### Direct market valuation

**A1. Price-based**

**Market price**

**Definition**

The most straightforward and commonly used method for valuing any good or service is to look at its market price, i.e. how much it can be bought or sold for. In a competitive market without distortions (e.g. taxes or subsidies) price is determined by the relative demand for and supply of the good or service in question, and reflects its marginal value (i.e. the value of a small change in the provision of that good or service). Market prices are useful for valuing environmental goods and services that are directly traded in markets, for example products such as timber, fuel wood, fish, and other foods.

**Example**

*‘The timber and fuelwood production were estimated considering the local market price and the harvested volume subdivided by forest types. In the study area, the annual wood production is about 26.5 million of m3 per year and around 60% of harvesting volume is commercial timber, while the remaining 40% is used for energy purpose (fuelwood). The average price of timber varies between 65 and 150 €/m3 in consideration of the tree species and quality of wood (low, medium and high quality of wood), while the price of fuelwood is around 150 €/t with small changes due to the calorific value of the tree species.’*

Source: Paletto A., Geitner C., Grilli G., Hastik R., Pastorella F., Rodrìguez Garcìa L., 2015. Mapping the value of ecosystem services: A case study from the Austrian Alps. Ann. For. Res. 58(1): 157-175, 2015

**Steps:**

*1:* See the specification of the biophysical units or indicator units of ecosystem service

*2:* Collect data on prices of units specified above. Correct any distortion in prices or find comparable products at undistorted prices.

*3:* Multiply price by the quantity of ecosystem service.

***Type of required data and examples:***

*The biophysical measures of a given ecosystem service (e.g. the tonnes of carbon sequestered per hectare of a land use type)*

*The market price/ surrogate market price (e.g. The social cost of carbon in $ per tonnes of carbon)*

**A2. Cost-based method**

**Avoided damage cost**

**Definition**

Ecosystems frequently provide protection for other economically valuable assets. The damage cost avoided method uses either the value of property and assets protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem.

**Example**

*‘The total carbon storage capacity of green spaces in the main city of Nanjing is about 7.3 6105 t with an annual sequestration of 5.8 6103 t. Using a general afforestation cost of 251.40 RMB/t in China (Xiao et al., 2000), the economic value of green spaces, in terms of carbon fixation, was estimated at about 1.74 6 108 RMB with an annual benefit of 1.34 6106 RMB.’*

Source: Peng, L., Chen, S., Liu Y, Wang J., 2008. Application of CITY green model in benefit assessment of Nanjing urban green space in carbon fixation and runoff reduction. Front. For. China 2008, 3(2): 177–182

**Steps:**

*1:* Identify the protective services provided by the ecosystem.

2. Estimate the cost of the damage event using information on the value of the assets at risk.

***Type of required data and examples:***

*The biophysical estimates of the amount of service provided ( e.g. retention rates in litters per hectare)*

*The historic records of costs of similar damage from the past ( e.g. NPV of historic costs in $ per hectare)*

**Replacement cost**

**Definition**

The replacement cost method estimates the value of ecosystem services as the cost of replacing them with alternative man-made goods and services. The replacement cost technique assumes that the costs incurred in replacing lost environmental assets with man-made alternatives can be interpreted as an estimate of the value of the goods and services received from the environmental asset. Basically, it is assumed that the amount of money society spends to replace an environmental asset is roughly equivalent to the lost benefits that asset provides to society.

**Example**

*‘The replacement cost method has been used to estimate the protective function of forests and grasslands, using the prices of artificial substitutes of public engineering works in South Tyrol (year 2012), being a good proxy for the Vorarlberg area, where such a price list is not available. The total costs of carrying out and maintaining the different artificial substitutes – distinguishing for land use (forest and grassland) and type of protection (direct and indirect protection) – were taken into account to calculate an annual cost per unit area (hectare).*

Refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition.

Source: Paletto A., Geitner C., Grilli G., Hastik R., Pastorella F., Rodrìguez Garcìa L., 2015. Mapping the value of ecosystem services: A case study from the Austrian Alps. Ann. For. Res. 58(1): 157-175, 2015

**Steps:**

*1*: Identify the services provided by the ecosystem and assess the extent to which ecosystem services are actually used.

*2*: Identify man-made goods, services, or infrastructure that can replace the ecosystem services at the scale at which they are utilised.

