



Economic
valuation of
ecosystem
services

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Departement
Leefmilieu,
Natuur en
Energie





**A Tool for the
Economic
Valuation of
Ecosystem Services
in Flanders**

 **vito**
vision on technology

 **Universiteit
Antwerpen**

 **Vrije *U* *U* *U* *U* Universiteit *amsterdam***
Institute for Environmental Studies



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Introduction

What are Ecosystem Services?

Nature is priceless, but it is worth a lot. Although ecosystems underpin all human life and activities, people are often not aware of the benefits they receive from nature nor of their value. A good understanding of ecosystem services can lead to win-win situations. Studies for the Scheldt estuary e.g. show that floodplains can provide a cheaper protection against flooding than the construction of higher dikes only.

But lack of knowledge on ecosystem services (ESS) and their value can lead to wrong decisions and even catastrophes. The overexploitation of the Aral lake in Kazakhstan and Uzbekistan has reduced this once largest inland water mass with 90%, leaving a desert and causing large economic losses and illness to the surrounding population. A lot more examples in the TEEB study (see box) illustrate the importance of ESS.

Ecosystem services (ESS) are the benefits people obtain from ecosystems.

Different groups of ESS can be distinguished (Millennium Ecosystem Assessment):

- ★ *provisioning services,*
- ★ *regulating services,*
- ★ *cultural services*
- ★ *and the supporting services maintaining the conditions for life on Earth, like nutrient cycling and photosynthesis.*

Figure 1 shows the relationship between the intermediate and final services. The last column shows the benefits, the value for society, of these services. An intended new policy or policy reform or project can affect these services, in a positive or negative way, increasing or decreasing the benefits for society.

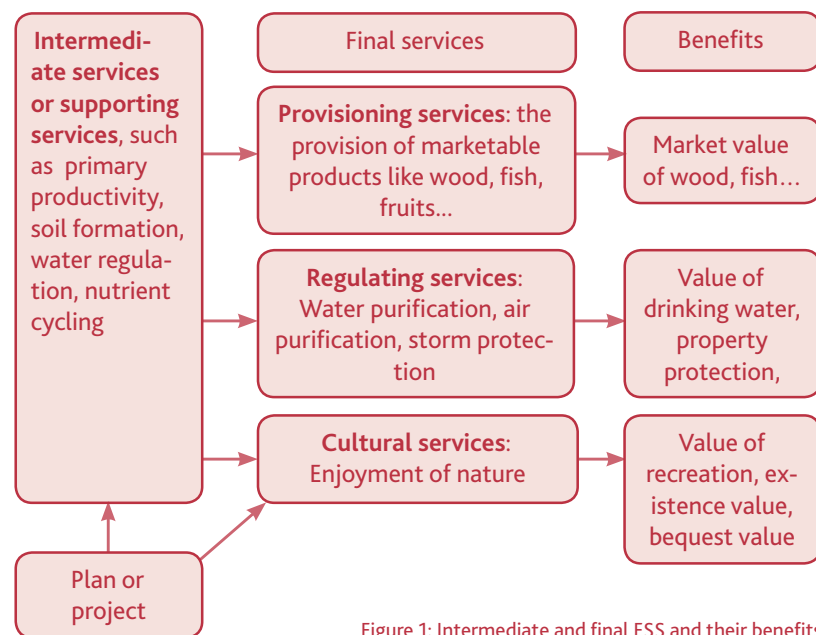


Figure 1: Intermediate and final ESS and their benefits

TEEB: The Economics of Ecosystems and Biodiversity

TEEB is a major international initiative to draw attention to the global economic benefits of biodiversity, to highlight the growing costs of biodiversity loss and ecosystem degradation, and to draw together expertise from the fields of science, economics and policy to enable practical actions moving forward.



