theoretical background

3.1 Total cost concept

The cost of a productive activity consists, in theory, of the opportunity costs of the necessary inputs. The opportunity cost of employing an input is the highest benefit generated had it been employed elsewhere. This is the cost to society of use of the resource. Opportunity costs seek to measure the full societal cost of an action or policy option that employs a natural resource such as water. It is considered in terms of a change at the margin, i.e. marginal opportunity cost, because management decisions usually entail relatively small changes in resource use. Opportunity costs comprise three components (Pearce and Markandya, 1989; Turner et al., 2004):

- Direct economic user cost of water, such as for example the costs of labor, equipment and materials used for abstraction or wastewater treatment. Such costs require adjustment for any subsidies, taxation and market imperfections in order to reflect true opportunity costs (shadow pricing).
- External cost that arises from water use (abstraction or pollution). This is the net value of any losses and gains in welfare that water use imposes on individuals other than those engaged in the activity (direct user)². External costs arise because changes in one component of the natural resource base affect other components and the efficiency with which other (production and consumption) activities can be conducted.
- Scarcity rent due to resource exploitation resulting in its non-availability for future use. The scarcity rent relates to the value of the opportunity foregone by exploiting and using a water resource in the present period rather than at some time in the future. It also incorporates increases in the costs of future resource use and exploitation that occur as a consequence of current use and exploitation. For example increases in costs of future groundwater pumping in alternative, less easy accessible places.

If input and output markets exist and function well (e.g. perfect competition, full information, no external effects), the opportunity costs are reflected in the market prices paid for the inputs. For example, the price of the necessary labour, equipment or electricity to produce a good or service. However, in some cases, inputs are used or outputs produced for which no markets exist and hence also no market prices are available to reflect their opportunity costs or which are traded in distorted markets, which do not reflect the real opportunity costs of the inputs used or outputs produced. These inputs or outputs usually involve so-called public goods or services, i.e. goods or services which can technically and often also institutionally not be broken down in separate and individually purchasable units. Examples include natural resources such as air and water and their natural purification processes or their function as a disposal sink for emitted pollutants. Here, environmental damages caused by water use (e.g. water abstraction or the emission of pollutants) often do not result in a private cost to individual agents, but in a social cost to society. Failure to set water charges for irrigation on the basis of opportunity costs has for example been a classic cause of inefficiency in the agricultural sector (Repetto, 1986).

3.2 Total economic value concept

Opposite the opportunity costs of water is the economic value or benefit of a specific water use. Here a distinction has to be made between market and non-market values. Market value is the value of water when sold on a market if there exists any. For example water sold on a market as a raw input in an economic production process, for final domestic use (tap water), or the value of market goods and services provided by aquatic ecosystems, such as fish or reed. In cases where there exists no market, for example when the water resource is treated as a common property, open-access resource where property rights are not defined or not enforced, and water use is non-exclusive and non-rival in nature (i.e. public good) or open-access results in rivalry such as congestion, values can be measured through individuals' preferences for the conservation or improvement in water resource quality as well as individuals' loss of welfare owing to resource depletion or quality decline. The value people attach to un-priced natural resources such as water and the services these

² An external cost exists when the following two conditions prevail (Pearce and Turner, 1990):

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

resources provide is measured in money terms through the concept of individuals' willingness to pay (WTP) or willingness to accept (WTA) compensation. 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.* Cummings *et al.*, 1986; Arrow *et al.*, 1993). One important reason for this endorsement is that WTP is theoretically constrained by income levels whereas WTA is not. The WTP measure is therefore believed to produce more reliable valuation outcomes.

Aggregated across those who benefit from natural resources and their services and who will hence be affected by any change in their provision level, including quality level, the aggregated WTP or WTA amount provides an indicator of their total economic value (TEV). Environmental economists have introduced a taxonomy of this TEV, distinguishing between use values and non-use values, in order to account for the various reasons and motives people may have to value environmental change. 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.

An aggregate measure of the impact on social welfare does not consider inequalities in the distribution of gains and losses among individuals. Willingness to pay relates essentially to individuals' ability to pay, which determines the relative weights assigned to their preferences. Its use infers acceptance of the prevailing distribution of income.

