WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

EVALUATING ECOSYSTEM SERVICES

A methodological comparison of Cost-Benefit and Multi-Criteria Analysis based on an Austrian pilot region

Elisabeth Schwaiger
Barbara Färber
Lukas Kühnen
Sigrid Stagl
Sigrid Svehla-Stix
Johanna Vogel
Michael Weiß

Bundesministerium Nachhaltigkeit und Tourismus

ENGLISH SHORT VERSION
REP-0670

Vienna, 2019

Evaluating ecosystem services: A methodological comparison of Cost-Benefit and Multi-Criteria Analysis based on an Austrian pilot region

Elisabeth Schwaiger, Barbara Färber, Lukas Kühnen, Sigrid Stagl, Sigrid Svehla-Stix, Johanna Vogel, Michael Weiß

1. Introduction

The aim of the study is to compare methods of cost-benefit analysis (CBA) with multi-criteria analysis (MCA). The study examines which of the two is better suited to incorporate the values of nature into (political) decision-making. For this purpose, both methods were tested in practice, using tests based on specific questions relating to orchard cultivation (Streuobstanbau) in the Pöllauer Tal Nature Park in Styria. The main focus was the comparison of the methods, along with strong practical relevance and added value for the region.

Ecosystem services (ES) such as pollination, recreation and carbon storage are components of nature which are used to yield human well-being (BOYD & BANZHAF 2007). The economic valuation of ES has recently been presented as a pragmatic approach to demonstrate their value and incorporate it into management decisions. Monetary valuation has become one of the most important issues in the context of ecosystem services assessment (DE GROOT et al. 2012). The TEEB study, for example, suggests that these values should be assessed and incorporated whenever and wherever feasible and appropriate (TEEB 2010). A best possible estimate of the values for the respective framework and purpose should be given and these values should also be taken into account in decisions. According to critics economic valuation fails to capture social and ethical concerns because it is not amenable to monetary transactions (SAARIKOSKI et al. 2016). Considering the limitation of monetary valuation of ES there is a growing interest in alternative or complementary approaches such as the multi-criteria analysis. The different MCA methods are characterised by the fact that they represent a large number of qualitative and quantitative criteria that go beyond a monetary assessment. MCA is used in complex decision-making situations with multiple objectives.

The ecosystem services identified in the orchards of the Pöllauer Tal Nature Park include production function, erosion protection, groundwater protection, flood protection, carbon storage capacity, recreation and pollination. The ecosystem services were assessed in qualitative, quantitative and monetary terms. The results were incorporated into both CBA and MCA analyses.

Participation of local stakeholders was very important. When the respective evaluations were completed, a comparison of the two methods was made to demonstrate their advantages and disadvantages as well as their similarities.

2. Description of the case study area

LUCKE et al. (1992) defined orchards as “tall trees of different types and varieties of fruit, belonging to different age groups which are dispersed on cropland, meadows and pastures in a rather irregular pattern”. This also includes single trees on roads, streets and banks, and small groves. The tree shape is usually the standard fruit tree with a log length of 1.6 m or more, but half-standard trees with a log length of 1.0-1.2 m can be found as well.

Orchards play an important role in the Pöllauer Tal Nature Park in Styria, particularly the planting of the pear variety “Pöllauer Hirschbirne”, which is the leading product of the nature park and gain a higher price. The cultivation of orchards and their possible future development in the Pöllauer Tal Nature Park were examined on the basis of four different hypothetical scenarios.

3. Assessment of Ecosystem Services

Sustainable agriculture enables the provision of a variety of different ecosystem services. Many studies confirm the ecological importance of orchards, especially as a habitat for plant and animal species, for water and soil protection, climate regulation and as a gene reservoir (PEßLER 2012, ÖKL 2002). The aim of the project was to describe the ecosystem services of orchards as comprehensively as possible. Data from the MUFLAN project (UMWELTBUNDESAMT 2013) were used to identify the ES of the orchards in the area.

