Session/Week 4
Date March 23, 2014

2.0 The economist's toolbox for environmental valuation

Section Overview

This is a very short introduction to environmental valuation. This section aims to give you 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. Even though the following focuses on environmental valuation, these valuation methods are not specific to the environment and can be applied to other goods that are not traded on a market such as health and healthcare, proximity to schools.

This section is meant to provide you with a guide to analyse existing case studies or conduct a valuation exercise yourself. The method description, background, assumptions and limitations should help you help answering 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?

Section Learning Outcomes

By the end of this section students should be able to:

- Describe the total economic value framework
- Recognise that different valuation methods lead to slightly different estimates because of what they measure and how they measure it
- Describe the steps involved in each of the valuation methods, the main assumptions underlying each method and some methodological and empirical limitations

2.1 The concept of Total Economic Value: 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 your preference for consumption or non-consumption of a good. For example, let us assume you like eating fruit: in economics terms, you derive utility from consuming fruit. However, if you do not like fruit, you derive utility from *not* consuming fruit. Utility applies to individual's preferences between goods whilst society's preferences are measured by **welfare**.

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?

This framework divides the total economic value of a good or a service into a use value and a non-use value. **Use value** refers to the benefit derived from the use of the environmental good or service. Examples of use values are the revenues derived from harvesting fish or from extracting oil from the ground (including off-shore), 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. These uses can be **direct**, like fish harvesting or **indirect**, like flood regulation.

Non-use values are values allocated by society to goods and services but do not stem from the use of these good and services. You might for instance value the Great Barrier Reef in Australia or the Amazonian forest even if you do not nor will ever use it.

Use and non-use values are assumed 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

Non-use values can be further broken down into Option, Existence, Bequest and Stewardship values (Figure 1). **Option value** is the value allocated by society to the potential future use of a good or service and accounts in some measure for uncertainty. For instance, you 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. You would therefore be ready to pay to protect blue whales and maintain the option to watch them later in your life. **Existence values** refer to the value placed by society on the existence of an environmental good or service. For instance, you may never have the opportunity to personally see a live blue whale in its original habitat, but you like the idea that it exists and 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, you might want your 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…) typically have stewardship values.