*3*: Estimate the costs of the man-made replacement goods, services, or infrastructure.

***Type of required data and examples:***

*Secondary sources or ascertained through expert consultation and professional estimates.*

*The costs of carrying out and maintaining the different artificial substitutes (e.g. dikes construction and maintenance costs in $ per hectare).*

**Mitigation/Restoration cost**

**Definition**

The mitigation or restoration cost refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. It should be clearly distinguished from the replacement cost method

**Example**

*‘The filtering N or P was valued by using the costs of existing mitigation techniques for limiting the loss of these two nutrients. A number of mitigation techniques were considered in order to build a mitigation function for N and P, linking cost of mitigation and its efficiency. The mitigation techniques considered include the use of a standoff pad to limit urine and dung deposition on pastures and soil damage as it influences sediment and P losses, low water soluble P fertiliser, replacing N fertilisers with low N feed supplements and nitrification inhibitors. The cost of the mitigation, applied to the measure of the service, was used as a proxy for the value of the service’.*

Source: Dominati E., Mackay A., Green S., Patterson M., 2014. A soil change-based methodology for the quantification and valuation of ecosystem services from agro-ecosystems: A case study of pastoral agriculture in New Zealand. Ecological Economics 100. 119–129

**Steps:**

*1*: Identify the services provided by the ecosystem and assess the extent to which ecosystem services are degraded.

*2*: Identify infrastructure or services that can restore (or mitigate degradation of) the ecosystem services at benchmark condition.

*3*: Estimate the restoration costs.

***Type of required data and examples:***

*Secondary sources or ascertained through expert consultation and professional estimates.*

*The investment in restoring the level of ecosystem condition (e.g. costs of man-made equipment and its maintenance costs in $ per hectare).*

*The investment in restoring the level of ecosystem condition (e.g. costs of capital investment and maintenance of the restoration project with the use of Net Present Value).*

**A3. Production-based**

**Production function**

**Definition**

The production function method estimates the value of a non-marketed ecosystem product or service by assessing its contribution as an input into the production process of a commercially marketed good. A production function describes the relationship between inputs and outputs in production. By calculating the change in the value of production given a change in ecosystem input, you will be able to observe the value of that input.

**Example**

*‘Simple multiple linear regression is applied to the variables catch, effort and seagrass area to determine what reduction in catch, if any, can be expected due to seagrass loss. This will obviously impact those species with higher seagrass residency indices more than those with low indices and the relative impact may be quantified using regression models..... The ‘estimated annual value of seagrass loss’, for South Australian seagrass habitats is based on the predicted reduction in catch levels due to seagrass loss. The catch levels are determined from the regression models…..’*

Source: McArthur L. C., and Boland J. W., 2006. The economic contribution of seagrass to secondary production in South Australia. Ecological modelling 196, 63–172.

**Steps:**

*1*: Identify the ecosystems and services and the production process to which the ecosystem provides inputs.

*2*: Estimate the production function using data on production inputs (labour, capital, materials, ecosystem service as input etc.) and outputs, using statistical analysis.

3: Estimate the contribution which is the marginal product of the ecosystem service to the production output. The marginal product reflects how much the production increases when ecosystem service increase by one unit.

4: Multiply the price of the product output by the marginal product of ecosystem service.

***Type of required data and examples:***

*The amount of labour needed ( e.g. average salary in $per hour)*

*The amount of other inputs (e.g. kg of fertilizers per hectare)*

*The costs of other inputs (costs of 1kg of fertilizers)*

**Net factor income**

**Definition**

The net factor income method estimates the value of ecosystem services as an input in the production of a marketed good. It differs from the production function method presented above as it takes the quantities of outputs and inputs as given. The value of ecosystem service is estimated by the total production revenues (that generate the income) after subtracting the cost of other production inputs.

**Example**

 *‘Considering the number of cuts per year and the average cut hay production, the total value of this category of provisioning service is 232,764 € per year (1,400 €/ha of grasslands year)….. Taking into account the labour and mechanization costs estimable in 1,200 €/ha the net yield of hay production is 200 €/ha year.’*

Source: Paletto A., Geitner C., Grilli G., Hastik R., Pastorella F., Rodrìguez Garcìa L., 2015. Mapping the value of ecosystem services: A case study from the Austrian Alps. Ann. For. Res. 58(1): 157-175, 2015

**Steps:**

*1*: Identify the ecosystems and services and the production process to which the ecosystem provides inputs.