Depending on the data available, the first step was to identify ES and describe them in a qualitative manner. The next step was to assess the ES in quantitative terms using indicators where sufficient data were available. This step-by-step approach ensured that all relevant ES were considered. A corresponding inventory of these ecosystem services related to orchard meadows is given below (see Table 1 for an overview).

Table 1: Data bases and indicators of ES provided by orchards; Nature Park Pöllauer Tal.

Group	Ecosystem service	Data source	Indicator/unit
PS	Agricultural production	yield data for orchards as per questionnaire	t ha^{-1} yield for orchard fruits
			t ha^{-1} yield for grass or hay
	Forest production (= agricultural by-product)	data obtained from the region or expert judgement.	t ha^{-1} timber yield
RS	Erosion protection	zonal statistics (data source MUFLAN)	scale value 1-5
	Ground water protection	zonal statistics (data source MUFLAN)	scale value 1-5
	Flood protection	zonal statistics (data source MUFLAN)	scale value 1-5
	Sequestration capacity/ Carbon storage	data from the Austrian greenhouse gas inventory, literature, on site activity data	CO_2 ha^{-1} stocks in orchard (trees, above/belowground grass biomass and soil)
B	Biodiversity/Pollination	estimation of pollination capacity acc. to KLEIN et al. (2007)	kg ha^{-1} pollinator-dependent yield
CS	Recreation	estimation by local tourism assossiation	number of visitors
			Tourist spending in the area in €

PS … Provisioning services (goods and products obtained from ecosystems)
RS … Regulation services (benefits obtained from an ecosystem's control of natural processes)
B ….. Biodiversity
CS ….Cultural services (nonmaterial benefits obtained from ecosystems)

3.1 Agricultural production

Orchard meadows are an environmentally friendly cultivation method in which fruits are produced on tall tree trunks, which are scattered on mostly extensively used meadows and pastures. Agricultural production, therefore, generates yields from both fruit cultivation and grassland use. Fruit yields of a mature tree range from 250 kg (apples) to 400 kg (pears). Due to the amount of work involved, only a fraction of the total yield is harvested. The majority is processed into juice, must, jams and schnaps. The undergrowth beneath the fruit trees is used either as pasture or managed as meadow.

3.2 Forest production

Forestry production of mixed orchards is regarded as agricultural by-product as individual trees are repeatedly removed. These are used as fuel for heating or, if the quality is suitable, as wood for joinery. They are included in the cost-benefit calculation accordingly.

3.3 Erosion protection

Soils with intact soil functions represent an important basis for sustainable and thus long-term food and feed production. An important parameter is the susceptibility to erosion. This is dependent, amongst others, on slope inclination, soil structure, soil cover and cultivation. According to the soil erosion classification from MUFLAN, the susceptibility to erosion of the case study region is quite high (4 on a 1-5 scale). Orchards in these hilly regions make an important contribution to reducing erosion.

3.4 Ground water protection

The ES describes the ability to retain nutrients and pollutants in the soil and thus protect the underlying groundwater bodies. Plant crops with a long-lasting vegetation cover are only exposed to minor disturbances and therefore contribute more to groundwater protection than areas that are either subject to frequent disturbances or have a deficient soil cover. According to the ground water protection classification from MUFLAN, the level of ground water protection in the case study region is quite high (3.6 on a 1-5 scale).

3.5 Flood protection

Flood protection is influenced by soil characteristics and land cover. The ES depends on the retention capacity of the landscape, as well as on the risk of flooding in an area. A qualitative classification of the orchard areas for the Pöllauer Tal Nature Park (4.2 on a 0-5 scale) indicates a relatively high level of potential flood protection.

3.6 Carbon storage

The ecosystem service “carbon storage” makes a significant contribution to a stable climate, for example by reducing greenhouse gas emissions through the carbon storage capacity of orchard meadows trees, extensively managed grassland and soil. The following parameters were used to calculate the carbon stock (CO_2 stock) of orchards:

a. Carbon stock of biomass from orchard trees above and below ground,
b. Carbon stock of biomass from grassland above- and below ground,
c. Carbon stock of the soil (0-30cm).