The monetary WTP and WTA measures indicate how changes in the provision level of public environmental goods, including quality changes, impact upon individual welfare. The notion of individual welfare is at the core of neo-classical economic theory, from which the values above are derived. In this theory, values are determined by what individuals want (individual preferences) and measured by the extent to which they are willing to trade-off scarce means such as time or money income to obtain something (secure a gain), preserve something (prevent a loss) or accept in compensation when losing something (either forego a gain or tolerate a loss). A change in welfare is evaluated as the money income adjustment (WTP or WTA) necessary to maintain a constant level of welfare before and after these changes (Hicks, 1939).

A distinction can be made between two types of welfare measures based on two different points of reference (Hicks, 1943): the 'compensating surplus' (CS) and the 'equivalent surplus' (ES). The former equals the money income adjustment necessary to keep an individual at his initial welfare level before the change in the provision level of a public environmental good, while the latter equals the money income adjustment necessary to maintain an individual at his new welfare level after the change in the provision level of the environmental good. Four relevant welfare measures associated with welfare gains and welfare losses can be distinguished (Bateman and Turner, 1993):

- WTP to secure a welfare gain (CS_{WTP});
- WTA to forego a welfare gain (ES_{WTA});
- WTP to prevent a welfare loss (ES_{WTP});
- WTA to tolerate a welfare loss (CS_{WTA}).

The choice for one of these measures depends *inter alia* on the perceived distribution of property rights to the environmental good or service involved (*e.g.* Freeman, 1979; Knetsch and Sinden, 1984; Hanemann, 1991).

3.3 Costs and benefits

The distinction between costs and benefits is from an economic point of view based on the question whether a change in water use results in a welfare gain or a welfare loss and to whom. A welfare gain to one can be considered a cost to another and vice versa. The distinction depends furthermore on the point of reference or starting point as illustrated in the previous section through the four welfare measures. Benefits are usually defined as any positive effect for which identifiable affected parties are willing to pay, whereas costs are the

value of the opportunities foregone because of the commitment of resources to a specific project or policy, or the willingness to pay to avoid detrimental effects (Young, 2005, p.31-32).

From the discussion in the previous section, it has become clear that in principle environmental and resource costs are measured based on the total cost concept and environmental and resource benefits based on the concept of total economic value. However, in some cases the external cost or scarcity rent component in opportunity costs may consist of non-market welfare changes including benefits foregone, which are only measurable in money terms through direct or indirect non-market WTP or WTA valuation methods, i.e. based on the concept of total economic value.

An example is the case where a factory located upstream along a river uses water from the river in its production process to produce for example food or chemical products and discharges wastewater (after some treatment) from this production process in the river, which pollutes the water downstream. This polluted water results in higher purification costs for drinking water companies located downstream and loss of recreational fish stock. The higher purification costs of the drinking water companies and the loss of recreational opportunities are real welfare losses and are the opportunity costs of the factory's water use. The former can be measured through market prices, i.e. an increase in the material, electricity and labor costs of producing clean drinking water, while the latter concerns primarily non-market values, which can be measured through non-market based WTP or WTA approaches depending on the distribution of the rights to the river: does the factory have the right to pollute (what is the anglers' WTP to prevent this pollution?) or do the anglers have a right to clean water and a healthy and diverse fish stock (what is the anglers' WTA to tolerate the welfare loss?). Hence depending on the point of reference, costs can consist of benefits foregone, which can be measured through the concept of total economic value³. This close relation between costs and benefits is another reason why AquaMoney refers to both environmental and resource costs and benefits. A similar example would be the extraction of a limited stock of available freshwater during the dry summer period by multiple water users along a river, where water extraction in the face of scarcity by one water user upstream (e.g. agriculture) results in opportunity costs to other for the same water competing water users downstream (e.g. drinking water or recreation).

Finally, it is important to point out the difference here between price and value. Price and value are two distinct concepts. Water *per se* or water of a certain quality has value, but may have no price. Alternatively, water (of a certain quality) may have a price, but this price does not reflect the true economic value of water (or the value of a specific quality level). Hence the need to calculate and impute shadow prices for water use and the goods and services provided by aquatic ecosystems under circumstances where existing prices are believed to undervalue or overvalue the resource and economic efficiency is an important guiding principle in water (allocation) management. For the estimation of shadow prices different methods are available as we will see in section 5. These estimated shadow prices can subsequently be used to calculate the total economic value of a specific water use (e.g. the amount of water consumed times its shadow price), including environmental and resource costs and benefits of water use. Furthermore, existing pricing systems can be modified based on these shadow prices to allow economic market mechanisms of supply and demand re-allocate scarce resources, including water, across different water uses and users and reduce possible inefficiency in current resource use.