TEEB provides five deliverables:

- ★ *TEEB D0 ecological and economic foundations*
- ★ *TEEB D1 for international and national policy makers*
- ★ *TEEB D2 for local and regional policy makers*
- ★ *TEEB D3 for business*
- ★ *TEEB D4 for citizens*

More information can be found at www.teebweb.org

A tool for better informed decision making

A social cost benefit analysis describes and quantifies all the welfare effects of an intended new plan or project. It is a decision support tool that is used more and more, also in Flanders. A social cost benefit analysis provides an answer to the questions "Is society better off with or without this new policy?" and "Which policy alternative is best for society?" However, for a correct answer to these questions, we have to ensure that all welfare effects have been included in the trade-off. It should also include the welfare effects of possible impacts on ecosystems. In order to include these ESS changes in the trade-off, it is useful that they are quantified and **expressed in the same unit** as the other elements of the cost benefit analysis, and this unit is money.

In order to make this possible, the Flemish government has provided for a **Tool for Economic Valuation of Ecosystem Services in Flanders**. This tool

consists of a manual and a supporting on-line calculator. The tool results from an extensive study by a team of economists and ecologists of VITO (the Flemish institute for technological research), the University of Antwerp and the Free University of Amsterdam. This brochure presents a summary of this valuation study.

Pricing nature to recognise its value in decision making

For most ecosystem services there are no observable prices from which we can derive their value for society. Goods delivered by provisioning services like timber and firewood are an exception. For this reason we have to use **economic valuation techniques**.

Different methods exist to put a monetary value on ecosystem services that reflect their importance for human welfare and wellbeing. The choice of a method depends on the availability of data. In the next chapters of this summary, we explain which methods we have applied in our study.

It is important to understand that this study values a marginal change in ecosystem service provision, but does not measure the total value of certain ecosystems. The figures do provide information to policy makers about the loss/gain of welfare resulting from the degradation/improvement of ecosystem services.

Different valuation methods for different services

If goods (products) delivered by the **provisioning services** of ecosystems can be sold on a market, the market prices will be used to value that service. **Regulating services** can be valued by using stated preferences, revealed preferences (adjoining markets), marginal damage costs or marginal reduction costs. **Cultural services** combine the value people attach to nature from a recreational, spiritual or emotional point of view. This is the value people attach to walking or cycling in a natural area, the value they attach to simply knowing that nature is preserved, even without visiting it, and the value they attach to the preservation of nature for their children and grandchildren. This value can be expressed in monetary terms by using revealed and stated preferences.

The economic value of supporting services, being included in the valuation of the (provisioning, regulating or cultural) services it supports, is not estimated separately.

This study consists of two main parts: the first part studies the cultural services and the second one the regulating services. This report is **not an exhaustive overview** of all the possible ecosystem services. It is restricted to those ecosystem services which the study "Ecosystem Services in Flanders – an exploratory inventory of ESS and potential Ecosystem Gains"¹ considered important in Flanders and for which sufficient scientific research has been performed to have a sound base for the selected functions and numbers.

¹ Jacobs, S. et.al. 2010. Ecosysteemdiensten in Vlaanderen: een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. University of Antwerp, Ecosystem Management Research Group, ECOBE 010-R127, study for the Flemish Agency for Nature and Forests.





Cultural Services

We have developed a valuation function by carrying out a choice-experiment (CE). This is a sophisticated, state of the art **questionnaire technique**, based on extensive experience in different fields of economics. In a CE, respondents are asked to choose their preferred alternative from two or more alternative scenarios that are defined by attributes on different levels. CEs commonly present a series of such choices to each respondent: respondents get multiple chances to express their preference for a valued good over a range of payment amounts. In this choice experiment, respondents were asked to choose between different nature development scenarios, described in terms of their ecological quality and a full set of spatial characteristics to capture landscape preferences.

Choice experiment

In this choice experiment, we have asked the respondents to choose between two possible future policy scenarios, scenario A and scenario B on the one hand, and the status quo scenario C on the other hand. The status quo is land used for agriculture without any natural or landscape value, without walking trails through the area and with a low number of species. The two policy scenarios A and B describe the transformation from this agricultural land use into a natural land use with specific attributes. The interviews are conducted using choice cards, like the example in figure 2.














