THE ECONOMICS OF
LAND DEGRADATION

ELD CAMPUS
Module:
Valuation
of ecosystem services

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The content of this document was prepared based on materials of ELD's massive open online class 2014:
"Principles of economic analysis and valuation for sustainable management of land".
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Photography:
Jörg Böthling/GIZ (front and back cover); Andreas König/GIZ (pg. 16)

Visual concept: MediaCompany, Bonn Office
Layout: kippconcept gmbh, Bonn
Bonn, September 2019

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Suggested citation:

ELD Initiative (2019). ELD Campus.
Module: Valuation of ecosystem services.

Available from www.eld-initiative.org

Module:
Valuation of ecosystem services

September 2019

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Abbreviations

CBA	Cost-benefit analysis
CSF	Conservation Strategy Fund
ELD	Economics of Land Degradation
MOOC	Massive Open Online Course
TEV	Total economic valuation
UNU-INWEH	United Nations University – Institute for Water, Environment and Health

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Module: Valuation of ecosystem services

This module was developed based on materials prepared for the ELD's Massive Open Online Course 2014 by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) (Quillérou, 2014).

It is suggested to view, in parallel to studying this module, all the **self-learning videos on cost-benefit analysis** produced by the Conservation Strategy Fund, which can be accessed either on the CSF's website or on YouTube:

https://www.conservation-strategy.org/en/csf-econ-video-lessons?term_node_tid_depth=380
https://www.youtube.com/user/numbers4nature

The following videos are available:

1. Intro to valuation
2. Classes of values
3. Market-based valuation method
4. Replacement cost method
5. Avoided cost method
6. Travel cost method
7. Hedonic pricing method
8. Contingent valuation
9. Choice experiments
10. Benefits transfer
11. Public vs. private goods

This module aims to provide a basic understanding of the assumptions behind established valuation methods, why different methods lead to different estimates, how each of these methods works, what kind of results they lead to and some of their limitations. It shall enable the learners to describe the total economic value (TEV) framework, recognise that different valuation methods lead to slightly different estimates, because of what they measure and how they measure it and to understand the steps involved in each of the valuation methods, the main assumptions underlying each method and some methodological and empirical limitations.

Total economic value (TEV) concept

What value do we measure?

Total economic value is one of the most common frameworks for environmental valuation. This framework is anthropocentric because it is based on how society values these goods and services. This perspective is based on the use of utility as a measure of preference. **Utility** represents how much enjoyment society as a whole derives from a good and/or service. Utility is a flexible concept reflecting preference for consumption or non-consumption of a good. For example, someone likes eating fruit: in economics terms, utility is derived from consuming fruit. However, if the assumption does not apply, utility is derived from not consuming fruit. Utility applies to individual's preferences between goods whilst **society's preferences are measured by welfare**. Welfare is an economic measure of society's level of "happiness".

Evaluating ecosystem services requires a measurement of the changes in society's welfare associated with the loss or gain in environmental goods or services. These changes in welfare represent the benefits or costs to society as a result of a change in environmental service provision. Changes in welfare are assumed by neoclassical economists to depend on society's preferences. Changes in welfare require knowledge on both demand and supply, but are often estimated in contexts where demand is not easily observable. Welfare changes are thus not straightforward to measure in practice.

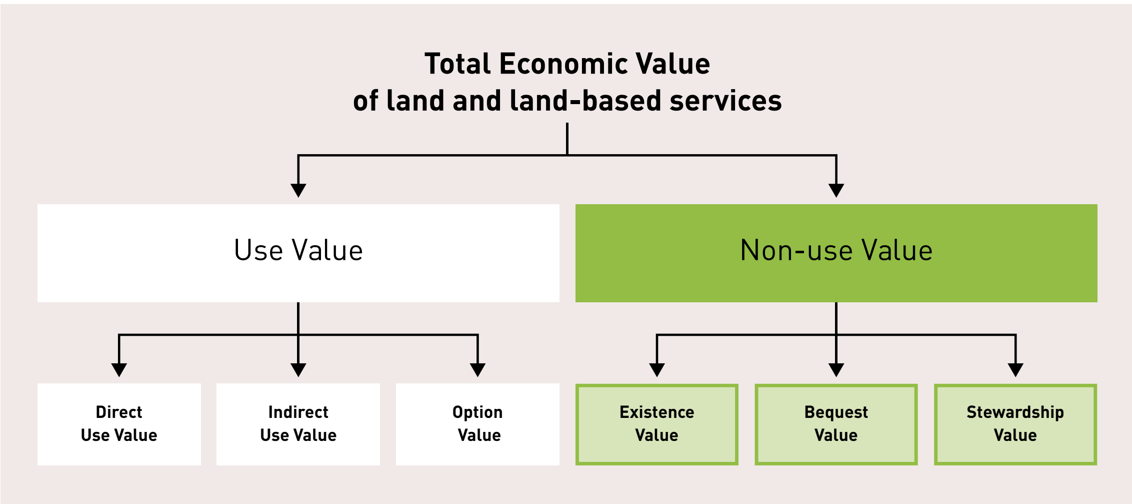
Total economic value and the associated utilitarian perspective is not the only economic approach available to decision-makers, but it is based on explicit trade-offs and social preferences. This corresponds to the way decision-makers take decisions in real-life: how much should society invest in mangroves versus clean air? How much should society invest in maintaining the quality of the environment versus investing in healthcare?

The framework divides the total economic value of a good or a service into a use value and a non-use value (figure 1).

FIGURE 1

The total economic value concept – use and non-use value

Sources: ELD Initiative, 2013, originally adapted from Bertram & Rehdanz, 2013, p.28



Use value refers to the benefit derived from the use of an environmental good or service. Examples of use values are the revenues derived from harvesting crops or fish or from extracting oil from the ground, from the recreational use of a given site such as a neighbouring park or forest, or from living in a home with an ocean view (figure 2). These uses can benefit people **directly**, e.g. by crop or fish harvesting, or **indirectly**, e.g. by flood regulation.

Option value is the value allocated by society for the **potential future use of a good or service** and accounts in some measure for uncertainty. For instance, one might live far away from a blue whale breeding site but would still like to be able to enjoy watching blue whales at some point in the future. One would therefore be ready to pay to protect blue whales and maintain the option to watch them later in life. Option values are could be considered to be in-between use and non-use values (figure 1).

Non-use values are values allocated by society to goods and services but do not stem from using these. A person might for instance value the Great Barrier Reef in Australia or the Amazonian forest even if it is not nor will ever be visited by him or her.

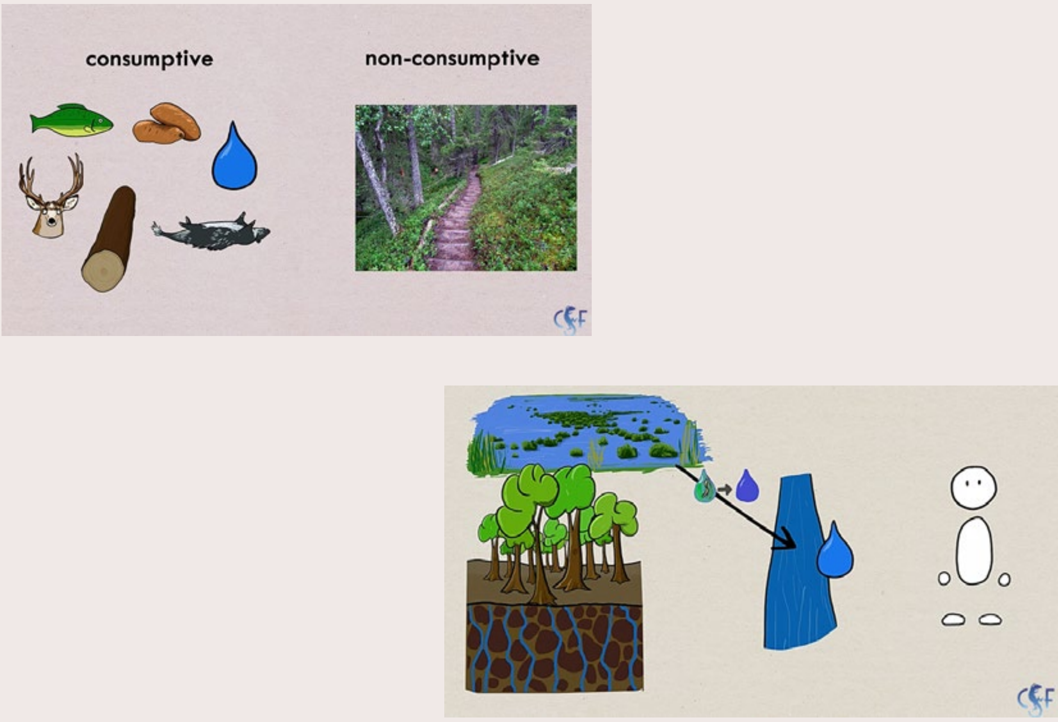
Non-use values can be further broken down into existence, bequest and stewardship values.

Existence value refers to the value placed by society on the **existence of an environmental good or service**. For instance, one may never have the opportunity to personally see a leopard in its original landscape habitat, but the idea that it exists is favourable and one would be happy to pay to help preserve its existence.

Bequest value is the value placed by society on the **environmental state passed onto the next generation**. For example, it might be desirable for

FIGURE 2

Direct (consumptive and non-consumptive) and indirect uses of a forest
Source: Conservation Strategy Fund



children to live in a pollution-free environment and therefore place a value on bequeathing them a pollution-free environment.

Stewardship value is the value placed by society on the **maintenance of a healthy environment for all living organisms** and not just humans. Conservationists and people living off services provided by the environment (farmers, fishers, etc.) typically have stewardship values.

Use and non-use values are assumed to be independent one from the other and mutually exclusive. This assumption means that use and non-use values can be estimated separately and then added up to derive the total economic value:

Total economic value = use value + non-use value

The total economic value provides a simple conceptualisation of the different types of economic values. It also serves as the basis for categorising the different valuation methods. Some valuation methods capture use value only whilst other valuation methods capture use value plus varying proportions of non-use value. However, this framework is not as easy to apply in practice. The difference between the types of values (e.g. use and non-use) is often fuzzier in real life than this TEV framework suggests. It is not always easy to differentiate between the different types of values in practice. Figure 3 therefore lists the economic value types typically estimated for ecosystem services.