³ It is important to point out that irrespective of property rights, there is always a damage cost as a result of water pollution if it involves a welfare loss to some party!

4. Practical working definition

Although no explicit distinction is made in the existing environmental economics literature between environmental and resource costs (for an overview see Schaafsma and Brouwer, 2006), the terms have been interpreted and defined as two separate concepts in the Wateco guidance and subsequently also in the ECO2 information sheet. In the Wateco guidance's glossary of terms, environmental costs are defined as '*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)*'. Resource costs are furthermore set equal to 'scarcity costs'.

Similar definitions are used in the ECO2 information sheet where environmental costs '*consist of the economic value of the physical environmental damage costs of aquatic ecosystem degradation and depletion caused by a particular water use (e.g. water abstraction or the emission of pollutants)*' and 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*'.

The distinction between environmental and resource costs in the Wateco guidance seems to be based primarily on the question whether the water resource is depletable (non-renewable) or not, while the ECO2 information sheet introduces the notion of use and nonuse values into the equation, where environmental damage costs could be argued to refer to non-use values attached to a healthy functioning aquatic ecosystem and the opportunity costs of those who use the water environment to the corresponding use values⁴. The ECO2 information sheet proposes to use the outcome of the gap analysis in the WFD (i.e. the established difference between the expected water status in 2015 and good chemical and ecological status in 2015) as the basis for the economic valuation of physical environmental damage costs. Both the Wateco guidance and the ECO2 information sheet use the term 'opportunity costs' to describe and delineate resource costs and this seems to be considered a distinctive feature between environmental and resource costs. However, given the definitions above, the concept of opportunity costs as described in the previous section may equally apply to both environmental and resource costs.

Hence, the concepts basically seem to be defined in a more or less distinctive way along the lines of either:

- their natural characteristics and depletable nature as a result of (non)sustainable water use, and/or
- the economic and institutional conditions (e.g. water allocation and/or pollution rights) under which a variety of cost types arise as a result of specific water use, including the current and future opportunity costs of water use.

A distinction based on terms such as 'depletion' (used in the Wateco guidance for resource costs) and 'degradation' (used in the ECO2 information sheet for environmental costs) and a corresponding distinction between renewable and non-renewable (stocks of) water resources along the first line depends on available information and indicators regarding practical and operational threshold levels of water use (e.g. at what point does degradation turn into depletion of a natural resource?). This type of information (e.g. extraction rate < regeneration rate; emission rate < absorption rate) is not always available or clear-cut in practice given the functional complexity of aquatic ecosystems. A distinction along the second line depends on the estimation of demand for and supply of water in specific quantities and qualities, at different locations now and in the future.

⁴ According to the ECO2 information sheet, resource costs 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 arise in this sense only 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 such as historical water abstraction rights or the current or future distribution of pollution permits. Contrary to the definition in the Wateco guidance, resource costs are in the ECO2 information sheet not necessarily confined to water resource depletion only in terms of water quantity or water quality. They arise as a result of an economically speaking inefficient allocation of water and/or pollution over time and across different water users in view of the fact that alternative water use generates a higher economic value in terms of net benefits.

For practical economic valuation purposes, we start here from the notion that:

- 1) water is an economic good, meaning that there is a temporal and spatially defined demand for water of a certain quantity and quality and water can be used in alternative ways, i.e. there is scarcity, the core of any economic analysis;
- 2) water as an economic good has – by definition otherwise it would not be considered an economic good – both an economic value and an opportunity cost;
- 3) resource costs are distinguished separately from environmental costs to account for the fact that across Europe important differences exist in terms of water quantity and water quality management issues;
- 4) resource costs refer to competing and/or conflicting human water use, primarily as a result of its limited quantitative availability in time and space, but not exclusively as there exists a close relationship between water quantity (scarcity) and water quality;
- 5) environmental costs refer to all physical environmental damage costs related to the chemical and ecological status of a water body or river basin, primarily as a result of water quality problems, but not exclusively as there exists a close relationship between water quantity and water quality;
- 6) physical environmental damage is measured in practice as the difference between the baseline state of a water body or river basin and its good ecological status as defined in the WFD.