	Scenario A	Scenario B	Present situation C
Nature type	marshes 	forest 	Field or meadow 
Size	10 ha (100m x 1 km) 	200 ha (2 km x 1 km) 	
Adjacent to...	Existing industrial land use 	Existing agricultural land use 	
Richness in species	Low 	high 	
Walking- or biking trails present in the area	Not present 	present 	
Distance to your home	50 km 	5 km 	
Yearly payment to a fund per Household	20 € / year	10 € / year	0 € / year

Figure 2: Example of a choice card

This example shows that the policy scenarios have **different characteristics** regarding nature type², size, richness in species, adjacent area, availability of walking or biking trails and the distance of the potential new natural area to the respondents' residence.

The respondent is told that a fund will be created to finance the new nature developments and that every household in Flanders will have to contribute. In each of the scenarios the amount of that contribution is specified. In the example, scenario A requires a contribution of 20€ per household per year and scenario B one of 10€ per household per year. For the status quo nothing has to be paid. The respondent is then asked: "which one do you prefer: A, B or C?" and this for a series of six choice cards.

² The six nature types that have been used are: pioneer vegetation, mudflat and marsh, natural grassland, forest, open water reed and swamp, heath land and inland dunes.

When making a choice, the **respondent makes a trade-off** between the value of the natural area and the additional tax, and in doing so he **reveals his preferences and willingness to pay** for natural landscapes. Varying the characteristics of the natural areas between the alternatives, we make the respondent reveal his preferences for these characteristics during a sequence of choices.

The data were obtained from an internet survey, using the panel of a market research agency from which respondents were chosen at random in three different provinces of Flanders. 3.000 residents filled out the survey. After incomplete forms (no choice section) and protest bidders (19%) had been removed, approx. 2.000 respondents were included in the analysis. The sample is representative for the Flemish population, after correction for the differences in income (lower incomes were slightly underrepresented) and the overrepresentation of members of environmental organizations.

Valuation function

All answers of all respondents pooled provide us with a wealth of empirical information on the preferences of people regarding nature. With statistical analysis this information can be expressed in a valuation function.

The valuation function expressed in **yearly WTP (willingness to pay) per household** can be written as:

$$\text{WTP} = 122 * \text{pioneer vegetation} + 93 * \text{mudflat and marsh} + 92 * \text{natural grass land} + 157 * \text{forest} + 133 * \text{open water, reed and swamp} + 133 * \text{heath land and inland dunes} + 0,05 * \text{size in ha} + 28 * \text{species} + 34 * \text{availability of walking trails} - 0,63 * \text{distance in km} + 8 * \text{natural surroundings} + 8 * \text{residential surroundings} - 15 * \text{industrial surroundings} - 0,36 * \text{high number of species} * \text{age} + 0,01 * \text{monthly net income} - 37 * \% \text{ women} + 108 * \% \text{ membership}.$$

The results show that people are willing to pay for additional natural landscape and that the amount depends on the characteristics mentioned above. **The nature type is important.** Forests are valued higher, pioneer vegetation, marshes and grass lands are valued lower than open water, swamps and heath land. The respondents are willing to pay more for easily accessible nature, but this is not a dominant attribute. As expected, people are also attaching a higher value to nature that has a rich biodiversity and is not surrounded by industry.

Distance decay

We can see that the people's **willingness to pay decreases with the distance** from the respondent's house to the natural area. A distance-decay function could be derived to show the relationship between distance and WTP for a particular natural landscape, see figure 3.

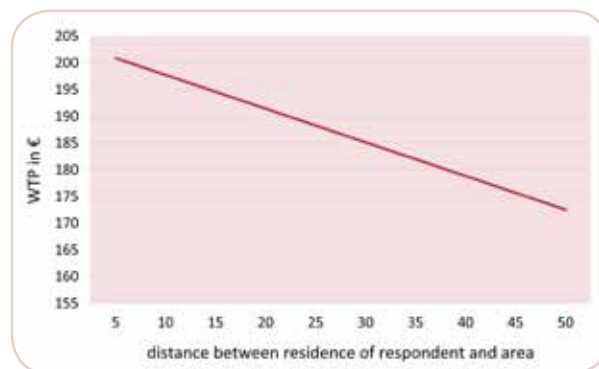


Figure 3:
Relationship between
WTP for a new natural
area and its distance
to the home of the
respondents

The results of our study are in the same order of magnitude as previous research that shows that distance decay is an important effect to be taken into account when aggregating the results over the relevant population.