FIGURE 3

Economic value types typically estimated for ecosystem services

Source: ELD Initiative, 2013, originally adapted from Quillérou & Thomas, 2012

		Provisioning services	Regulating services	Cultural services	Supporting services
Use value	Direct use	✔	✔	✔	
	Indirect use		✔	✔	✔
	Option	✔	✔	✔	
Non-use value	Existence			✔	
	Bequest				
	Stewardship				

CHAPTER

02

Introduction and selection of appropriate methods according to TEV

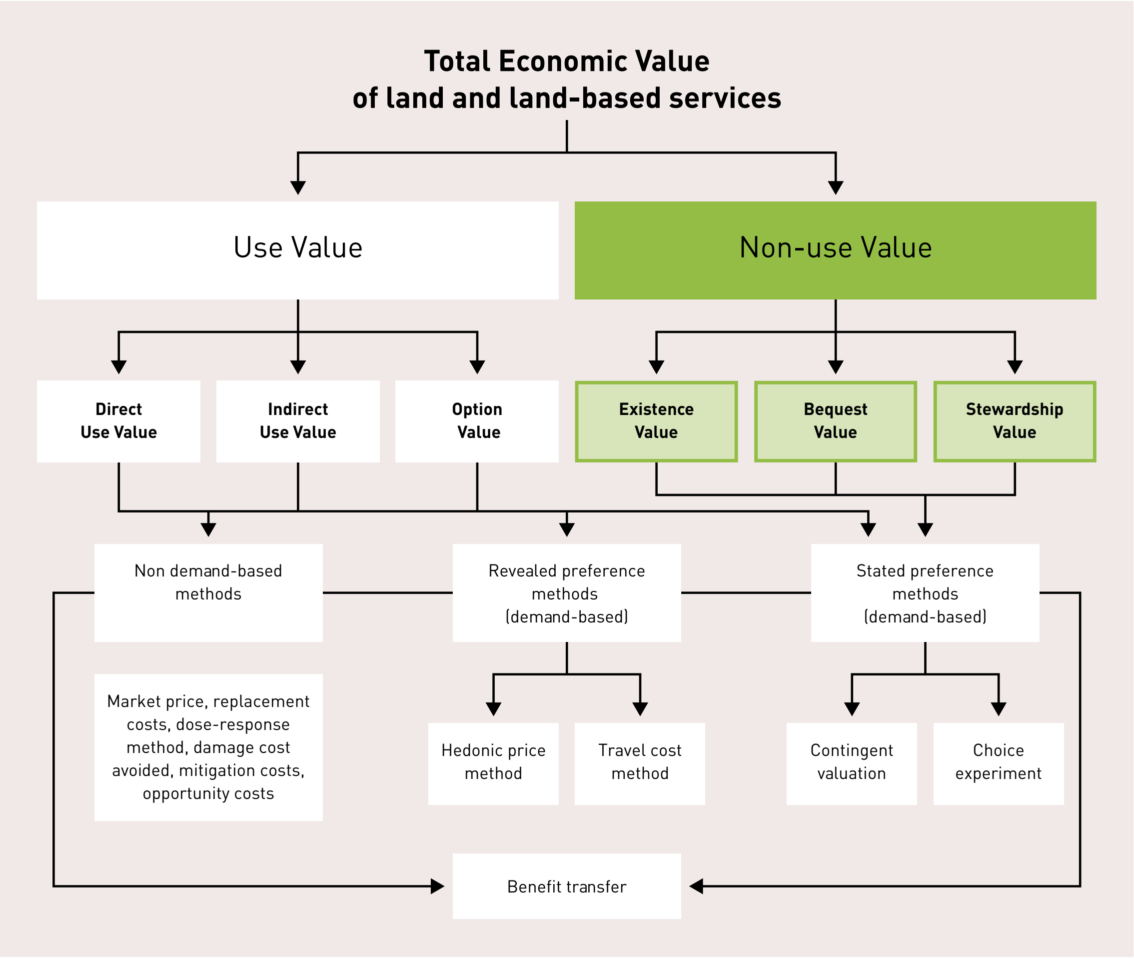
This section is meant to provide a guide to analysing existing case studies or conduct a new valuation exercise. The method description, background, assumptions and limitations should help answer the following questions when faced with an economic value estimate: How reliable is the value? Can it be replicated? How valid is it? Does it match the value allocated by society as a whole or a specific group in society? Does it correspond to the total economic value allocated by society or only a fraction of this value?

The methods described in the following sections are based on slightly different measures of welfare changes. They are described in more details in the next chapters.

FIGURE 4

The total economic value concept and existing valuation methods

Sources: ELD Initiative, 2013, originally adapted from Bertram & Rehdanz, 2013, p.28



There are three types of valuation methods (see figure 4):

1. Non demand-based methods
2. Demand-based revealed preference methods
3. Demand-based stated preference methods

Non demand-based methods

Non demand-based methods consist of estimating the costs incurred from an increase (decrease) in environmental quality. This increase (decrease) in costs leads to a decrease (increase) in quantity supplies for a given demand associated with an increase (decrease) of the economically optimal price. What is measured here is the **change in welfare associated with the change in the cost of provision**. These methods can be very useful for policy decisions in practice as cost data is often available. However, because the influence of demand for environmental goods and services is ignored by these methods, economists often prefer to use demand-based methods to estimate demand for environmental goods and services.

In contrast, demand-based methods are called so because they rely on changes in demand.

Demand-based methods

Demand-based methods result in a demand curve for comparison to the cost of provision (supply curve) – there are revealed preference and stated preference methods.

Revealed preference methods use surrogate markets[1] to estimate the value of non-marketed goods and reveal preferences from market behaviour. These methods do not involve changes in income levels and rely on existing payments or costs incurred. A fraction of that cost is explicitly associated with the non-marketed environmental good or service. For example, apartments near Central Park in New York are more expensive than similar apartments elsewhere simply because they are close to the Park. A proportion of their market value is linked to the proximity to Central Park. The property market is the surrogate market for the ecosystem service in this example. Revealed preference methods estimate the fraction of the apartment market value and assume it corresponds to the social value of being close to Central Park. Because they rely on existing surrogate markets, these methods typically capture use values but not non-use values. The **hedonic price** and **travel costs methods** are examples of revealed preference methods and are described in more detailed in the following sections.

Stated preference methods have been developed to capture some of the non-use value of an environmental good or service. They are called "stated" because they involve people directly stating how much they would be willing to pay for an increase in the provision of an environmental good or service (or how much they would be willing to accept for a decrease in provision). Stated preference methods are based on intended rather than on actual behaviours such as revealed preference methods. However, these methods do not lead to the same type of demand being estimated because they involve changes in income levels contrary to revealed preference methods. The **contingent valuation and choice experiment or modelling methods** are examples of revealed preference methods and are described in more detail in the following sections. Because they rely on people stating their preferences rather than expressing them through actual markets, these methods capture the use value and (some of) the non-use value of the environmental good and/or service.

In practice, all demand-based methods are prone to experimental biases and often lead to very diverse estimates of value. These methods are still criticised in the academic literature. They are however improving over time and remain the only methods available to capture non-use values so far.

What is important to remember is that the chosen method influences the estimate of the economic value obtained as a result. This is because the chosen method not only influences how much of the total economic value is estimated (for either use value only, or use and non-use values), but also what kind of approach (non demand-based or demand-based) is used to estimate welfare changes and how it is measured (changes in consumer surplus (see box 1), willingness to pay or willingness to accept). Additionally, because peo-

[1] *Markets used in place of the missing markets for environmental resources*

ple's willingness to accept is higher than their willingness to pay, estimates of economic values depend on the question asked and the direction of the change under consideration. **A good understanding of the context of one's study is critical for choosing a valuation method that gives reliable and valid estimates of the true economic value.**

BOX 1

The theory behind it – Demand curves

Economists can use two different types of demand curves: the Marshallian demand curve and the Hicksian demand curve. Revealed preference methods measure economic value as a change in consumer surplus and rely on Marschallian demand curves. Stated preference methods measure economic value as a change in the area under a Hicksian demand curve. Consumer surplus can be defined as the difference between the money consumers would be willing to spend and the actual price they are paying. This is detailed below.

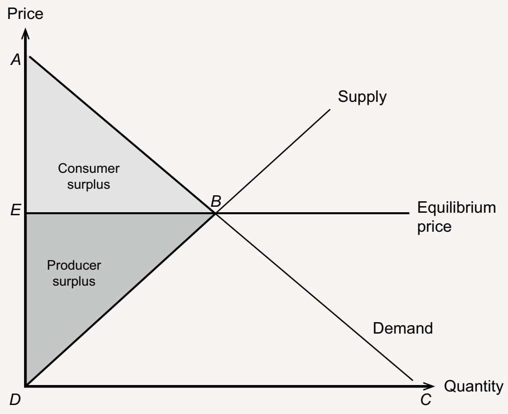
The **Marshallian demand curve**, named after Alfred Marshall, is the demand for a good when income is held constant and utility derived from the good varies. The **Hicksian demand curve**, named after John Hicks, is the demand for a good when the utility derived from the good is held constant and income varies. It is mathematically possible to derive one type of demand curve from the other. The type of demand curve that is considered for further economic analysis and assessment depends on the study context and assumptions. In practice, it is often easier to estimate the Marshallian demand curve empirically because it is based on observable variations in consumer surplus.

Three different measures of preferences are used in environmental valuation: consumer surplus, willingness to pay and willingness to accept. Consumer surplus is the area between a demand curve and the market price as represented in figure 5. Consumer surplus variations can be derived from observed data to estimate a Marshallian demand curve. Revealed preference methods estimate changes in consumer surplus and therefore lead to the derivation of a Marshallian demand curve.

FIGURE 5

Consumer surplus is the area ABE and producer surplus the area EBD. The sum of consumer and producer surplus is equal to welfare (area ABD). The demand curve is a Marshallian demand curve.

Source: Quillérou, 2014



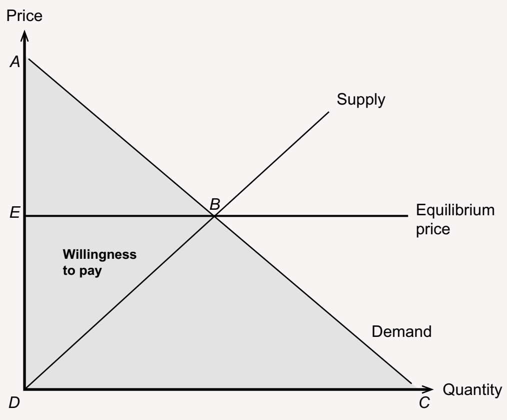
Willingness to pay is the area under the demand curve (figure 5). It is basically the amount of income the individual is willing to give up to secure a reduction in price for the same quantity provided. This is a theoretical concept which is measured in practice by what is called a **compensating variation**. The compensating variation is the income people would be willing to give up to prevent the loss of environmental good or service and keep the same level of utility (or level of "enjoyment"). Compensating variation refers to a change in price (income) whilst compensating surplus refers to a change in quantity of good and/or service.