So in conclusion, environmental costs are defined here as the total economic costs (welfare loss) of the physical environmental damage to a water system (water body or river basin) as a result of the chemical and/or ecological state of the water system. The physical environmental damage is measured through the difference between a water body or river basin's current and good chemical and/or ecological state. By definition, the total economic costs include possible benefits foregone (opportunity costs), such as loss of the economic benefits derived from, for example, recreational opportunities or wildlife habitat and biodiversity conservation. That is, related to and included in the environmental costs are also the (indirect) impacts of the physical environmental damage on various relevant water uses.

Resource costs explicitly refer to the economic value of the opportunities foregone of water use in its best current or future alternative use (in order to avoid having to measure all possible current and future water uses) due to specific current water use and resource exploitation (rights), resulting in its physical non-availability (scarcity also in terms of a specific quality) for current or possible future alternative use. They are measured in terms of the net welfare loss of current water use and therefore include both the economic value of current water use and the highest economic value of alternative current or future water use (i.e. benefit foregone). Resource costs are specifically linked to water availability (scarcity) in order to avoid overlap between environmental and resource costs and in view of the fact that in the field of 'resource accounting' water resources are usually included as a stock resource and the accounts measure their abstraction levels.

Finally, environmental benefits are defined as the total economic value of the goods and services provided by aquatic ecosystems when implementing the WFD, including the use and nonuse values associated with drinking water quality, irrigation water, commercial and recreational fishing opportunities, wildlife habitat and biodiversity. Resource benefits are the economic benefits associated with the use of available water stocks and flows of a certain quality at a certain time and place.

These costs and benefits can be measured with the help of different valuation methods. A brief overview of the available economic valuation procedures will be provided in the next section.

AquaMoney working definitions environmental and resource costs and benefits

Environmental cost

Total economic market and non-market based value (welfare loss) of the (physical) environmental damage to a water system (water body or river basin) as a result of the chemical and/or ecological state of this system, including the benefits foregone measured through the difference between the baseline state of a water body or river basin and its good ecological status as defined in the WFD (see definition environmental benefits).

Environmental benefit

Total economic market and non-market based value (welfare gain) of the goods and services provided by a water body or river basin as a result of reaching a good chemical and/or ecological state as defined in the WFD, including their use and non-use values.

Resource cost

Total economic market and non-market based value (welfare loss) of the opportunities foregone of alternative water use and exploitation of a water body or river basin as a result of the limited availability of water (of a certain quality), including the future benefits foregone as a result of water resource depletion, measured as the difference between the economic value of current and the economic value of best alternative use now and in the future (see definition resource benefits).

Resource benefit

Total economic market and non-market based value (welfare gain) of water extraction and exploitation of a water body or river basin now and in the future.

5. Practical estimation of environmental and resource costs and benefits

Economic valuation studies of the environmental and resource costs and benefits associated with the specific scope of the WFD are rare or non-existent in Europe and elsewhere. For that reason, a first preliminary overview is presented in this section of existing economic valuation methods that may be used and be useful for the estimation of environmental and resource costs and benefits in practice (including the AquaMoney pilot case studies presented at www.aquamoney.org). However, before discussing these possible valuation methods, first an overview is provided of current practical problems with the assessment of (full) cost recovery of water services.

5.1 Current problems with full cost recovery assessment

Besides possible environmental damage not accounted for through market prices, i.e. market prices only reflecting the private opportunity costs and not the full social opportunity costs as explained in section 3, Renzetti and Kushner (2004) distinguish a number of other reasons why a government agency or firm's private accounting of the costs of its activities may differ from the full economic cost of those activities.

First, there may be accounting guidelines set out in government regulations, which dictate the way in which costs are recorded. For example, utilities may be prevented from assigning a competitive rate of return as part of the opportunity cost of its purchased capital goods.

Secondly, a water utility may receive subsidies from other agencies. These could include direct subsidies such as capital grants from senior levels of government or indirect subsidies as might occur if a municipal water utility were to receive services from the city's legal department without charge.

Thirdly, analysts and utility regulators may disagree in how completely they wish to see an agency move to full cost accounting. For example, some may argue that it is sufficient to see that operation and maintenance costs are fully accounted for. Others may argue that operating and maintenance plus capital costs must be fully accounted. Still others would argue that also external costs such as environmental damages and the opportunity cost of raw water supplies must be included.

A fourth factor that inhibits implementation of full cost recovery is a lack of standardized guidelines for these types of accounting. Although there exists a large body of economic research devoted to measuring whether a household, government agency or firm's accounting of the costs of its activities accurately reflect the costs borne by all of society, such as road transportation or the generation of electricity⁵, there is a limited literature that is concerned with applying the principles of full cost accounting to water and sewage utilities.