Scope and substitution

The results show that there is sensitivity to scope, i.e. respondents are willing to pay more for a larger area than for a smaller one. Size of the area being just one of the parameters, a 200 ha area is not valued twice as high as an area of 100 ha. This stresses the importance of using this valuation function instead of the mean value/ha. The valuation function illustrates that **size is not a dominant factor**, and the additional WTP for a larger area is relatively small (€0.05 per extra ha) compared to the total WTP. This element has to be considered when the function is used to estimate the WTP for larger areas (more than 200 ha) or when more than 200 ha of additional nature have already been created compared to the situation in 2009.

Tests have shown that this function can be transferred between the three regions where the survey was performed, which suggests that the **valuation function can be applied for benefit transfer to other regions in Flanders.**

Economic theory makes us expect that substitution possibilities affect the willingness to pay, meaning we would expect people that attach the highest value to an additional natural area in regions where nature is most scarce. However, we did not find a statistically significant relationship between willingness to pay and the availability of substitutes in our study. This issue requires further work to develop and test relevant indicators.

It is not straightforward to compare our results with literature. For the first time a choice experiment was carried out for the economic valuation of Flemish natural land use covering so many different aspects. As far as we know, this is the **first choice experiment in this field that includes such a large variety of parameters** (attributes), particularly both size and distance. That is why this study contributes significantly to the empirical research on the valuation of natural areas.

Use of the valuation function in cost benefit analysis and other decision tools

The valuation function is deduced from a choice experiment in which people judge specific scenarios. This kind of scenarios can only approximate a specific real world project that is being studied by means of a cost-benefit analysis. The characteristics of these scenarios and choice sets have consequences for the applicability of the valuation function. The following elements are important:

- ★ *The size of new areas compared to the total natural land area in 2009 in the study region;*
If a policy alternative consists of several small areas, we recommend to consider them as one single area. Depending on the availability of natural areas at the time of the study compared to 2009, we recommend to use either the valuation function with coefficients directly derived from the survey, or with coefficients that account for the new situation.
- ★ *The characteristics of the original land use;*
The valuation study values a land use change from an agricultural land use (with no natural or landscape value) to a natural land use. If the present land use in the study area is different, this has to be taken into account when using the valuation function. The valuation function can be used as a proxy to estimate the willingness to pay to prevent the destruction of nature, bearing in mind that this estimate is less certain but can be considered as an under bound.
- ★ *The applicability of the function for Flanders and adjacent regions.*
The valuation function can be used in Flanders. We discourage the use of this function for households living within the 50 km range

outside Flanders, because the survey was restricted to inhabitants of Flanders and we don't know to which extent foreigners are willing to pay for a natural area outside their own country.

The manual (only available in Dutch) provides practical rules and examples on the use of this valuation function. The valuation function in this study is a big step forward, but we recognise that it cannot give the final answer to all questions concerning the valuation of cultural services of nature in Flanders.





Regulating Services

The second part of our study provides functions and key indicators for quantification and valuation of provisioning and regulating services.

Provisioning services

In Flanders, provisioning services hardly provide any benefits in areas where biodiversity is the primary objective. There are several reasons. First of all, the quantities that can be extracted in these areas compared to commercial areas are minimal. Secondly, there often is little or only informal demand for specific products. Finally harvesting costs can be substantial, with the possible exception of timber and firewood, but there is little transferable information on quantities and the costs of harvesting.

Quantification of regulating services

Valuing changes in quantities of different regulating services is a complex, but crucial element in the valuation of impacts on ecosystems (or the creation of new ecosystems). We often lack the tools and models to assess the effect of changes in physical, biochemical and ecological processes on the delivery of ecosystem services. While performing the study, we noticed that quantification figures reported in literature can vary widely, the context and driving processes not being sufficiently detailed. We recognise that further research on the influence of different ecosystem functions on ecosystem services is required.