Willingness to accept is also the area under the demand curve and could be represented similarly to willingness to pay in figure 6. Both willingness to pay and willingness to accept rely on changes in income to keep utility constant and are therefore linked to a Hicksian demand curve. Willingness to accept is basically the amount of income the individual is willing to accept to compensate for a change in price of goods and/or services. This is a theoretical concept which is measured in practice by what is called **equivalent variation**. The equivalent variation is the income people would be willing to accept to keep the same level of utility (or level of "enjoyment"). An equivalent variation applies to a change in price (income) whilst an equivalent surplus applies to a change in quantity of good and/or service.

FIGURE 6

Willingness to pay is the grey area ACD. The demand curve is a Hicksian demand curve (utility is constant and income varies)

Source: Quillérou, 2014



In real life willingness to pay and willingness to accept do not overlap exactly despite what is theoretically suggested in the above. The direction of the change considered influences estimates of economic values. This phenomenon is called hysteresis. This is because people tend to be more willing to accept more money for an increased degradation in environmental quality compared to what they are willing to pay for a corresponding improvement in environmental quality. This leads to discrepancies economic value estimates depending on whether people are asked about their willingness to pay (for increasing environmental quality) or willingness to accept (for decreasing environmental quality).

It can be shown that:
compensating variation < change in consumer surplus < equivalent variation

The theoretical derivation of this inequality is beyond this unit. This inequality implies that, in theory, a change in consumer surplus constitutes on average a good estimation of economic value. However, in practice, any of these may be underestimated or overestimated, so despite being theoretically appealing, the change in consumer surplus might not always be the best average estimate. The most appropriate measure of welfare change needs to be determined based on the specific study context.

03 Non demand-based methods

Non demand curve approaches to valuation can refer to the use of market prices, replacement costs, dose-response methods, mitigation behaviour and/or opportunity costs to value a given good or service provided (see figure 4).

Market prices are the result of trade. In neoclassical economic theory, perfect competition is a necessary condition for prices to reflect the true economic value of the good or service considered, as if driven by an 'invisible hand'. Market prices can thus be used for environmental goods (for example a forest) or services (for example timber) that are traded; see figure 7 for an ELD study example as well as box 2.

Prices can be distorted compared to the true economic value by policies (minimum price or wage), market settings (monopoly, oligopoly), the mode of trade (auctions). In non-perfectly competitive markets settings (monopoly and/or oligopoly) prices are set higher than under perfect competition and are consequently also considered as distorted. Price distortions can also be introduced when goods are auctioned rather than traded under a perfectly competitive market. Taxes and/or subsidies need to be removed from market prices to estimate the true economic value. Taxes and subsidies are transfer payments within the economy and do not change society's welfare nor the true economic value of the good considered. The use of market prices is an easy enough proxy for economic value, but is not as straightforward as it first appears and should be used with caution.

Replacement costs also rely on market prices, but the value of the good or service is measured instead by how much it would cost to replace it. For instance, a forest could be valued by how much it would cost to replant it. The **damage cost avoided** is a related method that estimates values of ecosystem services based on the costs of avoiding damages due to lost services; see figure 7 for an ELD study example as well as box 3 and figure 8 for more explanations on replacement costs.

This method relies on market prices and is thus prone to the same problems as the market price method. Replacement costs only measure a fraction of the true economic value of a good: it does not include the value of the good linked to preventing changes nor takes the demand for this good into account. For instance, benefits provided by an established forest are timber exploitation, water filtration, carbon storage, recreational and amenity values. Newly planted forests however do not provide these benefits. The value of this established forest is thus greater than the costs of seedlings (replacement costs)!

Dose-response methods, also called **change in productivity approach**, are based on linking a change in output – typically a change in productivity – to a change in environmental quality. Environmental quality is considered as a factor of production in this approach and increasing production has an impact on environmental quality (and vice versa). For instance, a paper mill produces paper, but its production also creates water pollution. Increasing paper production increases water pollution (decreases the environmental quality). In this example, the cost of improving environmental quality is the cost (forgone profit) of decreasing paper production; see figure 7 for an ELD study example related to soil moisture and nitrogen fixation. It is however not always possible to link a production output to a change in environmental quality so this approach is not always applicable.

FIGURE 7

Example for the valuation methods: Productivity change, market price, avoided damage and replacement cost – Ecosystem Valuation in Gedaref (Sudan)
Source: ELD User Guide, 2014

An ELD Initiative study performed by IUCN took place in 2014 in Gedaref, Sudan (Aymeric et al., 2014). Researchers set out to assess the value of sustainable land management in a future scenario that integrated agroforestry, when compared to the baseline ('business-as-usual') scenario. Historically, the area of Gedaref was known as a breadbasket, but the past few decades saw unsustainable agriculture practices like near-monocropping and low nutrient replenishment. These practices lead to land degradation, which significantly impacts ecosystem function and provisioning of ecosystem services.

To assess a pathway forward in Gedaref that was suitable for both economic and environmental health, authors performed an ex-ante cost-benefit analysis to compare the ecosystem services and economic impact of the future landscape restoration scenario against the baseline scenario. The restoration scenario they proposed was agroforestry, using *Acacia senegal*, known for its soil nitrogen enhancing properties and production of gum Arabic (for which there is demand on the international market), intermixed with sorghum, Sudan's primary staple crop. This scenario would ideally support both economic and environmental health. To estimate potential societal net benefits, a household survey was implemented in the village of Um Sagata, where over a hundred surveys were provided. These were complemented by detailed land use and land cover classification maps based on biophysical production functions using AquaCrop (an integrated soil and water balance model) and a soil and water assessment tool (ArcSWAT) with a GIS plugin. Ecosystem services assessed included impacts of land use change on yields and productivity, groundwater infiltration, water runoff, and carbon sequestration.

Authors found that the aggregate value of all ecosystem services provided by sustainable land management interventions, as outlined in the future landscape restoration scenario, provides 1.3 billion USD for the entire watershed. The valuation methods used and related ecosystem services that were assessed are outlined below.

Type of valuation method	Purpose of valuation method	Ecosystem service assessed
Productivity change	Estimates economic values of ecosystem services that contribute to the production of commercially marketed goods	Differences in yields with or without soil erosion, as measured by soil moisture and nitrogen fixation
Market price	Estimates economic values of ecosystem services that are bought/sold in commercial markets	Financial values of changes in supplies of fuelwood and gum Arabic
Avoided damage and replacement cost	Estimates economic values of ecosystem services from either avoiding damages from lost services or the cost of replacing them	Enhanced soil moisture and nitrogen fixation, and carbon sequestration (for avoided damage) and groundwater recharge functions (for replacement costs)

Mitigation behaviour relates to actions that people take to avoid the negative consequences of environmental degradation. For instance, one way to mitigate the impact malaria is to limit the probability of contracting the disease, that is getting an infected mosquito bite. This can be done by using mosquito nets and repellents. The cost of malaria mitigation is in this example the cost of mosquito nets and repellents, and provides one proxy indicator (also called "proxy") for the social cost of malaria to society as a whole. The cost of malaria to society as a whole is however not limited to preventing the contraction of the disease and includes the costs of palliative care and healthcare treatments. Mitigation costs only represent a fraction of the total economic cost to society.

Opportunity costs are based on the next best alternative available (the first best alternative being the current state). This is typically used when several mutually exclusive management options exist. For example, the second-best alternative to preserving a forest can be to convert the land on which it stands to agriculture. The profit that would be made from agricultural production represents the opportunity cost of preserving the forest. In other words, the opportunity cost of forest preservation is the forgone agricultural profit. For instance, land under forest often corresponds to lower value agricultural land, that is, land that has lower than average forgone profits. Taking the average agricultural income forgone profit as a proxy for the forest value in this case overestimates the true agricultural value of the land when converted to agricultural production. Also, if the proxy measure of opportunity cost is highly variable, its average value is not an accurate value of the true opportunity costs incurred either. Also, because agriculture is the second-best use of the land after the forest, even if the true opportunity cost is estimated, it is lower than the current value of the forest. If this was not the case, then there is no reason to keep the land under forest and not clearing it.

Most of these methods are convenient for estimating economic value of environmental goods and services. They however lead to values which do not directly reflect people's preferences for the environmental good or service, but rather their preferences for the proxies considered. For instance, the cost of mosquito nets is a proxy of the value of mitigating malaria. The price of mosquito nets does reflect perfectly on society's preference for mosquito nets assuming nets are traded in a perfectly competitive market, but only indirectly measures of people's preference for avoiding malaria. Because of these drawbacks, economists have favoured the demand-based methods, which rely on the elicitation of people's preferences as described in chapter 4.

BOX 2

How to apply the market price method

Source: adapted from http://www.ecosystemvaluation.org/market_price.htm

The market price method estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. The market price method can be used to value changes in either the quantity or quality of a good or service.

It uses standard economic techniques for measuring the economic benefits from marketed goods, based on the quantity people purchase at different prices, and the quantity supplied at different prices. When applying the method there is need to determine individuals' preferences by observing their willingness to pay for the goods and services at the prices offered in the market. The standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using market price and quantity data. The total net economic benefit, or economic surplus, is the sum of consumer surplus and producer surplus (see box 1 for more explanations on these terms).

To estimate consumer surplus, the demand function must be estimated. This requires time series data on the quantity demanded at different prices, plus data on other factors that might affect demand, such as income or other demographic data.

To estimate producer surplus, data on variable costs of production and revenues received from the good are required.

An example application can be studies here: *http://www.ecosystemvaluation.org/market_price.htm*

Limitations of the method

Market data may only be available for a limited number of goods and services provided by an ecological resource and may not reflect the value of all productive uses of a resource. The true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures. Seasonal variations and other effects on price must be considered.

The method cannot be easily used to measure the value of larger scale changes that are likely to affect the supply of or demand for a good or service. Usually, the market price method does not deduct the market value of other resources used to bring ecosystem products to market, and thus may overstate benefits.

BOX 3

How to apply the replacement cost / damage cost avoided method

Source (the entire box): Adapted from http://www.ecosystemvaluation.org/cost_avoided.htm

These methods do not provide strict measures of economic values, which are based on peoples' willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. This is based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. Thus, the methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be, made. They are less data- and resource-intensive than other methods.