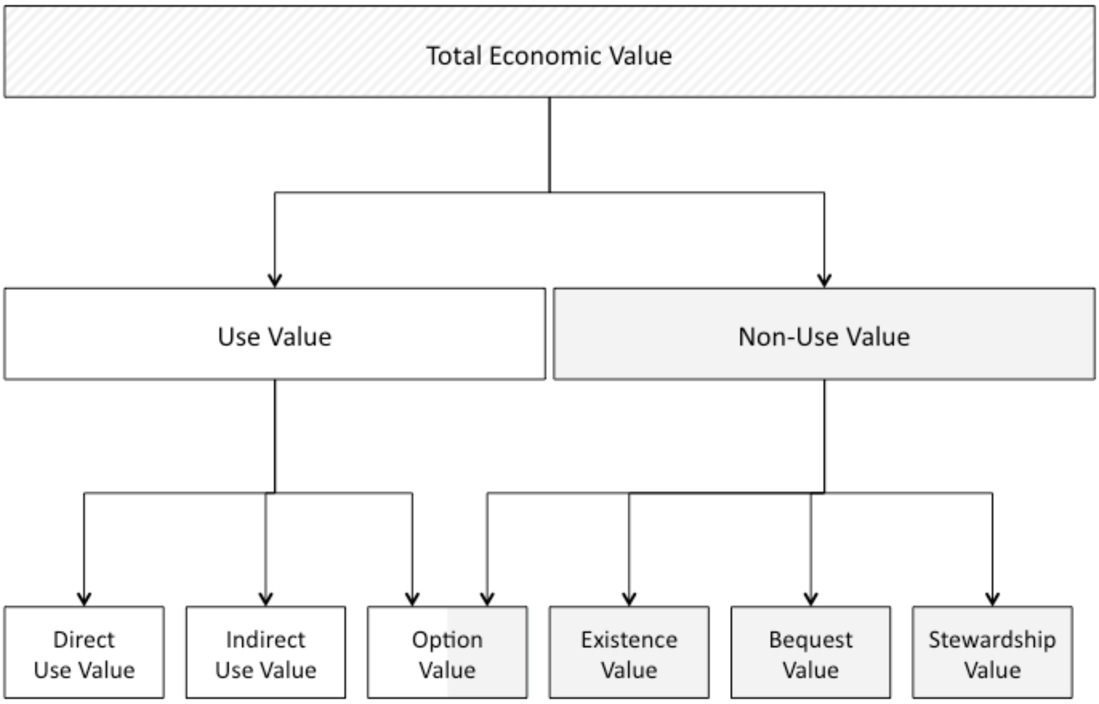

Figure 1: Decomposition of the Total Economic Value into use and non-use values. The sizes of the boxes are not representative of any order of magnitude. Source: unit author.

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 Total Economic Value framework suggests. It is not always easy to differentiate between the different types of values in practice.

2.2 Economic measures of value: How do we measure changes in welfare?

What we want to measure are changes in society's welfare associated with the loss or gain in environmental goods or services. Welfare is an economic measure of society's level of "happiness". 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.

The methods described in the following sections are based on slightly different measures of welfare changes. These are described in more details in the next sections. There are three types of valuation methods:

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

The **non demand-based** methods consist in 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 to a increase (decrease) 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.

Demand-based methods are called so because they rely on changes in demand. They allow to derive a demand curve for comparison to the cost of provision (supply curve). **Revealed preference** methods use surrogate markets to estimate the value of non-marketed goods and reveal preferences from market behaviour. These methods do not involve change sin 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 fraction of their market value is linked to the proximity to Central Park. The property market is the surrogate market 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 detailed more specifically in the following sections.

Stated preference methods have been developed so as 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 like 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 modelling methods are examples of revealed preference methods and are detailed more specifically 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.

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 in more details below.

Economists can use two different types of demand curves: the Marshallian demand curve and the Hicksian demand curve. 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.

This is an optional activity. You may want to find out more about Alfred Marshall, John Hicks and their work on demand. You now have the opportunity to take time to do so.

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 on Figure 2. 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.

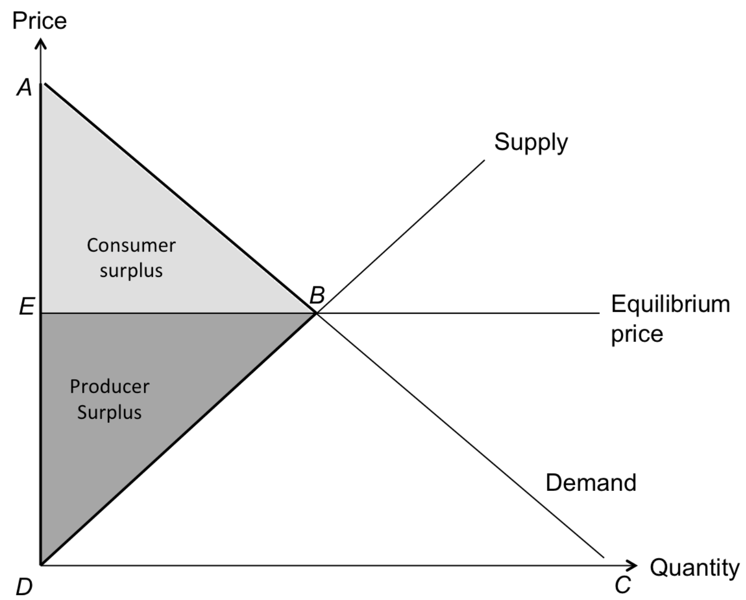

Figure 2: Consumer surplus is the area ABE and producer surplus the area EBD. The sum of consumer and producer surplus is equal to welfare (area ABD). The demand curve is a Marshallian demand curve. Source: unit author.

Willingness to pay is the area under the demand curve (Figure 3). 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.