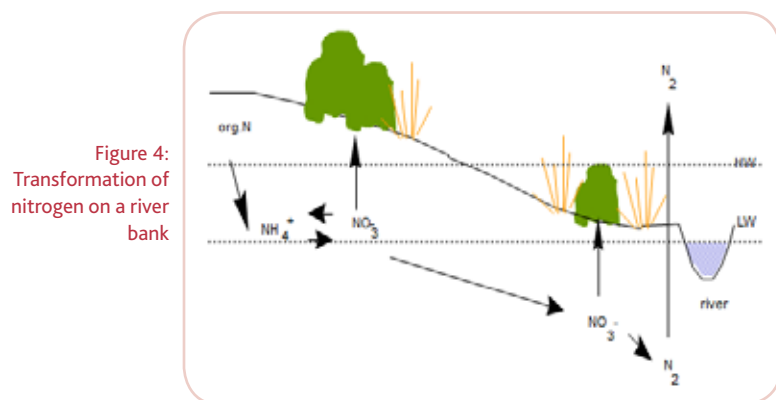
In order to enable the quantification of regulating services in a CBA with only limited data available, our manual provides for **simplified quantification functions and indicator values**. We have translated the information from literature into practical quantification functions for the most relevant services for which sufficient information is available.

These are:

- ★ *denitrification (contribution to water quality),*
- ★ *N, P and C sequestration in soils (contribution to water quality and to climate regulation),*
- ★ *N, P and C sequestration in forest biomass (contribution to water quality and climate regulation),*
- ★ *improvement of air quality by capturing pollutants as PM10,*
- ★ *noise mitigation by providing a buffer function.*

For the service “pollination”, it is impossible with the information available at present to provide quantification functions and hence the study only gives an overview of the available literature. The quantification of the service “water retention” (flood control) depends on too many factors for a simple quantification function, and requires the running of a hydrological model.

Denitrification in wetland ecosystems and river banks is preferably calculated with respect to the residence time of the water in the ecosystems. This can be calculated or estimated using inflow and/or outflow measurements regarding the size of the ecosystem. For terrestrial ecosystems, we can deduct potential denitrification, based on soil moisture and soil texture.



Concerning **carbon sequestration**, we have determined a potential maximal carbon content for a particular soil drainage, vegetation type and soil texture. Changes in soil drainage and/or vegetation will result in changes to the potential maximal carbon content. The annual carbon sequestration potential is a relevant factor for the difference in potential carbon content, which can be represented by an asymptotic function. This process-based approach incorporates changes in potential storage and the associated temporal dynamics.

For other services such as the adsorption of fine dust and noise suppression, we have used literature reviews and meta-analysis to provide simplified functions and indicator data.

Valuation of regulating services

For all these regulating services, water and air purification, climate regulation and noise buffering, we need price tags that best represent the value of these services for the Flemish society. We used different economic valuation techniques in order to determine these prices.

Valuing N and P removal

The avoided abatement cost method is used to value nutrient removal, because due to the natural denitrification that an ecosystem delivers, **costly abatement measures to obtain environmental goals can be avoided**. The value of an additional kg nitrogen removed by an ecosystem can be derived from the marginal cost curve of nitrogen removal. This cost curve was calculated for the Flemish watershed management plan. Figure 5 shows the cost curve for nitrogen removal. The graph gives an overview of all abatement measures, ranked from the cheapest measure per kg N removal to the most expensive. The measure representing the highest marginal cost still included in the programme of measures to reach the Water Framework Directive’s objectives costs 74€/kg N. This marginal cost of the last necessary measure to reach the reduction goal is used as a proxy for the value of denitrification in Flanders.