Some examples of cases related to ELD subjects where these methods might be applied include:

- Valuing improved water quality by measuring the cost of controlling effluent emissions;
- Valuing erosion protection services of a forest, erosion protection measures or wetland by measuring the cost of removing eroded sediment from downstream areas or the cost of recovering or replacing lost soils and nutrients;
- Valuing the water purification services of soils or a wetland by measuring the cost of filtering and chemically treating water.

These methods require the same initial step-assessing the environmental service(s) provided.

This involves specifying the relevant service(s), how they are provided, to whom they are provided, and the level(s) provided.

The second step for the damage cost avoided method is to estimate the potential physical damage to property, either annually or over some discrete time period. The final step for the damage cost avoided method is to calculate either the monetary value of potential property damage, or the amount that people spend to avoid such damage.

The second step for the replacement cost method is to identify the least costly alternative means of providing the service(s).

The third step is to calculate the cost of the substitute or replacement service(s). Finally, public demand for this alternative must be established. This requires gathering evidence that the public would be willing to accept the substitute or replacement service(s) in place of the ecosystem service(s).

An application example for avoided costs is given here (e.g. soil erosion in Korea):

http://www.ecosystemvaluation.org/cost_avoided.htm

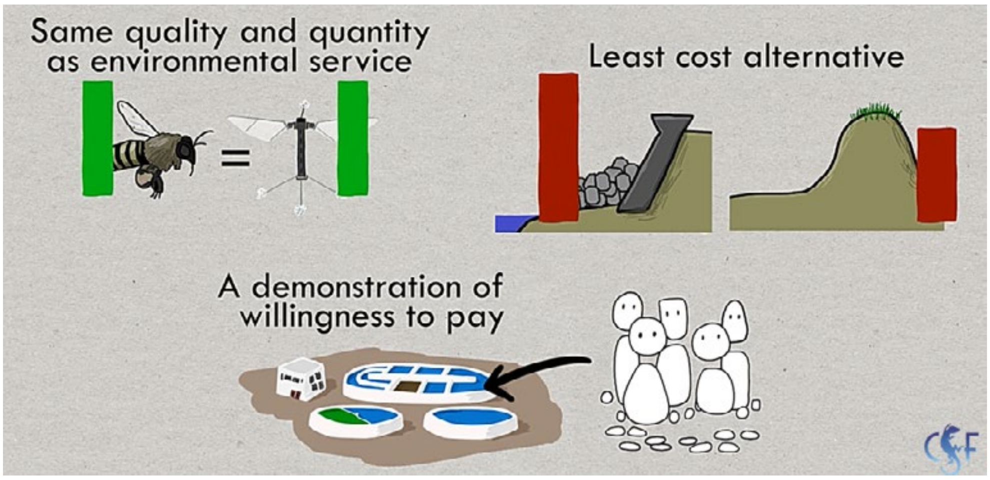
Limitations of the methods

Because these methods are based on using costs to estimate benefits, it is important to note that they do not provide a technically correct measure of economic value, which is properly measured by the maximum amount of money or other goods that a person is willing to give up to have a particular good, less the actual cost of the good. Instead, they assume that the costs of avoiding damages or replacing natural assets or their services provide useful estimates of the value of these assets or services. This is based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. This assumption may or may not be true. However, in some cases it may be reasonable to make such assumptions, and measures of damage cost avoided or replacement cost are generally much easier to estimate than people's willingness to pay for certain ecosystem services.

FIGURE 8

Replacement cost method requirements

Source: Conservation Strategy Fund



A summary of limitations is provided here:

- These approaches assume that expenditures to repair damages or to replace ecosystem services are valid measures of the benefits provided. However, costs are usually not an accurate measure of benefits.
- These methods do not consider social preferences for ecosystem services, or individuals' behaviour in the absence of those services. Thus, they should be used as a last resort to value ecosystem services.
- The methods may be inconsistent because few environmental actions and regulations are based solely on benefit-cost comparisons, particularly at the national level. Therefore, the cost of a protective action may actually exceed the benefits to society. It is also likely that the cost of actions already taken to protect an ecological resource will underestimate the benefits of a new action to improve or protect the resource.
- The replacement cost method requires information on the degree of substitution between the market good and the natural resource. Few environmental resources have such direct or indirect substitutes. Substitute goods are unlikely to provide the same types of benefits as the natural resource.
- The goods or services being replaced probably represent only a portion of the full range of services provided by the natural resource. Thus, the benefits of an action to protect or restore the ecological resource would be understated.
- These approaches should be used only after a project has been implemented or if society has demonstrated their willingness-to-pay for the project in some other way (e.g., approved spending for the project). Otherwise there is no indication that the value of the good or service provided by the ecological resource to the affected community greater than the estimated cost of the project.
- Just because an ecosystem service is eliminated is no guarantee that the public would be willing to pay for the identified least cost alternative merely because it would supply the same benefit level as that service. Without evidence that the public would demand the alternative, this methodology is not an economically appropriate estimator of ecosystem service value.

04 Revealed preference methods

The **hedonic price** and **travel costs methods** are examples of revealed preference methods.

Hedonic pricing is based on the use of a surrogate market with actual (observed) market behaviours to estimate the value of non-marketed goods (referred to as "characteristics" for this method). This method relies on the assumption that people value a good based on the sum of its characteristics. Welfare changes are measured by changes in consumer surplus. The most cited contributor to the development of this method is Lancaster (1966). See box 4 for more information.

The idea behind the **travel cost method** is that the more people pay to travel to a site of interest, the more that site is economically worth to society as a whole. This method is therefore based on the use of the travel cost to estimate the value of non-marketed goods and relies on surveys. The Marshallian demand curve is derived by relating the number of visits (quantity) to the costs of each visit (price). As for the hedonic price method, this method measures welfare changes through changes in consumer surplus. See box 5 for more information.

BOX 4

How to apply the hedonic price method

The hedonic price method consists of one generic and two specific steps:

Step 0: Build the survey and sampling plan to collect data on the good's price, the good's levels (quantities) of individual characteristics, respondent's characteristics and timing of survey

Step 1: Estimate the "hedonic price function", that is, price as a function of the characteristics

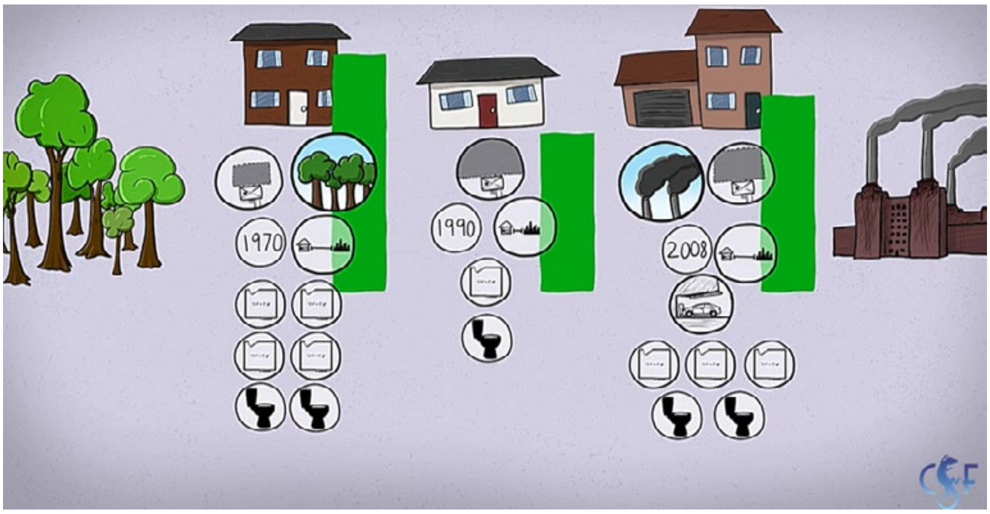
Step 2: Estimate the inverse Marshallian demand equation, that is, price as a function of quantity

Step 0 is in most textbooks not considered to be an actual step of the hedonic price methodology. Step 0 consists in: i) identifying the environmental characteristic to be valued, the surrogate market good with this environmental characteristic, and the stakeholders (users as this is a use value method) to state explicitly how "society as a whole" is defined; ii) designing a survey (questionnaire) and a sampling plan; iii) creating a database with the collected data. This step is not specific to hedonic pricing but is essential to obtain representative data to derive reliable and valid estimates of economic values. Step 0 builds the hedonic price database required to undertake both steps 1 and 2. A hedonic price database typically includes the price (e.g. a house price) and levels (quantities) of individual characteristics of the good (e.g. number of rooms, distance to nearest school, percentage of sea view), respondent characteristics (income range, age, education level), timing of the survey (spring, summer, fall, winter).

Reliable and valid estimates can be extrapolated from a sample to the overall population. Estimates are said to be (statistically) **reliable** when repeated measures lead to the same value, in other word when results can be replicated. Estimates are said to be (statistically) **valid** when their value is close to the true unknown value. There are two ways of ensuring collection of data representative of the overall population. The first is to design a sampling plan to collect data from a representative sample from the population (in this context "society as a whole") before data collection. The second is to collect data on respondents and check that average values and distributions

FIGURE 9

Comparison of house prices according to characteristics
Source: Conservation Strategy Fund



of each respondent characteristic match those of the population after the data is collected. This is often done by asking respondents to provide characteristics about themselves: the area where they live, their income range, their age, their education level, in other words anything that might make preferences vary across individuals. We also need to take seasonal variations into account as they could influence people's willingness to pay. Respondent characteristics and time patterns are typically included into regression analysis to "control for variation" and derive reliable and valid estimates.

Step 1 is often referred to as the first stage of the hedonic price method. It consists in regressing the price of a good (e.g. a house) on its characteristics (size of the house, number of rooms, distance to the nearest school, distance to the park considered, distance to other parks). The coefficient of one characteristic estimated by the regression corresponds by assumption to a marginal willingness to pay, i.e. the marginal unit price for each characteristic (e.g. price paid for an extra square meter, price for an extra room, price for an extra meter to the nearest school). This method often assumes a specific relationship between the overall (known) price and its characteristics, which is mathematically modelled by a specific functional form (need to refer to an econometrics course for more details on potential functional forms and estimation techniques). The influence on the coefficient values of this assumed relationship can be tested by changing the functional form adopted.