Fifth, because of the novelty of this approach to water and sewage utility accounting, there may be difficulties in collecting the data needed to estimate some cost components.

Other important issues that play a role when trying to assess the level of cost recovery of water services and which add to the level of complexity and uncertainty when trying to assess cost recovery of water services include:

- In some cases there does not exist a clear direct relationship between the service in question, the provider of the service and the user of the service. For example, the management of rivers and watercourses (e.g. dredging) serves both commercial and recreational shipping and flood control. Flood control management is another example of the provision of a public good, which cannot technically be broken down in individual units and sold to individual beneficiaries.
- In other cases, there exist interdependencies between water services and their costs. For example, an increase in the level of sewerage provision levels (e.g. increase in connection rate) will also result in an increase of water treatment costs.

⁵ In Europe, a major EU funded research study was undertaken over the past 10 years to estimate the external costs to the environment and human health of electricity production from fossil, nuclear and renewable sources (ExternE: Externalities of Energy).

- Not all costs are always clearly visible. For example, environmental and resource costs. Or costs are financed through different financial channels and by different institutions (e.g. local tax revenues and general income taxation).
- Cost recovery accounting and assigning costs to different user groups may involve substantial extra administration costs, especially when there are large numbers of different users. These costs may exceed the benefits of the development of a new and more adequate contribution mechanism or the modification of an existing contribution mechanism.

5.2 Economic valuation of environmental costs and benefits

Any assessment of environmental costs or benefits starts with and is based upon an environmental impact assessment, hence requiring the input (knowledge, expertise and information) from environmental experts. In the case of an assessment of the environmental costs associated with water use, a first step is to identify the significant pressure, which causes a water body to change and not reach the set environmental WFD objective(s). In principle, if there is no significant pressure (reduction) and a water body is already in a good state, there will also be no additional environmental cost (benefit).

A second step is to assess the impact of this pressure (reduction) on the water environment, in relevant chemical and/or ecological terms⁶. This requires the selection and description of the relevant attributes or characteristics of the water system for the economic valuation exercise.

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 4) and the corresponding effect on the provision and quality of the goods and services involved. In principle, a dose-response damage function is needed for this, estimated based on existing dose-pathway-response frameworks such as the Driving Forces-Pressure-State-Impact-Response (DPSIR) or the Source-Pathway-Receptor (SPR) framework.

In the next steps, the extent of the environmental damage (reduction) and the associated welfare losses (gains) are measured in economic terms. The economic value of environmental costs or benefits is often referred to as environmental values. This value can be measured 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.). The various steps are visualized in Figure 1.

Depending on the nature of the specific environmental (biogeochemical and/or ecological) change in the water system, the presence of a market where the goods and services involved are exchanged and data availability, economic values can be estimated using direct or indirect market and non-market based valuation techniques.

Market valuation means that existing market behaviour and market transactions are used as the basis of the valuation exercise. Economic values are derived from existing market prices for inputs (production values) or outputs (consumption values), through more or less complex econometric modeling of dose-response and/or damage functions. Examples include the economic value of fish, which is sold on a fish market (market analysis), the costs of replacing impaired environmental riparian functions such as nutrient retention and export through the installation of a wastewater treatment plant (replacement costs) or the costs of a water filter on tap water (avertive behaviour/defensive expenditures).

⁶ Alternatively, also geo-morphological and ecological restoration and rehabilitation measures are possible, which do not really reduce a pressure, but repair and restore a water system.