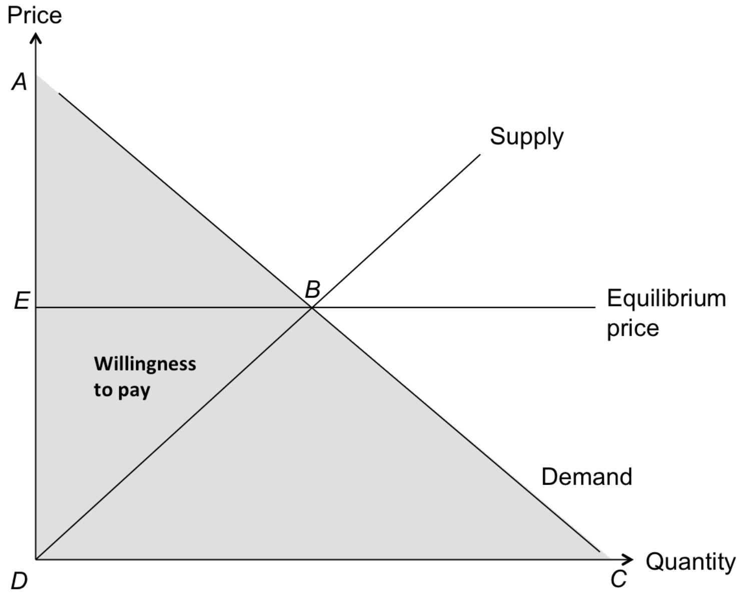

Figure 3: Willingness to pay is the grey area ACD. The demand curve is a Hicksian demand curve (utility is constant and income varies). Source: unit author.

Willingness to accept is also the area under the demand curve and could be represented similarly to willingness to pay in Figure 3. 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.

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.

Depending on your economics background, this section might not make sense to you yet. You should try reading through the description of the different methodologies and then come back to it. It should be clearer the second time! In the end, this section should have given you a feel for the complexity of the theory behind environmental valuation methods.

What is important to remember is that **the method you choose 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 you estimate (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, willingness to pay or willingness to accept). Additionally, because people'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 your study is critical for choosing a valuation method that gives reliable and valid estimates of the true economic value.

2.3 Non-demand curve approaches to valuation

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.

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 (forest) or services (timber) that are traded. 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. 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 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. For instance, a paper mill produces paper but its production also create 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. It is however not always possible to link a production output to a change in environmental quality so this approach is not always applicable.

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 the next section.

2.4 Revealed preference method: the Hedonic Price Method

Hedonic pricing is one of the two revealed preference methods. It 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).

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 leads building 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 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. You 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.

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.

2.5 Revealed preference method: the Travel Cost Method

The travel cost method is the second revealed preference method. The idea behind this 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.

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 leads building a travel cost database that allows us to undertake both steps 1 and 2. For this we need 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. 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. You need to refer to a more specific econometrics course for more details on regression techniques. In the following example, step 1 has led to determine 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.

Table 1: Example of a travel cost table of results. Source: unit author.

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

From this, the total number of visits to the site can be graphically represented for a given travel cost (Figure 4). 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.

Figure 4: Distance decay function derived from the application of the travel cost method. Source: unit author.

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.

Table 2: Computation of the total number of visits for a $1 entrance fee. Source: unit author.

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

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 3: Total number of visits for each level of entrance fee. Source: unit author.

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

The results of Table 3 have been graphically represented in Figure 5 to visualise 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.