Step 2 is often referred to as the second stage of the hedonic price method. Willingness to pay is the area under the demand curve. Knowing willingness to pay, we can easily derive the demand curve using mathematical techniques. Step 2 consists in using the marginal willingness to pay (characteristic coefficients) estimated in Step 1 as parameters in the estimation of an inverse Marshallian demand equation. In other words, this step assumes that the price of the characteristic is a function of the quantity of this characteristic as well as other parameters that can influence demand for a good or characteristic. The variables used for Step 2 regression need to be independent from the variables used in Step 1. Step 2 regression ideally includes variables such as income, quantities and prices of substitute and complementary goods, tastes, the type of environmental good considered ("normal", "inferior", or "superior" good). As this second-stage is often not undertaken in practice, further details are beyond the scope of this unit.

Limitations of the method

Step 1 is prone to the following limitations. First, it relies on a surrogate market. This market needs to be perfectly competitive so that prices reflect the true economic value of the good. If not, then a bias is introduced in the estimation of the willingness to pay (Step 1). This in turn causes to a bias in the estimation of the demand curve (Step 2). The second limitation is linked to the functional form chosen in Step 1. Depending on the functional form chosen, the marginal prices of characteristics can vary drastically. The robustness of the results obtained in Step 1 can be assessed by repeating the regression for several functional forms. The third limitation is linked to the fact that the hedonic method relies on the explicit underlying assumption that the value of the good is equal to the sum of its characteristics'. This assumption is often not met in real-life, as the sum of the parts (characteristics) is very often greater than the total (the observed price). By design, the hedonic price method also only allows to estimate the use value but not the non-use value of an environmental characteristic. The non-use value can be just as high (if not higher) than the use value depending on the context. Not taking it into account is therefore limiting and does not reflect the full economic value to society.

Step 2 is prone to the following limitation: it is not always possible to include variables that influence demand not correlated to those used in Step 1 in Step 2.

Also, the hedonic pricing method relies on deriving a price for individual characteristics from a surrogate good with an observed market price. This market price is the result of the interaction of both demand and supply for the surrogate good. The willingness to pay for each attribute estimated in the hedonic price function is therefore a proportion of market equilibrium prices. This leads to the derivation of a demand curve based on a series of market equilibrium points and not just demand. In economics, demand and supply are assumed independent one from the other and should therefore be estimated separately in theory. This is not fully the case in the hedonic price method and this method is therefore not theoretically optimal despite being suitable for empirical analysis.

BOX 5

How to apply the travel cost method

The travel cost method consists in one generic and two specific steps:

Step 0: Build the survey and sampling plan to collect data on the origin of travel, journey cost and time, number of visits, distance to substitute goods, respondent's characteristics and on the timing of survey

Step 1: Estimate the cost of one trip as a function of the number of visitors, also called distance decay curve

Step 2: Estimate price as a function of quantity following the introduction of a hypothetical entry fee that is the inverse Marshallian demand equation

Step 0 is not specific to the travel cost method and consists of the same steps as the hedonic method, the only difference being that the survey questions focus on travel cost and time rather than surrogate good prices and characteristics. Step 0 builds a travel cost database that allows us to undertake both steps 1 and 2. For this there is need to know the origin of each respondent's journey to the site of interest (e.g. from their home or hotel to the park or reserve), the journey cost and time, the number of visits for a given time (week, month, year), the distance to substitute goods (e.g. another nearby park), some respondent characteristics (income range, age, education level) to control for variations between individuals, and the time of year the survey was taken to control for seasonal patterns in usage.

FIGURE 10

Example of a Travel Cost Questionnaire – Niagara Region (Ontario, Canada)
Source: ELD Practitioner's Guide, 2014

1. Would you please tell us your nationality and the location of your home? […]
2. Are you visiting the Niagara and the surrounding tourist area for the first time?
3. How many times have you visited the site in the past 10 years?
4. Would you please tell us the period of visit (the number of days including travel)
5. How many days would you like to stay in this pristine environment?
6. What financial planning did you do prior to the visit? Can you please give us a rough estimate on the cost of the visit?
7. Are you a sponsored tourist […]?
8. Is your visit limited to the Niagara region or other tourist attractions in Ontario?
9. Is there other purpose involved in the visit […]?
10. Being a natural heritage, would you please comment on the serenity and environmental quality of the site? Is the water quality […] good […]?
11. Tell us about similar sites that are of interest to you?
12. Have you prepared a shopping list before the visit? What unique commodities (wine/souvenir/fruit products etc.) did you purchase? Is there any other item you may wish to purchase?
13. After visiting the Niagara region, would you recommend visiting the site to family and friends or online?
14. We did our best to provide extensive service for tourists. Would you please comment on the quality of services you received?
15. What improvements would you like us to make in the future (logistics, travel, accommodation, tourism, informative media, etc.)?

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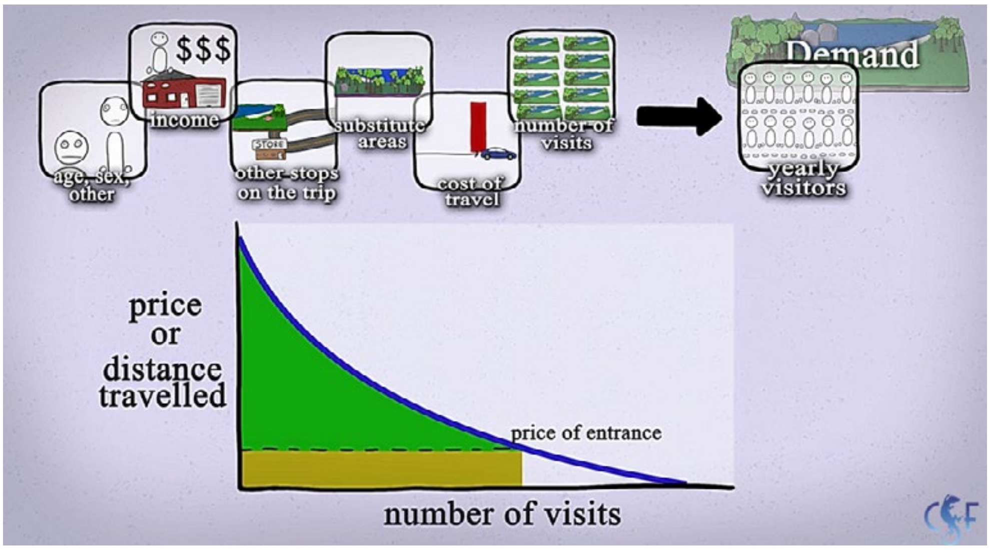
FIGURE 11

Logic of the travel cost method
Source: Conservation Strategy Fund



Time needs to be transformed into a monetary value to be added to the observed cost of travel stated by the visitor. This is often done by taking the opportunity cost of time, that is the forgone benefit derived from the next best alternative. In the case of travel costs, the alternative to travelling is working and the opportunity cost of time is measured by the working wage forgone.

Step 1 relies on a regression of the number of visitors or visits per level of travel cost (need to refer to a more specific econometrics course for more details on regression techniques). In the following example, step 1 showed that, out of the total 200 people coming to visit the reserve, 100 people pay $1, 60 people pay $2, 40 people pay $3 and none pay $4 or over. This is summarised in table 1.

From this, the total number of visits to the site could be graphically represented for a given travel cost. Typically, the more expensive the travel journey, the lower the number of visitors coming to the site. This curve is called the distance decay curve.

Step 2 consists in introducing an entrance fee to the site and using the results from step 1 to derive the number of people that would come to visit the site for this entrance fee. Introducing an entrance fee of $1 means that people formerly paying $1 travel cost now pay a total of $2. Step 1 of this example has established that 60 people come to visit the reserve at a total cost of $2. The same reasoning can be applied to people formerly paying $2 and over. The number of people paying a $0 entrance fee is the total number of people surveyed, potentially extrapolated to a larger population. The results are summarised in table 2, with the number of visits to the reserve for a given total cost.

Applying the same reasoning for a $2 entrance fee and for a $3 entrance fee, the overall results shown in table 3 are obtained.

TABLE 1

Example of a travel cost table of results
Source: Quillérou, 2014

Travel cost	Number of visits
$1	100
$2	60
$3	40
$4 and over	0
	Total = 200

TABLE 3

Total number of visits for each level of entrance fee
Source: Quillérou, 2014

Entrance fee	Total number of People
$0	200
$1	100
$2	40
$3	0

TABLE 2

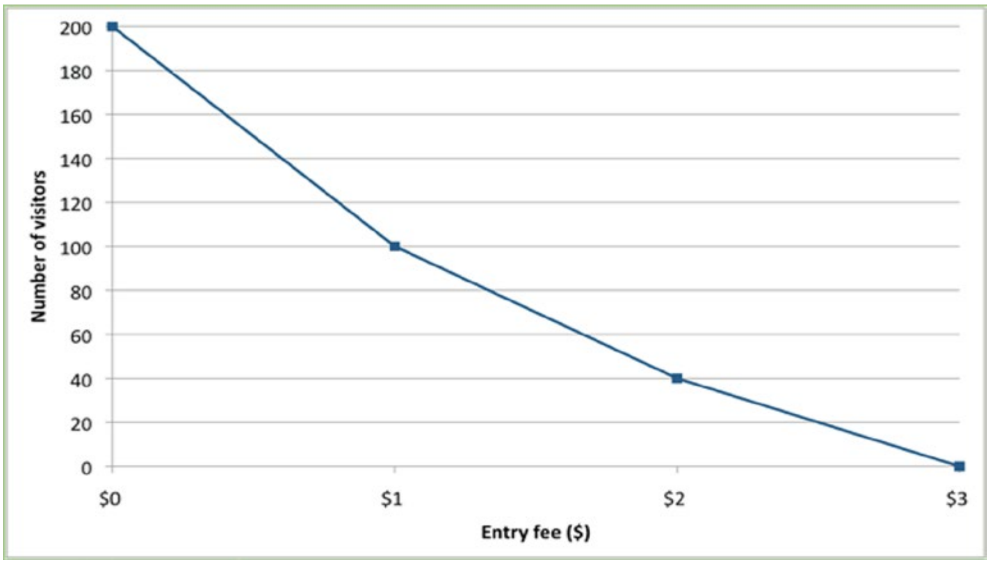
Computation of the total number of visits for a $1 entrance fee
Source: Quillérou, 2014

Entrance fee	Travel cost	Total cost	Number of people
$1	$1	$2	60
$1	$2	$3	40
$1	$3	$4	0
			Total = 100

FIGURE 12

Marshallian demand curve derived from the application of the travel cost method

Source: Quillérou, 2014



The results of table 3 show the demand function for the reserve. This is not the same as the distance decay function from Step 1 because entrance fees have been introduced and the number of visitors to the reserve refers to a level of entrance fee rather than a travel cost.