According to the calculation, total carbon stocks for the orchard meadows (grassland, trees, soil) in the Pöllauer Tal Nature Park amount to 111,664 t CO_2.

3.7 Pollination

Biodiversity comprises natural diversity at the level of ecosystems, species, gene pools and landscapes. Irrespective of the actual use, biodiversity is considered to have value in itself, and thus a contribution to welfare. Orchards with over 5,000 animal and plant species and over 3,000 fruit varieties play an outstanding role in Central European biodiversity[1]. The nature conservation value of orchard meadows is derived from their specific habitat characteristics.

[1] [1] https://www.nabu.de/natur-und-landschaft/landnutzung/streuobst/streuobstwissen/streuobstbau.html

Biodiversity also plays a key role in food production. The yields of many agricultural crops (fruit, vegetables, oil and legumes) depend on insect pollination. That pollination service (ZULKA & GÖTZL 2015) was used to carry out a quantitative assessment of biodiversity, being aware that this is a first crude approximation and not comprehensive. In order to assess the pollinator-dependent production output, an average pollination dependence coefficient was attributed to each fruit as suggested by KLEIN et al. (2007). The average reduction in productivity induced by a loss of the biotic pollination service for apples and pears is 65%. The pollinator-dependent production output for the Nature Park Pöllauer Tal was estimated to be 4,269 t.

3.8 Recreation

Recreational services include the use of the environment as a recreational area and for sporting or educational activities. Orchards characterise the landscape and give a feeling of spatial depth and diversity (LUCKE et al. 1992). They also play a role in tourism. According to the tourist information office, tourism in the Nature Park is directly related to the occurrence of orchards. Therefore, the ES was estimated by measuring the benefit that orchards provide for recreation in the Nature Park Pöllauer Tal. The amount of money spent per guest (124€/person) and the number of overnight stays (2017: 79,955) were used as indicators.

4. Description of scenarios

Hypothetical but realistic scenarios for the development of the orchards in the Pöllauer Nature Park were generated with the involvement of regional stakeholders. The scenarios provided the basis for multi-criteria analysis as well as cost-benefit-analysis.

Scenario I: Trend - Continuation of traditional orchard cultivation (status quo): Continued efforts are undertaken by regional farmers to maintain the traditional orchards (planting of fruit trees…). The scenario comprises:

- ✓ Only a fraction of the total fruit yield (30 %) is harvested.
- ✓ Use of manure (25 t/ha).
- ✓ Use of the by-products of orchard meadows, such as hay, silage and wood.
- ✓ Marketing for the promotion of orchard products (esp. Pöllauer Hirschbirne).
- ✓ Subsidies for agri-environment measures generate an average of 467 €/ha per year.

The effects of the trend scenario on the production function, recreational function, flood protection, ground water protection, carbon storage and pollination are described in detail in Chapter 3.

Scenario II: Extensification - Expansion of traditional orchard cultivation: Expanding the orchard area by 20 % (from 293 ha to 352 ha) and planting additional standard fruit trees (log length > 1.6 m) is intended to overcome the previous shortage of supply (particularly of the Pöllauer Hirschbirne).

- ✓ As the demand for high quality orchard products increases, more time is invested in harvesting; hence, a higher share of the total fruit yield (60 %) is harvested.
- ✓ The costs for maintenance measures and planted trees increase.
- ✓ Use of manure as in Scenario I (25 t/ha).
- ✓ 20% increase in the use of the by-products of orchard meadows (hay, silage and wood).
- ✓ Costs for advertising increase at the same rate as the increase in overnight stays.
- ✓ Investments are made in the joint purchase of a farm shop vehicle.
- ✓ Consistent funding conditions like in scenario I (467 €/ha annually).

The expansion of the orchard area leads to a total increase in erosion, flood and ground water protection, as well as carbon storage and pollination (while remaining the same per hectare).