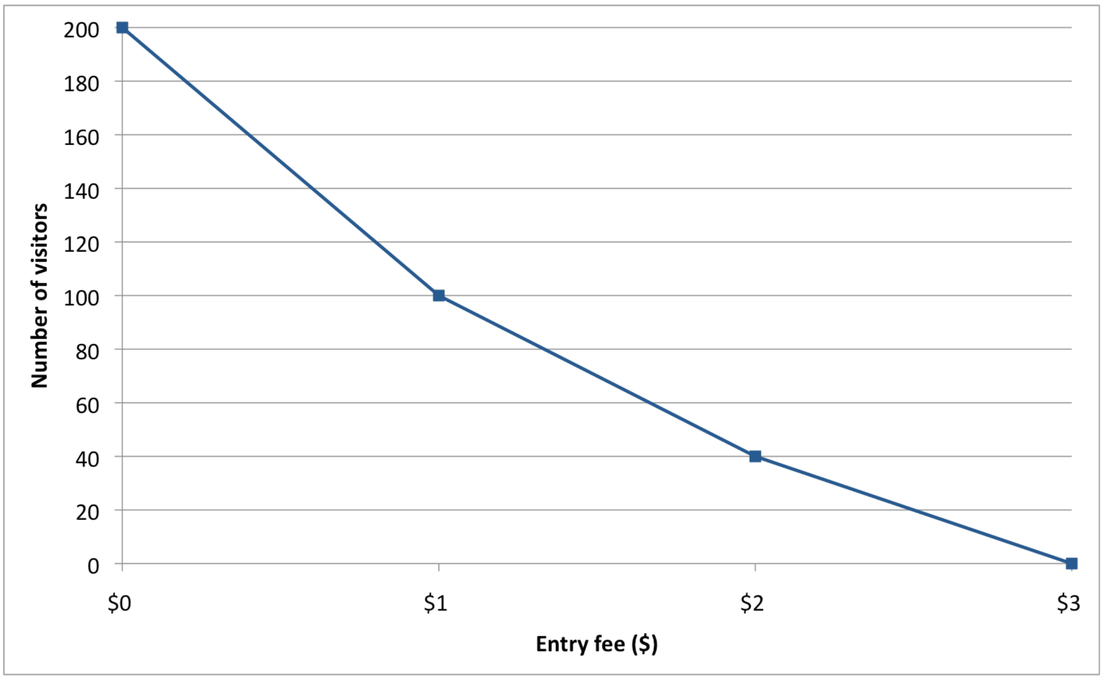

Figure 5: Marshallian demand curve derived from the application of the travel cost method. Source: unit author.

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, he 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.

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 is does not reflect the full economic value to society.

2.6 Stated preference method: the Contingent Valuation Method

The Contingent Valuation method is one of the two stated preference methods. a stated preference method because it does not rely on a 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.

Welfare changes are measured through changes in willingness to pay (accept). In theory, an income-compensated Hicksian demand curve can be mathematically derived by integrating the willingness to pay (accept) function. However, in practice this is not often done and the average or median willingness to pay (accept) is directly taken as a proxy for the economic value to be used in cost-benefit analysis.

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, you 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). You 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.

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.

2.7 Stated preference method: Choice experiment

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. 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.

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 not often done. The main interest of using the method 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.

> 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: unit author.

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

Table 5: Example of land-based attributes from a case study. Source: adapted from Borresch et al. (2009, Table 2 Indicators for the included Landscape Functions page 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	Percentage of desired population of eleven indicator bird species

	• 90% of desired population • 100% of desired population	
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.

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. You may have even been asked to fill in one of those before, without knowing how researchers would analyse these!

Table 6: Example of a choice card structure. a*m_k* refers to attribute *m*, level *k*; and *pj* to the payment level. Source: unit author.

	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 <u>**one**</u> box corresponding to your preferred scenario	☐	☐	☐

There are several methods to select attributes and build up the choice cards but this is beyond the scope of this unit. 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 in 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. You 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.

2.8 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.

Benefit transfer 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 (site 1)

Step 2 – Transfer the economic value from the case study of reference to the case study to be valued (site 2)

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. You 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.

2.9 Multi-criteria analysis

Multi-Criteria Analysis (MCA) or Multi-criteria Decision Analysis (MCDA) is a semi-qualitative procedure used to compare or determine overall preferences between alternative and often conflicting options. It helps identify a preferred option in multi-disciplinary contexts without requiring agreement on the preferred option or how to weight assessment criteria or how to value all criteria in monetary terms. Assessment criteria can be quantitative or qualitative (score) and can relate to social, technical, environmental, economic and financial changes. It is easy to use and has a wider scope than cost-benefit analysis because it includes qualitative as well as quantitative data.

Multi-criteria analysis is **not** an environmental valuation method as such but rather helps identify preferred scenarios without using economic valuation techniques. It is used as an alternative to cost-benefit analysis. It can however be seen as the ancestor of the choice modelling method because of it similar structure, hence its description here. It does not involve a variation of attribute and price levels but rather assesses options (scenarios) along several quantified or scored criteria (attributes). This method can be used as a preliminary to environmental valuation to screen scenarios and identify a preferred scenario and its criteria to be economically valued for more formal economic assessment.