The travel cost method applied to individual visitors is referred to as the **individual travel cost method**. Visitors can also be grouped by zone of origin, i.e. zones defined for a common range of travel distance or travel time. This application is referred to in the literature as the **zonal travel cost method**. The zonal travel cost method has been initially designed and favoured because of limited spatial information available. Both variations of the travel cost method (individual and zonal) rely on the same steps described above, the only difference being whether individuals are aggregated for travel cost estimation or not. Choosing one or the other depends on the context of the study and available data. Data availability and computing capacities permitting, the individual travel cost method should be preferred to the zonal travel cost method.

Limitations of the method

One of the main problems faced when applying the travel cost method is the valuation of the journey time into money units. The value of journey time is often valued based on its opportunity cost. Some people enjoy the journey just as much as the destination and the value of time measured in money therefore changes from one person to the other. It is not always easy to isolate the time and costs relating to visiting a specific site, especially when people make multi-purpose trips. This is because the journey time and costs are shared across several sites and the relationship between travel costs and utility derived from the site is not as direct as for a single purpose trip. Also, seasonal patterns and socio-economic factors need to be taken into account so as to derive a meaningful value from the extrapolation of survey results to a whole population for a year.

By design, and similarly to the hedonic price method, the travel cost method allows the estimation of a use value only. The non-use value can be just as high (if not higher) than the use value depending on the context. Not taking it into account can therefore be limiting because it does not reflect the full economic value to society.

05 Stated preference methods

Contingent valuation is one of the two stated preference methods. It is a stated preference method because it does not rely on surrogate markets to "reveal" preferences, but is based on a **statement of how much (or rather how much more) respondents would be willing to pay**. The contingent valuation method is based on establishing a credible hypothetical market and asking people to state how much they are willing to pay to conserve a given non-marketed good or to accept a reduction in provision in order to estimate the economic value of this good. See box 6 for more information.

Choice experiment, also called **choice modelling or conjoint analysis**, is the second stated preference method. It was designed to overcome the warm glow and part-whole biases of the contingent valuation method by making respondents explicitly choose between alternative scenarios. These scenarios include levels of environmental or non-environmental attributes and a level of payment which varies between scenarios. The **choice experiment method forces respondents to trade-off explicitly different proposed scenarios**, thereby revealing their preferences for overall scenarios and individual attributes of the scenarios (see figures 12 and 13). For the same reasons as the contingent valuation method, it is a stated preference method. By varying the scenarios for each respondent and across the different respondents, the willingness to pay (accept) for each scenario and each attribute can be statistically estimated. Refer to box 7 for more information.

FIGURE 13

Example of attributes for a choice experiment

Source: Conservation Strategy Fund

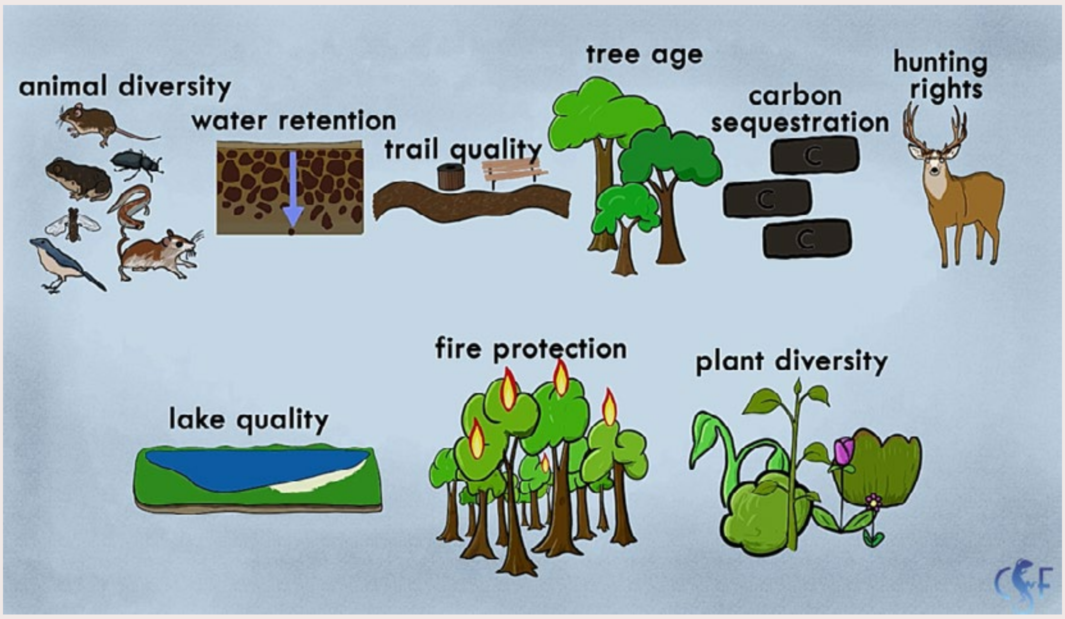


FIGURE 14

Example for a choice experiment survey from Dedoplistskaro district (Georgia)
Source: ELD Case Study of Georgia, 2016

Choice set 13	STATUS QUO	Future Alternative 1	Future Alternative 2
Windbreaks	20% windbreaks 	No windbreaks left 	20% windbreaks 
Crop residue management	Fire allowed 	Fire allowed 	Fire banned 
Land registration fee Relative to what you pay today	87 Lari/ha 0 Lari/ha	80 Lari/ha -7 Lari/ha	110 Lari/ha +22 Lari/ha
Your choice			

Welfare changes are measured through changes in willingness to pay (accept). In theory, the income- compensated Hicksian demand curve can be mathematically derived by integrating the willingness to pay (accept) function. However, in practice this is often not done. The main interest of using the methods is to obtain a proxy for the economic value from the change in welfare induced by a change in environmental provision: the average or median willingness to pay (accept) is often directly plugged into a cost-benefit analysis without going through a formal estimation of demand and supply.

BOX 6

How to apply the contingent valuation method

The contingent valuation method consists of four steps:

Step 1: Set up the hypothetical market by describing the environmental good, the institutional context and a credible payment vehicle.

Step 2: Build the sampling plan of survey respondents and collect survey data on the levels of environmental provision, obtained bids and respondent's characteristics

Step 3: Estimate mean and median willingness to pay (accept)

Step 4: Estimate the bid curve i.e. the willingness to pay (accept) as a function of respondent characteristics (income, age, education) and the level of environmental quality, then aggregate the data

Step 1 relies on building a hypothetical market for survey respondents to make credible bids. This involves describing this hypothetical market with the appropriate level of details, so respondents can make informed choices. This hypothetical market has three components: (i) a description of the environmental good or service, (ii) a description of the institutional context in which the environmental good or service is to be provided and (iii) the method of financing or payment vehicle. Focus groups representative of the society considered are useful in testing and refining the hypothetical market set up and description.

The description of the environmental good or service specifies precisely the current state of the environmental good or service, the consequences of a change for this state and who the change is likely to affect. It can be a simple text description but photos or animated films can also be used to show how changes impact the current state.

It also needs to clearly identify the time at which benefits from the change would arise as this might influence the respondents' willingness to pay. For example, one may be willing to pay more for benefits (e.g. replenished fish stock) arising within 5 years than in 10 years' time only.

The institutional context refers to whether the good or service is managed by a public body, a private firm, a stakeholder cooperative or individual stakeholders. People have preferences for these types of organisation and these preferences are reflected in their bids. Specifying this clearly is thus essential to obtain valid and reliable estimates of willingness to pay (accept).

The payment for the environmental good depends on the study context and the type of value targeted (use or non-use). Payment can be made through various payment vehicles such as entrance fees, local property taxes, national income taxes, sales taxes, development aid or special international funds, in-kind donations of labour or local subsistence crops. Similarly, the willingness to accept payment can be made as a lump sum, tax credits or tax reductions, in-kind donations of labour or local subsistence crops. The choice of a financing method influences the bid levels because of varying distributional effects on the population. The payment vehicle needs to be clearly identified in the hypothetical market set up.

Step 2 starts with the building of the sampling plan, in order to obtain representative bids for the whole population. There are different ways to conduct the survey but delivering it through face-to-face interviews often ensures a higher level of responses and helps better assess the respondent's understanding and commitment to the problem of interest. The goal is to obtain bids for each level of environmental provision described in the survey as well as data on the respondent's characteristics (income, age, educational level) that could influence how much they bid. They are several ways of deriving bids: as a bidding game, as a close-ended referendum with yes/no answers, as a payment card with a range of values, as an open-ended question.

Step 3 consists in estimating the average and median willingness to pay (accept) (need to refer to a more specific econometrics course for more details on regression techniques). The mean and median willingness to pay (accept) are estimated from the descriptive statistics or from the regression depending on the survey questions. Protest bids - that is bids of zero that do not reflect a zero value but rather a refusal to answer - are usually ignored in order to compute the mean and median willingness to pay (accept). If close-ended yes/no questions are used, a discrete choice model can be used to statistically (econometrically) estimate the probability of making a non-zero bid (or "yes" answer) as a function of environmental quality, income-level and respondent characteristics. In this case, the area under the curve gives the mean willingness to pay.

Step 4 consists in estimating the bid curve i.e. using a regression to estimate the willingness to pay (accept) as a function of respondent characteristics (income, age, education) and the level of environmental quality. This allows us to estimate how the willingness to pay (accept) varies with different levels of characteristics. The data can then be easily aggregated to derive an estimate of the total willingness to pay (accept). To be able to aggregate results and derive valid and reliable estimates of economic values implies that the population of reference (i.e. society as a whole) has been identified, that the mean willingness to pay of the population can be derived from the sample mean and that the time period over which the benefits are gained is well identified.

Limitations of the method

Although fairly straightforward in its design, the contingent valuation methodology is prone to many biases (a form of measurement error) and its application can be tricky. Firstly, the method is prone to design biases. These biases are a result of the hypothetical nature of the market, the strategic behaviour of the respondents and interviewer, the "warm glow" effect (i.e. feel-good factor from giving money to what is perceived as good cause) or a social desirability effect. This can lead to respondents providing higher (or lower) estimates than they otherwise would. The chosen starting point, chosen payment vehicle, type of questions asked, scale, scope, sequencing and context also affect the willingness to pay (accept) estimate.

Secondly, the method is also prone to several information biases. The quantity and quality of information embedded into the hypothetical market specification and provided to respondents has been shown to influence willingness to pay (accept) estimates. This may represent more information or different information than respondents would be faced with in the real world. This might lead to economic values that do not represent preferences of society as a whole but rather values of specific stakeholder groups.

Thirdly, the contingent valuation is prone to the part-whole bias. This refers to the fact that the sum of values of individual components of a good (e.g. elements of a landscape such as crops, trees, biodiversity) is greater than the value allocated to the good as a whole (e.g. landscape).