*2:* Calculate the revenue from production by multiplying the output by the market price and the cost of production by multiplying the unit cost of each input by its quantity.

*3:* Calculate the net factor income by subtracting the cost of production from the revenue.

***Type of required data and examples:***

*Value of production (e.g. $ of agricultural production)*

*Value of variable inputs (e.g. the costs of fertilisers, pesticides, feed in $ per hectare)*

*Depreciation (e.g. the loss of value of an asset in $ per year)*

*Total taxes (e.g. on products and production in $ per year)*

*Wages (e.g. average wages in the sector in $ per year)*

*Rents borrowed/rented production factors (e.g. costs of rents in $ per year)*

*Interest paid (e.g. interest payments in $ per year)*

### Indirect market valuation

**Hedonic pricing**

**Definition**

The hedonic pricing method should be used to estimate economic values of ecosystem services that directly affect the price of marketed goods. The basic premise of the hedonic pricing method is that the price of a good is related to its characteristics, including its environmental characteristics. The hedonic pricing method is often used to value environmental amenities that affect the price of residential properties (hedonic property value studies). However, potential limitation of this method in the case of SEEA EEA is based on the fact that it is based on producer surplus.

**Example**

‘*This study uses hedonic pricing, a household production function technique that estimates the partial economic value of changes in an ecosystem service or amenity based on the sale prices of similar properties (e.g., residential homes) with different levels of that amenity, to assess the economic values of the three target services and amenities in the year 2005…..The present study uses the sales prices of single-family residential homes to construct a hedonic pricing model that relates sale price to the structural, neighbourhood, and environmental aspects of homes’*

Source: Sander A. H., and Haight G. R., 2012. Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. Journal of Environmental Management 113. 194-205

**Steps:**

*1*: Identify the ecosystems and services that are provided within the boundaries of a natural area

2: Collect data on residential property sales (real estate market data) in the region of the area being valued.

3: Statistically estimate a function that relates house prices to property characteristics, including the distance to the area under consideration. The function indicates how much more a property close to the natural area is valued compared to a similar property that is located further away.

***Type of required data and examples:***

*House prices and locations (e.g. transaction prices of houses, geographical coordinates)*

*Structural data (e.g., number of bedrooms and age of house)*

*Neighbourhood attributes (e.g., population demographics, crime, and school quality)*

*Accessibility (distances to difference facilities and amenities)*

*Environmental property characteristics (e.g., air quality and proximity to hazardous waste sites, proximity of forests, lakes etc.).*

**Travel cost**

**Definition**

The travel cost method is used to estimate the value of ecosystems or sites that are used for recreation. The premise behind this method is that the travel expenses that people incur to visit a site represent the “price” of access to the site. Travel expenses include the actual travel costs (e.g. price of using public transport, petrol and maintenance for travel by private car, aeroplane ticket etc.), time costs, and admittance fees. With this information, peoples’ willingness to pay to visit a site should be estimated based on the number of trips that they make at different travel costs.

**Example**

*‘The Zonal travel cost method is applied by collecting information on the number of visits to the site from different distances. The first step is dividing the surrounding area into zones of increasing distance. ….Next step is to find number of visitors from each zone, and the number of visits made in the last year. The third step is to calculate the visitation rates per population in each zone. ….. The fourth step is to calculate the average round-trip travel distance and travel time to the site for each zone.….. The fifth step is to estimate the equation using regression analysis that relates visitation rate to individual travel costs. The sixth step is to construct the demand function for visits to the site, using the results of the regression analysis. ….. The final step is to estimate the total economic benefit of the site to visitors by calculating the consumer surplus, or the area under the demand curve’…*

Source: Jalaa and Nandagiri L., 2015. Evaluation of Economic Value of Pilikula Lake using Travel Cost and Contingent Valuation Methods. Aquatic Procedia 4, 1315 – 1321

**Steps:**

*1*: Identify the ecosystems and services under consideration. Define a set of zones surrounding the recreational site being valued. Travel costs to the site should be approximately equal for any location within each zone

*2*: Within each zone, sample visitors to collect information about the costs incurred in visiting the ecosystem , motives for the trip, frequency of visits, site attributes and socio-economic variables such as the visitor’s place of origin, income, age, and education .