Multi-criteria analysis consists of three steps:
Step 1 – Determine alternative options (scenarios) and criteria (attributes) for appraisal
Step 2 – Measure criteria or indicators, physically, in monetary terms of by scoring them
Step 3 –Aggregate the criteria values for each option by weighting the criteria and select the option with the highest score

Step 1 identifies potential options (scenarios) as well as criteria or indicators to assess whether these options are socially desirable or not. For instance, Option 1 could correspond to a business-as-usual scenario with a reduction in productive land area of 10% per year, Option 2 to actions leading to a 5% decrease in productive land area per year, Option 3 to actions leading to a 0% decrease in productive land area per year. Examples of criteria to assess whether these options are socially beneficial are: the number of land-based jobs lost because of the reduction in productive land size, the number of jobs created by establishing alternative land-based livelihood options (economic activities), the likelihood of floods, pollution levels, recreational and cultural activities… The general structure of a multi-criteria analysis is represented in Table 7.

Table 7: Example of a multi-criteria analysis structure. Source: unit author.

	Option 1	**Option 2**	**Option 3**
Criteria c1			
Criteria c2			
…			
Criteria cn			

Step 2 involves putting a quantitative or qualitative value for each criterion and each option. Ideally, the more socially desirable the outcome, the higher the criterion value to ensure consistency of ranking across the different criteria. What really matters are the relative variations for a given criterion between options - that is, the trade-off between 2 options for a given criterion. For

instance, Option 1 is associated with losing 10 land-based jobs, Option 2 with losing 8 jobs and Option 3 with losing no job. To obtain the right ordering between options, a score of 0 (=10-10) can be given to option 1, 2 (=10-8) to option 2 and 10 to option 3 (=10-0). A similar ranking process can be applied to each criterion (Table 8).

Table 8: Example of multi-criteria analysis criteria. Source: unit author.

	Option 1: Business-as-usual scenario, 10% decrease in land area per year	**Option 2:** 5% decrease in land area per year	**Option 3:** 0% decrease in land area per year
Criteria c1: loss of land-based jobs (score)	0	2	10
Criteria c2: likelihood of floods	80%	60%	30%
Criteria c3: loss of recreational and cultural activities	40%	5%	1%

The absolute value of one criterion might affect the overall outcome if it is too different from the others. That is, if all criteria but one have their values between 1 and 10 and the last criterion has values between 100 and 200, this last criterion affects the final choice of option. A change of scale for this criterion can effectively solve this scaling problem.

Step 3 involves determining weights for each criterion. This can be done through selected focus groups and for various stakeholders. Ideally the final mix of stakeholders should be representative of society as a whole. Each individual stakeholder can assign weights to each criterion. The weights are then aggregated to derived mean weight across all respondents for each criterion. The scores are then computed for each option as the weighted sum of the criterion values (Table 9). The highest value corresponds to the most socially desirable option, either for one stakeholder group or society as a whole depending on the nature of the respondent.

Table 9: Example of the general outcome from a multi-criteria analysis for selection of the most socially desirable option. Source: unit author.

Criteria	**Weight**	**Option 1**	**Option 2**	**Option 3**
Criteria c1	w1	c1_1	c1_2	c1_3
Criteria c2	w2	c2_1	c2_2	c2_3
Criteria c3	w3	c3_1	c3_2	c3_3
Criteria c4	w4	c4_1	c4_2	c4_3
VALUE (SCORE) OF OPTION		w1*c1_1 + w2*c2_1 + w3*c3_1	w1*c1_2 + w2*c2_2 + w3*c3_2	w1*c1_3 + w2*c2_3 + w3*c3_3

	+ w4*c4_1	+ w4*c4_2	+ w4*c4_3

This method also has its limits. There is a risk of double counting for overlapping objectives. It relies on expert judgement which does not always correspond to preferences of society as a whole. The ordinal scoring of qualitative impacts is potentially too arbitrary. Where significant differences in weightings occur between particular groups, preferred scenario might drastically differ between groups. It might be difficult to derive a scenario that would be acceptable to all groups. Finally, this method is subject to small sample biases which arise when the sample is too small to allow for extrapolation to the entire population.

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