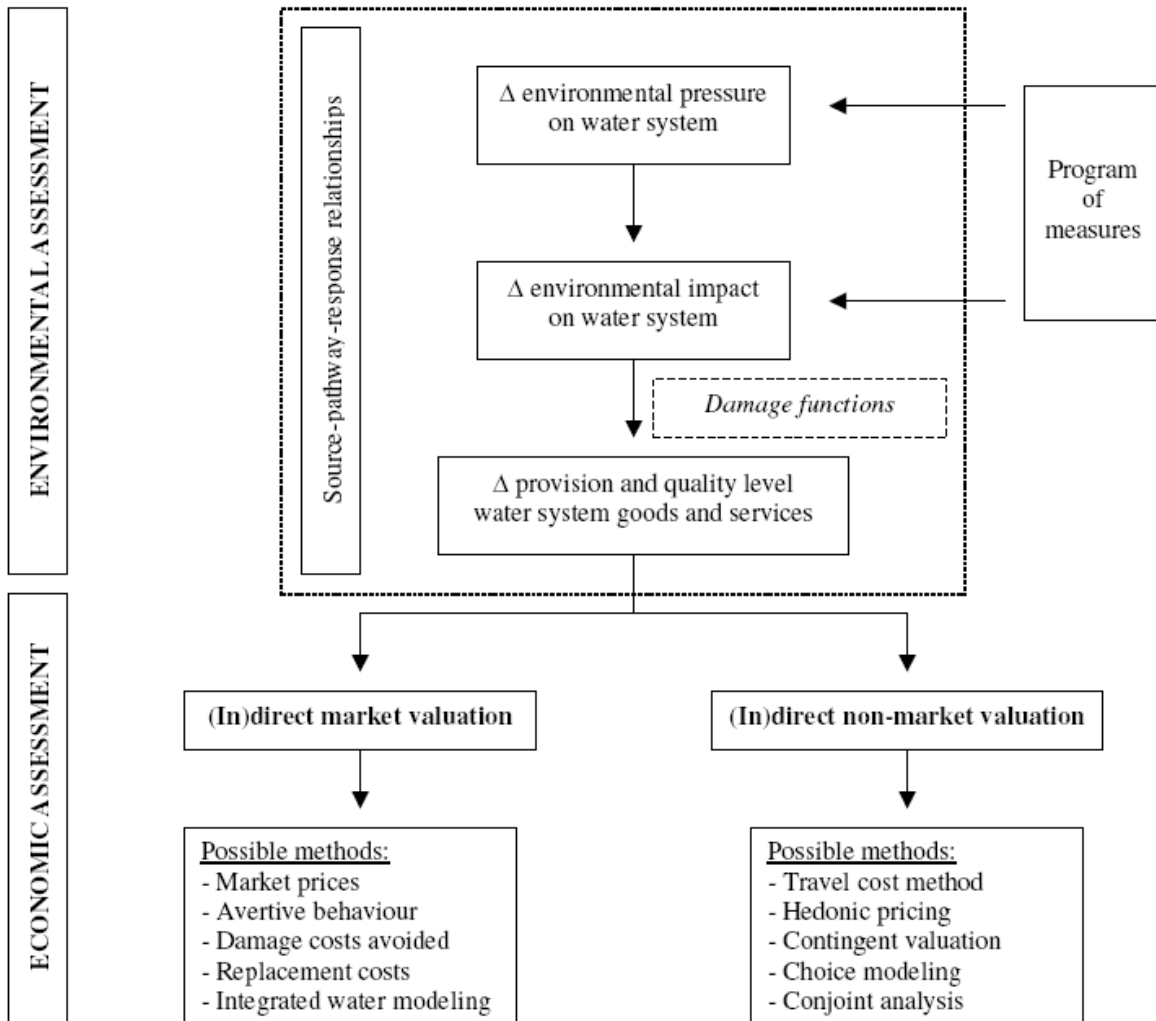


Figure 1: Economic valuation of environmental costs and benefits

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* non-market valuation methods (e.g. Johansson, 1987; Mitchell and Carson, 1989; Freeman, 1993; 2003). Non-market valuation means deriving economic values in cases where such markets are non-existent or distorted. Direct methods (also called stated preference methods) refer to contingent valuation (CV), discrete choice experiments (CE), and contingent ranking (CR) techniques, where individuals are asked directly, in a social survey format, for their WTP for a pre-specified environmental change. 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 neighborhoods (hedonic pricing studies) (also called revealed preference methods). The latter two approaches measure environmental use values through revealed preferences, while CV and CE are believed to be able to also measure non-use or passive use values through stated preferences. Of these methods, CV is probably the most widely applied method in contemporary valuation research (Carson *et al.*, 1995; Bateman and Willis, 1999).