Fourthly, the market set up is hypothetical and respondents might provide estimates of their willingness to pay that are also hypothetical and might not materialise in real-life when the hypothetical market is implemented. This is especially true when the change considered is very risky or very political and more respondents make protest bids.

A fifth step could be included to assess the reliability of the contingent valuation exercise in terms of the answers gathered and the credibility of the values obtained.

BOX 7

How to apply the choice experiment method

The **choice experiment method** consists of four steps:

Step 1: Identify the current situation, likely changes and their consequences. These help to identify attributes, attribute levels and payment levels for each scenario

Step 2: Build unique choice cards by selecting combinations of scenarios (i.e. a bundle of attribute and payment levels)

Step 3: Design the survey instrument with the following five sections: i) describe the changes and their consequences, ii) describe the method of payment, iii) select a set of choice cards for each respondent, iv) add questions to elicit the respondent's attitude and v) finish with questions on the respondent's characteristics (income, age, education)

Step 4: Estimate willingness to pay and aggregate the results

Step 1 consists in developing an understanding of the context of the study, which is just as important as for any other piece of research. This step prepares for the description of the study context to be provided to the respondents. It is critical as it is used to identify the individual building blocks to establish the scenarios provided to the respondents, which have been summarised in table 4. This identification can rely on selected representative focus groups.

TABLE 4

Identification of attributes, their current level or (most likely) levels for a given change

Source: Quillérou, 2014

Attributes	Levels
a1	1,2,3
a2	1,2,3
a3	1,2,3
Payment	p1, p2, p3

Step 2 consists in building unique choice cards by selecting combinations of scenarios from all the possible scenarios. Each scenario is a bundle of attributes and payment. Table 5 provides an example of attributes from an existing choice experiment. Table 6 represents the typical structure of a choice card.

There are several methods to select attributes and build up the choice cards, but this is beyond the scope of this module. One constraint is that the attributes and their levels need to be orthogonal, that is, any attribute is fully independent from all others. This is a necessary condition to be able to correctly measure the trade-off between attributes and estimate a willingness to pay. This approach is very computationally demanding and a newer approach - called efficient designs - has been developed more recently. The efficient designs approach consists of making assumptions on the sign and relative magnitude of the willingness to pay (accept) coefficient for each attribute. This approach has been recently shown to lead to more efficient estimates of willingness to pay (accept).

Step 3 is the design of the survey instrument (questionnaire). As for contingent valuation, it is necessary that the respondent understands the problem fully and gives a credible and accurate answer reflecting their actual – rather than hypothetical – willingness to pay. Also as for contingent valuation, the survey instrument includes a description of the current state, likely changes and their positive and negative consequences. It should include just enough information so that the respondent gives an answer as close to a real-life setting as possible. Respondents are often presented with several choice cards. One respondent faces several choice cards and no two respondents face the same set of choice cards. This ensures enough variability in the answers provided to undertake a reliable and valid estimation. Questions on the respondent's attitude towards change and/or conservation can be included to better assess the credibility of the answers provided and provide information on reasons behind choosing one or another alternative. As for all environmental valuation methods, the survey finishes with questions on the respondent's characteristics (income, age, education…). This survey may be delivered face-to-face for increased effectiveness and better direct assessment of answer validity and accuracy. A pilot questionnaire can be tested on representative focus groups to identify how to improve the questionnaire before the formal data collection.

Step 4 consists in estimating the willingness to pay and then aggregating the results. Depending on the specific format of the choice card, discrete models (logit, probit), paired-comparison models or random utility models can be used to statistically estimate the marginal willingness to pay associated with each attribute (need to refer to a more specific econometrics course for more details on these estimation techniques). Aggregation of the results to derive the total willingness to pay depends on the assumptions on the marginal willingness to pay. Willingness to pay typically decreases with increasing scale or scope: the willingness to pay per hectare is higher for small sites (scarcer resources) than for bigger sites (less scarce). The total willingness to pay for the bigger site is typically lower than the willingness to pay per hectare in the small site multiplied by the surface of the big site. Extrapolation of a willingness to pay value from a small site to a bigger site needs to take this into account.

Like the contingent valuation method, the choice experiment method captures the non-use value of a good or service. The choice experiment method also relies on a hypothetical market set up in experimental conditions and may be prone to biases. This method is very demanding in terms of data and data collection. It requires a high level of human, institutional and computational capacity because of the specific statistics and technical skills involved. Because respondents are requested to make explicit choices between scenarios, this method also relies on the assumptions that preferences are both stable (i.e. which do not change in time) and consistent (i.e. if scenario A is preferred to B, and B is preferred to C, then A is preferred to C). This has been proven not to always be valid in real-life and these assumptions should be checked upon using statistics or checking individual answers.

TABLE 5

Examples of land-based attributes from a case study
Source: Adapted from Borresch et al. 2019, Table 2 Indicators for the included Landscape Functions, p.4

Landscape function/characteristic	Values/Levels	Explanation
Plant biodiversity	▮ 170 plants/km² ▮ 190 plants/km² ▮ 205 plants/km² (status quo) ▮ 225 plants/km² ▮ 255 plants/km²	Absolute number of plants investigated per km²
Animal biodiversity	▮ 50% of desired population ▮ 70% of desired population (status quo) ▮ 80% of desired population ▮ 90% of desired population ▮ 100% of desired population	Percentage of desired population of eleven indicator bird species
Water quality	▮ Less than 10mg Nitrate/l ▮ 10–25mg Nitrate/l ▮ 25–50mg Nitrate/l ▮ 50–90mg Nitrate/l ▮ More than 90mg Nitrate/l	Water quality measured as the content of nitrate/l due to communication with respondents
Landscape aesthetics	▮ Status Quo ▮ Multifunctionality scenario ▮ Grassland dominated scenario ▮ Intensity scenario (with increased field sizes) ▮ High price scenario (with increasing percentage of cereals)	Landscape options were presented with images in the survey.
Price variable	▮ 0/€/household/year ▮ 40€/household/year ▮ 80€/household/year ▮ 120€/household/year ▮ 160€/household/year ▮ 200€/household/year	Costs for provision of presented landscape options per household and year.

TABLE 6

Example of choice card structure.
am_k refers to attribute m, level k; and pj to the payment level
Source: Quillérou, 2014

	Scenario 1	Scenario 2	Scenario 3
Attribute a1	a1_1	a1_1	a1_3
Attribute a2	a2_3	a2_2	a2_1
Attribute a3	a3_1	a3_1	a3_2
Payment	p1	p2	p1
Tick **one** box corresponding to your preferred scenario	!	!	!

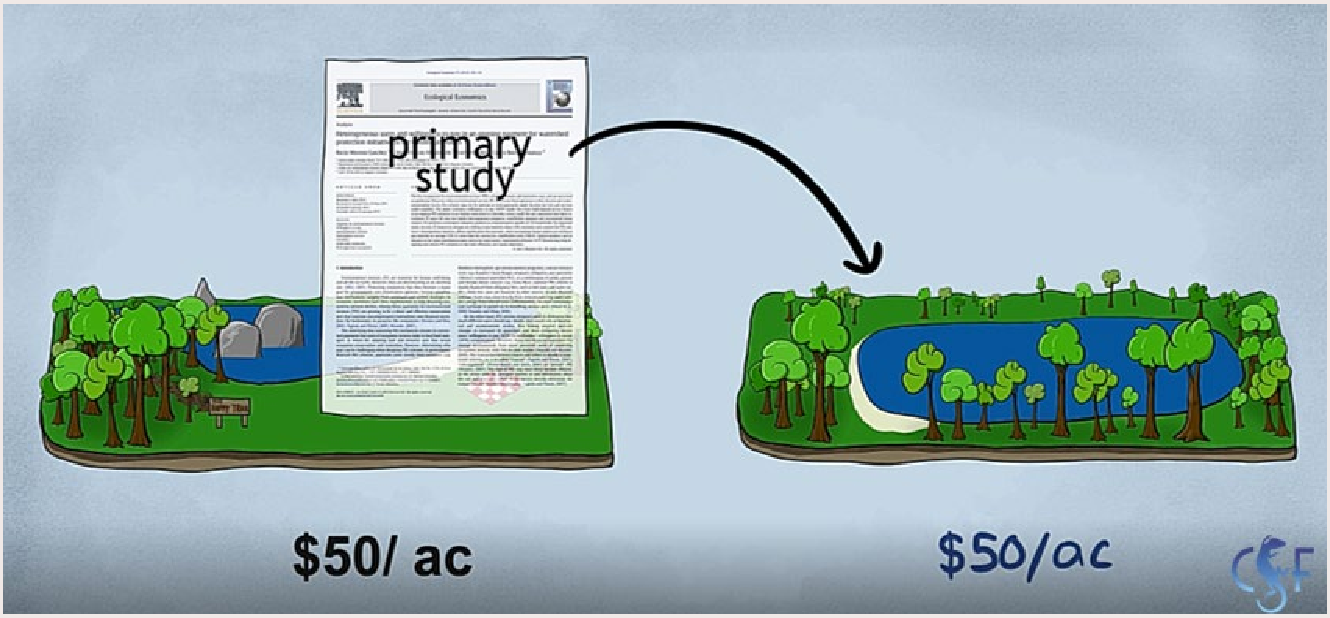
06

Benefit transfer

Economic valuations can be costly in terms of financial, time and human resources. Benefit transfer offers a cheaper alternative to other valuation methods as it reuses already available information. As a result, benefit transfer shows great potential for development as well as integration of environmental valuation into policy-making. The method has developed in relation to valuing demand for (rather than supply of) environmental goods and services. Benefit transfer simply consists in "transferring" economic values from one case study with a known non-market economic value to a similar site to be valued in monetary terms. This transfer of values can be in theory made across time, space, populations and sometimes across ecosystem goods.

FIGURE 15

Logic of a benefit transfer
Source: Conservation Strategy Fund



BOX 8

How to apply the benefit transfer method

This method consists of two steps:

Step 1: Identify a case study of reference as a source of economic value for the non-marketed good of interest. The study should have valued the same goods and services within a similar geographical setting.

Step 2: Define the similarity in terms of population sizes and characteristics as well as provided environmental goods and services between your case and the case you are transferring the benefits from. Then transfer the economic value from the case study of reference to the case study to be valued; decide if adjustments must be made to the existing values.