Scenario III: Intensification of orchard cultivation – non-traditional: In order to satisfy the demand for orchard products, farms will intensify orchard cultivation, on a sustainable basis, by 20 % per hectare (from 89 to 107 trees/ha) by planting half-standard trees with a log length of 1.0-1.2 m. In contrast to standard fruit trees, these trees are more productive and easier to harvest.

- ✓ 70% of the potential fruit yield is harvested.
- ✓ Harvesting machines are used.
- ✓ Use of less manure (10t/ha); pest control.
- ✓ 20% increase in the use of wood by-products; no use of hay, silage.
- ✓ Reduction of subsidies (150€/ha; loss of nature conservation premium due to intensification).

The effects on recreational function, flood protection, ground water protection are the same as in the trend scenario. However, more trees per hectare lead to an increase in carbon storage, production function and pollination.

Scenario IV: LUC forest - Land use change to forest (abandonment): In this scenario it is assumed that the orchards are no longer managed (lack of interest, low yield, too labour-intensive, etc.) and 90% become successional wood areas or afforested land. The large-scale disappearance of orchards, a very important tourist attraction, leads to a reduction in overnight stays to 75%.

- ✓ 20% of the potential fruit yield is harvested; only for private use.
- ✓ Investment in machines for forestry work.
- ✓ No manure application/no pest control.
- ✓ Loss of agri-environmental subsidies.
- ✓ No advertising costs.

Land use change to forest increases flood and ground water protection and carbon storage. Erosion protection remains the same as in scenario I and pollination is reduced to 10% of the orchard area.

5. Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is an economic evaluation method for comparing the costs and benefits of different project or policy options in monetary terms. CBA makes it possible to rank alternatives by a single monetary measure - often the net present value is used (SAARIKOSKI et al. 2016). The basic steps of the CBA process are (HANLEY & SPASH 1993):

1. Definition of the project
2. Identification of project alternatives
3. Which impacts are economically relevant
4. Physical quantification of relevant impacts
5. Monetary valuation of economically relevant effects
6. Discounting of cost and benefit flows
7. Calculation of the net present value
8. Sensitivity analysis

The aim was to find out which scenario represents a recommendable alternative to Trend Scenario I from a monetary point of view. Therefore, data for the year 2017 was used to evaluate all scenarios for the Pöllauer Tal Nature Park. All scenarios (not only the status quo) were considered as if they had already been implemented in 2017. Discounting was excluded as it was assumed that the benefits and costs for future generations would have the same value as for the current generation. CBA is based on aggregating monetary values for different impacts on provisioning, regulating and cultural services.

The ecosystem services selected for this evaluation were grouped into private goods, such as agricultural production, the yield of which goes to the farmers, and public goods. A public good is a product that one individual can consume without reducing its availability to another individual, and from which no one can be excluded. As public goods (e.g. recreational services, regulatory services and

biodiversity services) are not traded on the market, methods must be found to assess their monetary benefits.

Market prices were used to carry out the CBA of agricultural production. The benefits of agricultural production comprise: benefits from the sale of orchard products, hay and silage production, fertiliser application and the sale of the wood of orchard trees, and subsidies from the agri-environmental programme. The costs which were subtracted from these benefits included rent, acquisition costs of machinery, expenses for maintenance and harvesting of the orchards, as well as cost for processing and marketing. The estimation of the input parameters for the CBA of forestry production (see scenario IV) was based on expert assessments using regional input data and the literature.

There are various methods for estimating the benefits of non-marketed goods and services in CBA. Stated preference methods, based on representative surveys of the population affected, are applied to estimate the monetary values of a particular impact (e. g. willingness to pay). These surveys are very complex and have not been carried out for this study. Economic valuations of cultural ecosystem services focus primarily on tourism and recreation. An approximation of the benefit was made by the number of overnight stays. It was assumed that tourists only visited the region because of its characteristic orchard landscape. In addition, the average expenditure per tourist in the region was used. The advertising activities for the orchard areas and the orchard products were included as costs.