5.3 Economic valuation of resource costs and benefits

The economic value of water use and exploitation such as surface or groundwater abstraction for agriculture, the food or paper industry, the energy sector or for drinking water purposes can be measured directly through existing market prices for intermediate or final water products (e.g. drinking water price) or indirectly through the value water adds as an essential input factor in production processes if there exists no water market. In the former case, the market price is multiplied by the quantity of water consumed to yield the total market value. In the latter case, the economic value of water is derived through more or less complex production function approaches, where output is a function of labour, man-made capital, intermediate input and natural capital including the water resource. Regressing output on these input factors yields a marginal value for water use. This marginal value can be used to estimate the total economic value of a change in water use by multiplying it with the change in water quantity use assuming a constant marginal value of the estimated change. More complex integrated water modelling approaches also exist, where limited water availability and other key water system characteristics (e.g. water balance, water flows, seasonal variation, infrastructure and institutional conditions etc.) are coupled with and integrated in economic production and consumption functions, yielding shadow prices and opportunity costs of different existing and/or future water use patterns (e.g. Andreu et al., 2005)⁷.

When the water resource is depletable (non-renewable), and current use limits future use opportunities resource accounting methods like the net price method may be used, where a 'scarcity rent' is calculated as the difference between the market or shadow price of the water resource and its marginal extraction costs.

In some cases, human resource use may also include recreational activities, which depend on water availability. Examples are fishing on fish species with specific water depth requirements, surfing, or wild water rafting, but also the recreational activity swimming can be considered a function of water availability. In some cases recreational values can be derived from existing fish permits or entrance fees, but for most of these recreational activities usually no market exists. Hence their value has to be derived via indirect non-market valuation techniques, of which the travel cost method seems to be the most important one to estimate the associated use value. However, also stated preference methods like contingent valuation or choice modelling approaches may be applicable.

An overview of existing monetary environmental valuation methods is given in the annex to this paper. Based on the estimation of the environmental damage costs (avoided) and opportunity costs of limited water availability, through direct and/or indirect valuation methods, existing pricing and financing mechanisms can be reviewed to assess to what extent the estimated damage and opportunity costs are internalized for the purpose of cost recovery. Estimation of the total economic benefits of reaching the target situation (including damage costs avoided) also allows assessment of the economic efficiency of existing pollution abatement measures and water distribution patterns through CBA or assessment of the most efficient level (and corresponding prices) of pollution control and water abstraction and the economic justification for derogation in relation to disproportionate costs.

⁷ A distinction is generally made between 'holistic' and 'compartmental' integrated models (e.g. McKinney et al., 1999).

6. Glossary of terms⁸

Benefit

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.

Cost

The cost of a project, programme or policy is the full value of any resource in its best alternative use (opportunity cost). 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 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 cost

Welfare loss associated with the deterioration or degradation of the physical environment.

Economic analysis

Term used in the World Bank project evaluation literature to refer to evaluation of the social (contrasted with private) profitability of alternative investments or programs. In the project evaluation literature 'social' and 'economic' are used interchangeably. Profitability means efficiency and includes both monetized and non-monetized benefits.

Economic rent

Non-observable income imputed to an input in limited supply. Rents were originally attributed only to land, but are nowadays used for any resource in scarce supply. Hotelling rent is measured as the difference between the market or shadow price for a resource unit and its marginal extraction cost.

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.

External cost

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 externality to 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 leave them off as well as if the CSO discharge had not happened.

Financial analysis

Term used in the World Bank project evaluation literature to refer to evaluation of the private profitability of alternative investments or programs from the perspective of the private individual or firm affected by a project. Profitability is calculated in terms of actual prices, costs and revenues paid and received and therefore reflects the actual transfer of income.

Foregone benefit

The value sacrificed when one resource use option is chosen over another.

⁸ Definitions used here originate from Brouwer et al. (2004) and Young (2005).

Internal cost

Welfare loss, which has been compensated.

Marginal cost

Additional, incremental cost of producing one more unit of a good or service. Measurement of marginal cost depends on the time frame considered. Short term marginal cost may often be derived from variable cost (for example the extra labour and raw materials). 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 price

The price at which a commodity is bought or sold in a market.

Market value

Value of a commodity when sold on a market.

Nonmarket valuation

The study of economic behaviour for the purpose of assigning economic values in contexts where market prices are absent or distorted.

Nonuse value

Value assigned to a good or service by knowing it exists even though someone will never actually use it, now or in the future.

Opportunity cost

Refers to the 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.

Private good

Effectively a good that can be marketed.

Public good

Good where the provision of the good for one individual also makes it available for others and it is not possible to prevent others from using it.

Revenue

Monetary benefits derived from the sale of a good or service.

Shadow price

A concept which seeks to express the real value of goods and services. 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.

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.