Benefit transfer can be undertaken by identifying two sites (site 1 and site 2) that are similar in terms of the environmental goods and services they provide. If they have similar population sizes and characteristics, the transfer is simply the allocation of site 1's economic value to site 2. If site 1 and site 2 have different scales and/or scope (i.e. site 1 is 1 ha and site 2 is 100 ha and/or site 1 has 1 environmental good and site 2 has 10), the known economic values of site 1 obtained by other valuation methods need to be extrapolated before allocation to site 2. This is so that the value allocated to site 2 from site 1 reflects its true economic value. Sites can often be quite different and located in regions or countries with very different populations and incomes. Meta-regression models have been used to transfer values by controlling for some of the main factors of variation such as income level (need to refer to an econometrics course for more details on how to estimate the economic value for the case study of interest using meta-analysis).

Despite its theoretical appeal and potential, benefit transfer is still prone to scale, scope and sampling effects. These can impair the derivation of reliable estimates of environmental values and thus need to be tested for. In practice, adjustment factors might be required for benefit transfer, which depend on the change in scale considered. Whether or not to adjust values for accurate extrapolation and how to best do so still needs to be dealt with on a case-by-case basis.

Valuating the different types of ecosystem services

The **most common methods** used to capture the economic value of the different ecosystem services are identified in table 7 below, as well as the ease of which the ecosystem service translates into values and how the values can be used for sites. Table 8 summarises typical ecosystem services and valuation methods used in the context of ELD studies.

TABLE 7

Valuation methods for the different types of ecosystem services
Source: Farber et al., 2006

Ecosystem service	Amenability to economic valuation	Most appropriate method for valuation	Transferability across sites
Gas regulation	Medium	Contingent valuation, avoided cost, replacement cost	High
Climate regulation	Low	Contingent valuation	High
Disturbance regulation	High	Avoided cost	Medium
Biological regulation	Medium	Avoided cost, production approach	High
Water regulation	High	Avoided cost, replacement cost, hedonic pricing, production approach, contingent valuation	Medium
Soil retention	Medium	Avoided cost, replacement cost, hedonic pricing	Medium
Waste regulation	High	Replacement cost, avoided cost, contingent valuation	Medium to high
Nutrient regulation	Medium	Avoided cost, contingent valuation	Medium
Water supply	High	Avoided cost, replacement cost, market pricing, travel cost	Medium
Food	High	Market pricing, production approach	High
Raw materials	High	Market pricing, production approach	High
Genetic resources	High	Market pricing, avoided cost	Low
Medicinal resources	High	Avoided cost, replacement cost, production approach	High
Ornamental resources	High	Avoided cost, replacement cost, hedonic pricing	Medium
Recreation	High	Travel cost, contingent valuation, travel cost, ranking	Low
Aesthetics	High	Hedonic pricing, contingent valuation, travel cost, ranking	Low
Science and education	Low	Ranking	High
Spiritual and historic	Low	Contingent valuation, ranking	Low

TABLE 8

Typical ecosystem services and valuation methods used in the context of ELD studies
Source: ELD Initiative

Category	Ecosystem services	Biophysical impact	Valuation approach
Provisioning	increased crop production	incremental crop yield increase	market prices
	increased availability of forest products (non-timber forest products, firewood, medicinal plants)	fruits/timber/firewood produced	market prices; in case of medical plants replacement cost for treatment/medicines
	increased edible biomass on rangelands	increased natural forage available	replacement cost of livestock feed purchases
	availability of medicinal herbs (on grazing land)	improved animal nutrition and reduced animal diseases	replacement cost for treatment/medicines or stated preference choice experiment
	increased livestock product production	incremental meat (or wool etc.) production increase	market prices
	increased honey production based on increased availability of nectar plants	incremental honey production increase	market prices
Regulating	nitrogen fixation	increased crop yields	change in productivity approach and use of market prices
	soil moisture conservation	increased crop yields	change in productivity approach and use of market prices
	sediment stabilisation and reduction in soil erosion	positive impact on nitrogen and phosphorus, on erosion phenomena and/or on sedimentation down-stream	replacement cost for fertilisers in market prices and/or avoided damage regarding soil restoration and/or avoided damage regarding water reservoir cleaning
	increased infiltration and reduced runoff	increased infiltration to shallow aquifer / groundwater recharge	replacement cost for purchase of water in market prices
	increased infiltration and soil moisture on grazing land	extended grazing areas and periods, enhanced stream flows and landscape value	stated preference choice experiment
	infiltration and recharge of shallow aquifer	increase in available ground-water	replacement cost of trucked water for livestock
	reduced downstream sedimentation of reservoirs	sustained reservoir storage capacity	replacement cost of water storage capacity lost
Supporting	carbon sequestration / climate change mitigation	CO_2 sequestered	avoided damage cost, using the social cost of carbon
Cultural	recreation, eco-tourism, spiritual inspiration	Increased biodiversity through nature conservation	market prices (entry fees), travel-cost method and/or willingness-to-pay
	wildlife tourism – trophy hunting		market price (hunting fees), travel-cost method
	improved human health	—	replacement cost for treat-ment/medicines

08

Study design, sampling plan and survey instruments

The sections above gave a detailed overview and discussion of valuation methods appropriate according to the TEV. In addition to **choosing the appropriate method(s)** for a case, it is essential for successful demand-based valuations to outline a valid **sampling plan** and have appropriate **surveying instruments**.

Choosing the appropriate method(s) for a case

The following table provides as checklist of characteristics in order to choose the most appropriate method for your case:

TABLE 9

Choosing the most appropriate method for your case

Source: ELD MOOC 2014 – Choose a method, design a simple research, amended

Characteristics	Appropriate method
1. The ecosystem at stake produces goods and services bought and sold in commercial markets; changes in the environment (degradation, pollution etc.) affect their quantity or quality changes	Market price method
1. Degradation and/or pollution phenomena reduce the quantity and quality of environmental services 2. Damage avoidance or replacement expenditures have already been made or are being thought of	Replacement cost or damage cost avoided
1. Changes in the land use practice affecting positively or negatively, the quantity or quality of ecosystem services delivered	Dose-response / change in productivity
1. The majority of significant goods and services within the ecosystem constitute as non-use values. 2. Few people visit the site.	Contingent valuation
1. The majority of significant goods and services within the ecosystem constitute as non-use values. 2. Few people visit the site. 3. There are several possible options for preserving and/or using the site, each of which have different impacts on the site. Thus, several options must be weighed in terms of costs and benefits to the public.	Choice experiment
1. A literature research reveals that information from studies already completed in another location and/or context is available.	Benefit transfer
1. The majority of significant goods and services within the ecosystem constitute as use values. 2. Your study reaches out to estimate environmental benefits or costs associated with environmental qualities and/or amenities.	Hedonic price method
1. The majority of significant goods and services within the ecosystem constitute use values. 2. The site is primarily valuable to people as a recreational site. 3. The expenditures for projects to protect the site are relatively low.	Travel cost method

Avoid double counting!

Double-counting may occur where competing ecosystem services are valued separately and the values aggregated; or, where an intermediate service is first valued separately but also subsequently through its contribution to a final service benefit. For example, the value of a forest ecosystem for clearance timber logging should not be added to the value of the same forest patch for recreational benefits since the former will likely preclude the later. Nor should the value of a pollination service, which is already embodied in the market price of a crop, be counted separately unless the value of its input to the crop is deducted. In essence, double-counting is a feature of the complexity of ecosystem functioning and uncertainty surrounding our understanding of the systems and their interlinkages. Unfortunately, there are cases where researchers have incorrectly summed values in order to obtain aggregate estimates of ecosystem value (evidence from Fisher et al., 2008b). It is thus essential that that the analyst has a clear understanding of the various overlaps and feedbacks between services when undertaking aggregation (de Groot et al 2002; Turner et al 2003).

Sampling plan

The sampling plan defines the way in which a group of subjects is drawn out of a population of stakeholders to gather data from. Important aspects to consider when selecting samples are:

- The sample of participants should be representative for the whole population and all groups of stakeholders should be considered in the sample;
- Variables such as income, age, and level of education should be considered when defining a sample, and;
- Ideally, every member of the stakeholder population should (in theory) have the same chance of being selected for the survey (random selection). This can be achieved by randomly drawing names from a list with all potential stakeholders (e.g., from a phonebook). Another option is a selection method called **'convenience sampling'** where people are randomly selected for interviews or to fill out surveys in different public places. While 'convenience sampling' is very time and cost-efficient it has the disadvantage that it tends to attract a faction of people that have similar psychologies while it deters others. This might falsify the results. Different survey instruments are appropriate for different economic valuations.

Survey instruments

Whilst there are many instruments for economic valuation, one can consider including either **questionnaires** or **face-to-face interviews** into a survey design. Face-to-face interviews often ensure a higher level of responses and help better assess the respondent's understanding and commitment to the problem of interest. Questionnaires on the other hand are often more time and cost-efficient since multiple participants can partake in a survey simultaneously or they can even be filled out online. Questionnaires also facilitate collection of numbers for quantitative analysis.

Further reading

Ecosystem services valuation:
http://ecosystemvaluation.org/

Ecosystem valuation: Some principles and a partial application
https://www.econstor.eu/obitstream/10419/48823/1/621201006.pdf

The Value of Land Report:
https://www.eld-initiative.org/fileadmin/pdf/ELD-main-report_en_10_web_72dpi.pdf

TEEB Synthesis Report on the economic contribution of biodiversity and ecosystem services to human well-being
http://www.teebweb.org/our-publications/teeb-study-reports/synthesis-report/

Benefit transfer:

- ELD Initiative *http://eld-initiative.org/*
- UK National Ecosystem Assessment *http://uknea.unep-wcmc.org/*
- TEEB *http://www.teebweb.org*
- EVRI *https://www.evri.ca/*
- EnValue *http://www.environment.nsw.gov.au/envalueapp/*

Toolkits for valuation and assessment:

- ValuES *http://www.aboutvalues.net/*
- ARIES *http://aries.integratedmodelling.org/*
- SESAME *http://www.pdx.edu/ecosystem-services/*
- GLUES *https://www.ufz.de/glues/*
- INFFER *http://www.inffer.com.au/*
- MIMES *http://www.ebmtools.org/mimes.html*
- IVM Institute for Environmental Studies
  http://www.ivm.vu.nl/en/Organisation/departments/spatial-analysis-decision-support/research-themes/Mapping-and-modelling-ecosystem-services/index.asp
- PBL group *https://www.pbl.nl/en/*
- Ecosystem Valuation *http://ecosystemvaluation.org*

List of figures

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This document was published with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ)

Photography: Front and back cover © Jörg Böthling / GIZ
Design: kippconcept gmbh, Bonn
Bonn, September 2019

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