The benefit of the regulation services groundwater protection, flood protection and erosion control was estimated separately, using – as a modified form of cost-based methods - the replacement costs. It was assumed that the existing level of protection could only be provided if the orchard meadows were preserved. The benefit results from the costs that have to be spent in order to produce the service. However, since the validity of this method is associated with a high level of uncertainty, this monetary assessment was not included in the calculation of the net benefit in the end.

For the monetary valuations of the carbon stock content (see chapter 3.6), the carbon storage of orchard meadows was multiplied by the price of European Emissions Allowances[2] (per t CO_2); the respective value was included in the CBA. It has to be noted that this market price is very volatile and can change rapidly.

A monetary assessment of biodiversity is extremely difficult, as it is characterised in particular by its intrinsic value. The monetary value of pollination was estimated according to a formula used by GALLAI et al. (2009): pollinator-dependent production output (see 3.7) multiplied by the production price. It should be pointed out that this is an approximate value, since the actual value of biodiversity is in any case many times higher.

Table 2: Results of the Cost Benefit Analysis (in € ha^{-1}). Source: Environment Agency Austria

	Scenario I	Scenario II	Scenario III	Scenario IV
	Continuation	**Expansion**	**Intensification**	**LUC forest**
Agricultural production	3.811	8.054	7.420	3.760
Forestry production	-	-	-	190
Recreation	197	220	196	-
Pollination	2.371	2.751	2.517	2.371
Carbon storage	2.110	2.108	2.161	4.838
Ground water protection	3.009			
Flood protection	3.344			
Erosion protection	3.344			
Net Present Value	8.489	13.133	12.294	11.159
Ranking of options	**4**	**1**	**2**	**3**

[2] https://www.eex.com/de/marktdaten/umweltprodukte/auktionsmarkt/european-emission-allowances-auction#!

The result of the CBA is represented by the net present value, where the total costs are subtracted from the total benefits (see Table 2). The net present value shows that scenario II - expansion of traditional orchard cultivation - emerges as the recommended scenario from the CBA. A detailed examination of the ES clearly shows that agricultural production has the highest effect on the ranking of the scenarios; this is due to the yield increase in scenarios II and III (for details see chapter 4). The other ecosystem services are rated very similarly in all scenarios - with the exception of carbon storage capacity, which is rated highest in scenario IV. In addition, it must be noted that the forest also has a recreational function in itself. Within the framework of the project, however, only recreational performance in connection with orchard cultivation was estimated.

In the sensitivity analysis, the assumption was made that for scenarios II and III the crop yield would remain the same as in the status quo and that in scenario IV harvesting would be only for private use. As a result, scenario IV would have the highest net present value, followed by the trend scenario. The sensitivity analysis, therefore, confirms that agricultural production has a decisive influence on the ranking of the results. As a consequence, consultations should be held with local stakeholders to verify whether the implementation of higher crop yields to the extent described is realistic.

6. Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) is a general framework for supporting complex decision-making situations with multiple objectives. The different MCA methods are characterised by the fact that they do not consider a single overall criterion but a multitude of different criteria in order to evaluate options or alternatives and thus support decision-making. If individual dimensions are in conflict with each other, decision support is necessary and the methods of MCA can help by creating a ranking of options. The data is presented in an impact matrix representing criteria and options in a transparent form.

The steps of an MCA process are (HANSJÜRGENS et al. 2012):

Step 1: Determining the actions to be evaluated
Step 2: Identify the objectives
Step 3: Identify the evaluation criteria
Step 4: Weighting the criteria
Step 5: Evaluate the contribution of each action to each goal
Step 6: Ranking

When the identified criteria are not quantifiable, linguistic variables (e.g. the Likert Scale or fuzzy numbers) can be used to include qualitative information in the evaluation. This allows considering all criteria in the MCA despite their different units (e.g. yields in monetary units, carbon binding capacity in t CO_2, etc.). By means of a pairwise comparison, indices of dominance are calculated, which, however, only have an auxiliary function. The concrete values of the indices are of no importance; they merely serve as a basis for ranking. The emphasis in MCA applications in environmental management and policy-making is on multi-stakeholder processes which aim to structure problems and to facilitate dialogue on the relative merits of alternative courses of action (SAARIKOSKI et al. 2016).