Use value

Value assigned to goods or services, which are actually used, now or in the future.

Value added

The value generated in a firm's production process, measured as the difference between the value of a firm's output and the value of the inputs purchased from other firms.

Welfare cost

Any negative effect on human well-being (or benefit).

Willingness to accept

A monetary measure of the value someone accepts or would accept in compensation for a specified loss of the quantity or quality of a good or service.

Willingness to pay

A monetary measure of the value someone pays or would pay for a specified change in the quantity or quality of a good or service.

Annex: 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. I am grateful to Stavros Georgiou and his co-authors for allowing me to use this chapter in this paper. The annex is supplemented with information from Schaafsma and Brouwer (2006).

Choosing between valuation methods

All valuation techniques have strengths and weaknesses, and the decision on which to use for a particular application requires experience and judgment 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 methods

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

Contingent valuation (CV)

Applicability	Extensive, since it can be used to derive values for almost any environmental change. This explains its attractiveness to 'valuers'. Together with choice experiments 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 limit 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	Mitchell, R.C. and Carson, R.T. (1989). Using Surveys to Value Public Goods, The Contingent Valuation Method. Resources for the Future, Washington, DC, USA.

Contingent ranking (CR)

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 characteristics 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 theoretically questionable compared to choice experiments. See Bateman et al. (2002) for a more detailed discussion. Too few studies exist to test other validity measures but initial results suggest CR WTP exceeds CV WTP.
Reference	Bateman, I.J., R.T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett, M. Jones-Lee, G. Loomes, S. Mourato, E. Ozdemiroglu, D.W. Pearce, R. Sugden and J. Swanson (2002), Economic Valuation with Stated Preference Techniques: A Manual, Edward Elgar, Cheltenham, UK.

Choice experiment (CE)

Applicability	Extensive, since it can be used to derive values for almost any environmental change. Important advantage compared to CVM is the valuation of environmental attributes, making it possible to derive marginal economic values for a range of environmental changes. This explains its attractiveness to 'valuers'. Requires substantial knowledge of econometric analysis. Together with CV the only method for eliciting non-use values.
Procedure	Individuals are asked to choose between 2 or more alternative options or situations, including a baseline option or situation. Alternatives consist of the same attributes, including price, but different attribute levels. Implicit WTP value derived from choice behaviour modelled through multinomial regression analysis.
Validity	Use and applicability is increasing in the literature over the past 5 years. From a welfare-theoretical point of view superior to contingent ranking. Important methodological issue include the independency between attributes and the orthogonal design of the experiment.
Reference	Hensher, D.A., J.M. Rose, W.H. Greene (2005), Applied Choice Analysis, a Primer, University Press, Cambridge, UK.

Market based approaches: dose–reponse, replacement, and opportunity cost approaches

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.
Reference	Baumol, W.J. and Oates, W.E. (1971). The use of standards and prices for protection of the environment. <i>Swedish Journal of Economics</i> , 73: 42-54. Young, R.A. (2005). Determining the economic value of water. Concepts and methods. Resources for the Future, Washington DC, USA.

Surrogate market based: avertive behaviour

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. Econometric analysis on panel and survey data is sometimes needed. Can be fairly expensive.
Validity	Theoretically correct. Insufficient studies to comment on convergent validity. Uses actual expenditures so criterion validity is generally met.
Reference	Dickie, D., Gerking, S. and Agee, M. (1991) ‘Health benefits of Persistent Micropollutant Control: the Case of Stratospheric Ozone Depletion and Skin Damage Risks’, in Opschoor, J.B. and Pearce, D.W. (eds), <i>Persistent Pollutants: Economics and Policy</i> , Dordrecht: Kluwer.

Surrogate market based: travel cost method

Applicability	Generally limited to recreational sites and their characteristics. Distinction can be made between individual, zonal and random utility based travel cost models. WTP derived from travel costs, including travel time. 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	Ward, F.A. and Beal, D. (2000). Valuing nature with travel cost models, A manual. Edward Elgar Publishing, Cheltenham, UK.

Surrogate market based: hedonic property pricing method

Applicability	Applicable only to environmental attributes likely to be capitalised into the price of housing and/or land. Most applied to noise and air pollution and neighbourhood amenity, but also to water quality and flooding. 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 used 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	Freeman, A.M. III (2003). The measurement of environmental and resource values. Theory and methods. Second edition. Resources for the Future, Washington DC, USA.

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