3: Calculate the average travel cost from each zone using the average round-trip travel distance and the cost per km, and the average travel time and cost per hour.

4: Estimate a demand function for visiting the site using statistical analysis and the data collected. This function relates the number of site visits to the cost of visiting.

***Type of required data and examples:***

*Average travel cost from each zone ( e.g. distance in km, the price of 1liter of fuel, the average fuel demand for 100km)*

*Admission fees (e.g. entrance ticket price)*

*The average travel time cost (e.g. the average daily allowance for business travels)*

*The number of people travelling in one vehicle and their social status (e.g. how many adults, children, students, …)*

### Stated preferences methods

**Contingent valuation method**

**Definition**

The contingent valuation method is a stated preference method and involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. The contingent valuation method can be used to estimate economic values for all types of ecosystem service. The term “contingent” denotes that valuation is based on a specific hypothetical scenario and description of the environmental service. In some cases, people are asked for the amount of compensation they would be willing to accept to give up a specific environmental service rather than their WTP to avoid its loss.

**Example**

*‘A contingent valuation method was used to design a questionnaire to estimate the willingness to pay for forest ecosystem services including provision of timber, firewood, fruit and habitats, climate regulation concerned with temperature and precipitation, environment purification of water and air, soil water and biodiversity conservation. …. Single-bound dichotomous choice format was applied to elicit the maximum WTP.’*

Source: Tao M., Yan H., Zhan J., 2012. Economic Valuation of Forest Ecosystem Services in Heshui Watershed using Contingent Valuation Method. Procedia Environmental Sciences 13, 2445 – 2450

**Steps:**

*1*. Define the valuation problem in terms of which ecosystem services are to be valued and what the relevant population is.

*2*. Design the survey. This involves a number of steps including deciding what type of survey will be used (mail, telephone, face-to-face), the question format, payment vehicle, the WTP question, and pre-testing.

*3*: Survey implementation. This includes selecting the survey sample, which in most cases should be a random sample from the relevant population.

*4*: Analysing the results. This includes processing the data and dealing with nonresponses to the survey and zero bids. Mean WTP per person should be calculated and values should be aggregated at the relevant population size to give a total value for the ecosystem in question.

***Type of required data and examples:***

*Characteristics of respondents (e.g. their average income)*

*The annual willingness to pay/to accept of respondents in a form of a tax/other (e.g. 10 $ per year)*

**Choice experiment method**

**Definition**

Choice modelling is similar to contingent valuation in that it can be used to estimate economic values for virtually any ecosystem good or service. It is also a hypothetical method – it asks people to make choices based on a hypothetical scenario. Choice modelling is based around the idea that any good can be described in terms of its attributes or characteristics. Changes in attribute levels essentially result in a different good, and choice modelling focuses on the value of such changes in attributes. Values are inferred from the hypothetical choices or trade-offs that people make between different combinations of attributes. Choice modelling is different from contingent valuation in that it asks respondents to select between a set of alternatives, rather than asking directly for values. Values should be derived from the responses by including a money indicator (e.g. price of the good) as one of the characteristics. In a typical choice model study, respondents are presented with a series of choice sets composed of two or more multi-attribute alternatives (one alternative is often the status quo). For each choice set, a respondent evaluates the alternatives and chooses a preferred option. The alternative options in each choice set are described using a common set of attributes, which summarise the important aspects of the alternatives.

**Example**

*‘In this study the CE was comprised of a set of wetland attribute end points that are relevant to the study area and recognizable to the sample population.…. Riparian zone, wildlife populations and water quality represent separable dimensions of the valuation problem and are attributes that can partially describe the outcomes of alternative wetland management strategies that are of significance to policy makers. The levels of each attribute used in the CE survey were based on consultation with wetland and economic valuation experts from the University of Saskatchewan and the Saskatchewan provincial Ministry of Agriculture….. The fourth attribute, payment mechanism, was selected based on having applicability and relevance across the population, being widely acceptable to the respondents, and being not too costly and complicated to implement in a real world application.’*

Source: Dias V., and Belscher K., 2015. Value and provision of ecosystem services from prairie wetlands: A choice experiment approach

**Steps:**

*1*: Define the valuation problem in terms of which ecosystem services are to be valued and who the relevant population is.