Involvement of the regional stakeholders from the Pöllauer Tal Nature Park was achieved by workshops and interviews. The questionnaires for the interviews referred to criteria such as landscape protection, social cohesion and sustainable socio-economic developments in general. The participants were asked to give a personal assessment (scale: from extremely positive +++ to neutral 0, to very weak---) and weights (scale from 1 to 5 - 1=important, 5=not important) for each criterion and each scenario.

The outranking method PROMETHEE[3] was applied to analyse the data. It is a ranking method which calculates the most common statistical values, such as minimum, maximum, average or standard deviation. It is based on a comparison pair per pair of possible decisions along each criterion. Thus, positive or negative differences between the individual parameters can be determined and displayed both numerically and graphically. The results of the surveys are presented by means of rankings and walking weights. In collaboration with stakeholders, it was decided which objectives were to be achieved by changing the management of orchard meadows (e.g. preservation of the landscape, increase of yield, creation of jobs ...). Then the scenarios were assessed in terms of their impact on these objectives, taking into account data from literature and stakeholder surveys, and the individual criteria were weighted according to the preferences of the stakeholders. The following criteria were selected to describe the impact on the different scenarios: nature conservation, species protection, private life (family, regional), public, economy, sustainability and fairness.

6.1 Results of PROMETHEE

Participants' opinions on the scenarios were as follows: Extensive management (scenario II) of the orchard was mentioned by six of the twelve interviewees as the most preferred of the four possible scenarios, followed by maintaining the status quo (scenario I). The removal of the orchards (LUC forest) is mentioned as the least preferred option by the same six persons (Table 3).

Table 3: Results of the scenario ranking (12 stakeholders)

Stakeholder Ranking	**preferred**	**less preferred**	**low priority**	**even lower priority**
6 (II, I, III, IV)	Extensification (Scenario II)	Trend (Scenario I)	Intensification (Scenario III)	LUC forest (Scenario IV)
4 (I, II, IV, III)	Trend	Extensification	LUC forest	Intensification
2 (IV, II, I, III)	LUC forest	Extensification	Trend	Intensification

Figure 1 provides a graphical representation of partial ranking by PROMETHEE. The leftmost vertical bar corresponds to the positive flow values (Phi+), the rightmost to the negative flow values (Phi−), and the central vertical bar to the net flow values (Phi). For each alternative scenario a line is drawn between its Phi+ and Phi− values. When an alternative scenario is preferred to another, its line lies on top of the other's line. Positive scale values are green, while negative values are red. Alternatives are positioned according to their net flow values. This means that extensification is the best choice and outranks the others (Extensification>Trend>Intensification>LUC forest).

The analysis shows that the preference for Scenario II is expressed in different ways by the individual persons, which leads to (smaller or larger) differences between the scenarios (see Figure 1).