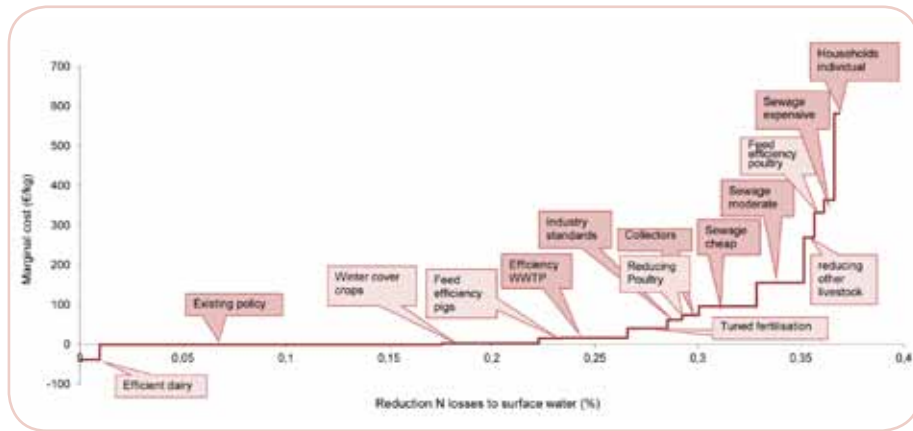


Figure 5: Marginal cost curve for N removal

The same methodology was used for P removal. The resulting values for N and P, 74€/kg N and 800€/kg P, are substantially higher than the values reported in literature for other regions. This is due to the high efforts and therefore very expensive measures that Flanders needs to take in order to reach its environmental goals.

Valuing carbon capture

The value for climate regulation is based on a literature review and the proposed value of 50€ per ton CO₂ is also based on avoided abatement costs.

Valuing noise buffering

In order to value noise mitigation, we have used the results of two extensive studies using the hedonic pricing method. By **paying more (less) for an identical house in an environment with a better (worse) sound climate**, people reveal their preferences for reduced noise pollution. Statistical analysis estimates the willingness to pay for a reduction of noise with one unit dB(A), as a function of the market value of properties. The manual recommends different levels of noise depreciation indices depending on the initial

noise level. E.g. in a relatively noisy environment (between 70 and 75 dB(A)) an increase of noise with 1 additional dB(A) leads to a depreciation of 1% of the property values.

Valuing air purification

The improvement of air quality is monetised through the marginal damage cost, the cost of the damage caused by one extra unit of pollution. Knowing the extent to which an **improvement of air quality reduces the damage to the human health or economy**, is information that can be used to value the service. European and Flemish research on health effects of particulate matter has developed indicator values regarding the capturing of particulate matter. The contribution of emissions to the concentrations is estimated. Epidemiological studies have estimated the correlation between concentration and health indicators (e.g. hospital admissions). These health indicators are valued by combined information on health insurance costs and the willingness to pay to prevent some diseases.

In order to use this information here, we have made a connection between the capture of particulate matter by vegetation and the concentrations in ambient air that are at the basis of negative health effects. The resulting values are 30€/kg PM₁₀ and 6,5€/kg NO_x.

Use of quantification functions and values in CBA

The quantification function and the indicators for valuation can be used for every (semi-) natural land-use in Flanders and can be used on every decision scale, because the growth in a **regulating service is relatively linear with the size of the area or the number of areas**. This study is definitely not exhaustive. Further research will deliver new information on ecosystem services and specific ecosystems.

Manual and Online Tool for Practical Application

A practical manual explains and illustrates the use of all the numbers and functions. This manual, the supporting web tool and the underpinning study are available on the environmental economics webpage of the Department Environment, Nature and Energy of the Flemish Government, <http://milieu-economie.lne.be>. Several scientific papers emerging from this study are forthcoming. A paper focusing on the spatial elements in the valuation function is already available (<http://www.bioecon.ucl.ac.uk/10papers12.htm>).

The manual and online tool will not remain static. The quantification and valuation functions that are presented are built on the present knowledge and data-availability. The list of ecosystem services described in this manual is not complete, because it was not possible to derive quantification functions for all the ecosystem services. They will be improved in the future when new scientific insights emerge and better data become available.

References

This summary is based on the following two publications. A complete list of the references can be found in these publications.

Liekens I., Schaafsma M., Staes J., De Nocker L., Brouwer R. en P. Meire (2009) Economische waarderingsstudie van ecosysteemdiensten voor MKBA. Studie in opdracht van LNE, Afdeling Milieu-, Natuur- en Energiebeleid, VITO, 2009/RMA/R308.

Liekens I., Schaafsma M., Staes J., De Nocker L., Brouwer R. en P. Meire (2010) Economische waardering van ecosysteemdiensten, een handleiding. Studie in opdracht van LNE, Afdeling Milieu-, Natuur- en Energiebeleid, maart 2010.

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