*2*: Design the survey. This involves a number of steps including deciding what type of survey will be used (mail, telephone, face to face), determining the choice set (i.e. what characteristics will respondents be required to choose between), choosing the payment vehicle (the monetary characteristic), and pre-testing. Ideally, focus groups followed by pre-testing should be used to set and test the relevant levels of the characteristics used.

*3*: Survey implementation. This includes selecting the survey sample, which in most cases should be a random sample from the relevant population.

*4*: Analysing the results. The average value for each of the characteristics included in the choice set should be estimated, and this is then extrapolated to the relevant population in order to calculate a total value for the ecosystem site under different scenarios.

***Type of required data and examples:***

*Characteristics of respondents (e.g. their average income)*

*The costs and benefits of different choices (e.g. the costs of planting 10 new trees)*

*The annual contribution of the respondents in a form of a tax/other (e.g. 10 $ per year)*

**Deliberative group valuation**

**Definition**

Deliberative method combines stated preference techniques with elements of deliberative processes from political science, and is being increasingly used as a way to capture value types that may escape individual based surveys, such as value pluralism, incommensurability, non-human values, or social justice. The method incorporates deliberative components that mostly reflect the citizens’ juries approach. The jury approach involves randomly selecting citizens as jurors, taking the time to inform jurors adequately, and convened only if a difficult-to-measure value, such as the value of a public good, is involved.

**Steps:**

*Steps are similar to contingent and choice experiment methods presented above. Though, the method is different by incorporating deliberative elements, such as providing information and allowing time for discussion.*

**Benefit transfer**

**Definition**

Benefit transfer involves borrowing an estimate of WTP from one site (the study site) and applying it to another (the policy site). What is borrowed is a mean value that is unadjusted or a mean value that has been modified to ‘suit’ the new site. With value transfer, environmental benefit estimates from existing case studies (i.e., the study sites) are transferred to a new, policy case study (i.e., the policy site). The method is applied in three versions: (a) unit transfer where use value estimates that have been elicited from other study sites are transferred to other policy sites, (b) value transfer where a single function that has been produced at another location is transferred to another site to provide value estimates and (c) value transfer function (meta-analytic approach) where a function is produced by value estimates that have been elicited from many locations and estimated values are provided by this function.

**Example**

*This paper presents a meta-analysis of the economic valuation literature on ecosystem services provided by wetlands in agricultural landscapes. We focus on the value of three regulating services, namely flood control, water supply and nutrient recycling. We construct a database containing 66 value estimates, mainly for wetlands in the US and Europe but also a substantial number in developing countries. Values are standardised to USD per hectare per year. …*. *The meta-regression is used to produce a value function for wetland regulating services, which can be used to transfer values to other wetland sites while controlling for site and context specific characteristics. An illustrative value transfer exercise is conducted to estimate global values for wetland regulating services in agricultural landscapes.*

Source: Brander L., Brouwer R., Wagtendonk A., 2013. Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis. Ecological Engineering 56, 89– 96.

**Steps:**

*1:* Identify the ecosystem goods and services that are to be valued at the policy site.

2: Identify existing, relevant studies. Conduct a thorough literature review to identify valuation data relating to the specific good(s)/ service(s) identified in step 1. Review available studies for quality and applicability. Assess the relevance (suitability) of the study site values for transfer to the policy site, considering the similarity of the policy site to the study site, the similarity of impacts considered, baseline environmental quality, the affected populations, etc.

*3*: Transfer the benefit estimates. Transfer the value measures from the study site(s) to the policy site.

*4*: Determine the geographical area over which impacts at the policy site are aggregated to obtain a measure of total value. This can account for the spatial extent of the effect, the number of affected individuals/households residing in the area, and possible substitutes for the affected good or service in question.

*5*: Address uncertainty. Value transfer involves judgments and assumptions. Throughout the analysis, the researcher should clearly describe all judgments and assumptions and their potential impact on final estimates, as well as any other sources of uncertainty inherent in the analysis.

***Type of required data and examples:***

*Criteria for suitability of the study (e.g. geographic)*

*Creating a database (e.g. excel sheet) with the Peer-reviewed articles and precise numbers that are transferred from them (e.g. basic physical measures of e.g. cubic meters of water extracted and distributed)*

*Adjustment of price levels across time and different countries (e.g. the use of Harmonized Consumer Prices Index (HICP) (by OECD) and Market Exchange Rates.*