[3] http://www.promethee-gaia.net

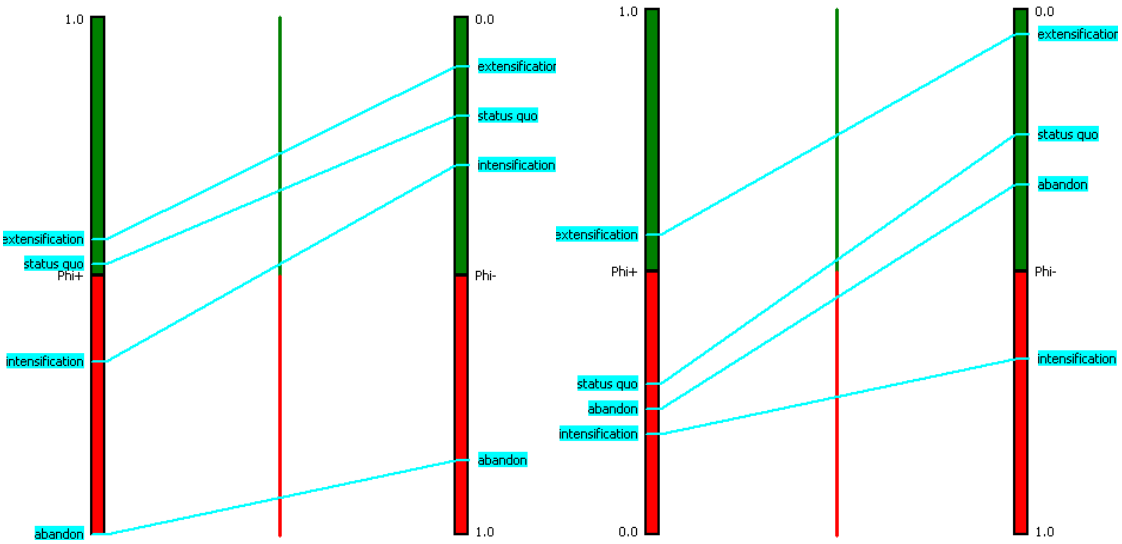

Figure 1: Ranking by Promethee (results for two stakeholders)

Figure 2 provides a different way of presentation, showing the ranking of scenarios using bars.

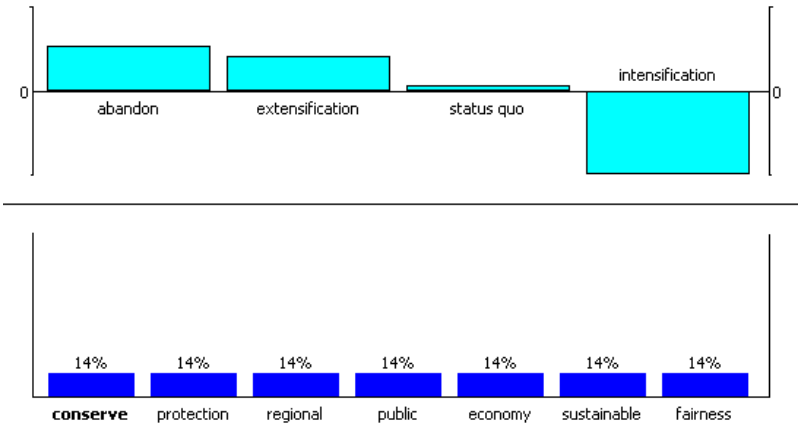

Figure 2: Ranking of the scenarios with equal weighting of the criteria (results for one stakeholder).Source: Vienna University of Economics and Business; Institute for Ecological Economics

6.2 Results of Multi-Criteria Mapping

In addition to the PROMETHEE analysis, Multi-Criteria Mapping was used in this project. Multi-Criteria Mapping focuses on the exploration of uncertainties and stakeholder expertise. Stakeholder scores are used to evaluate the options. In this case, experts were consulted as stakeholders. The use of two different methods of multi-criteria analysis allows for the triangulation of methods, which is good social science practice for complex problems.

Agricultural production (in €), carbon storage (in tonnes of CO_2), pollination (in tonnes of yield) and recreation (in €) were used as criteria for Multi-Criteria Mapping. Thus a comparison with the results of the CBA was possible. The results of the analysis, based on a separate survey of experts, show that the extensification of traditional orchard cultivation, as described in Scenario II, would be the preferred scenario, followed by Scenario III (intensification). Scenarios I (status quo) and IV (LUC to forest; abandonment), were regarded as the least promising scenarios and left far behind (see Figure 3).

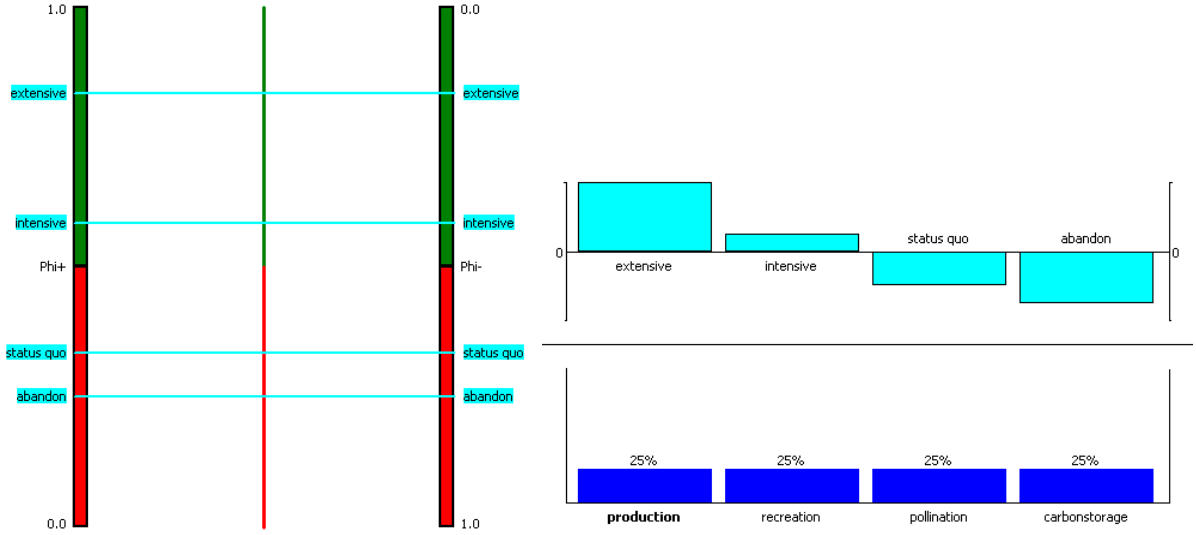

Figure 3: Expert ranking of scenarios for ecosystem services (with equal weighting of criteria). Source: Vienna University of Economics and Business; Institute for Ecological Economics

6.3 Comprehensive results of MCA

In summary, the majority of regional stakeholders chose the same scenario sequence as the experts. With one exception: after the extensification (scenario II) follows the status quo (scenario I) and not the intensification of orchard areas. This can be explained by the assumption of the experts that each additional orchard also has automatically an additional benefit for the ecosystem of the orchard meadow as well as for the income of the farmers.

In any case, the results also reveal many interesting points that offer discussion opportunities for the further development of the orchard, both for researchers and stakeholders in the region.

7. Comparison of the Cost-Benefit Analysis with the Multi-Criteria Analysis

The results of the CBA carried out for this project match the results of the MCA. For both methods, scenario II is the preferred option under the assumptions made.
CBA is often at the centre of economic valuation. The relevant benefits and costs are presented in monetary terms and thus in the same units; they are easily comparable. With the help of valuation methods, benefits from ecosystem services are determined and compared with costs in monetary units, and the advantage of the options in question is estimated from an economic point of view. The CBA is particularly effective for calculating compensation payments or for setting tax rates.

Where possible, market prices should be used. Services that nature provides which are difficult or impossible to assess in monetary units are usually not taken into account in CBA. They have to be estimated using valuation methods in order to arrive at monetary values. These values often do not reflect the actual value of the benefits, but can be seen as an approximation.

It is important to communicate the system boundaries in order to show what is included in the considerations. The project shows that in practice, an identification of the values is very time consuming and depends to a great extent on the availability of data. In addition, the project reflects that an evaluation through CBA has its limits in many cases. Since only monetary units are included in the evaluation, it has not been possible to include all criteria initially defined in the total CBA. Thus, no valid method could be found to represent the regulation services in monetary units. The application of CBA in practice requires experience in the implementation of valuation methods.

The MCA is particularly effective for presenting complex decision-making situations systematically and for making them transparent to stakeholders. Through participative processes, stakeholders can learn from each other (obtain information, gain a better understanding of the relevant system and/or learn about decision-making methods and processes). Although MCA requires that all the relevant dimensions of the impacts are included, the demands regarding the type of data are lower. MCA suggests that the relevant dimensions should be assessed in those units in which they occur and are usually measured. Qualitative data can also be taken into account. MCA also involves an explicit separation of values (assigning different weights to different criteria), to be carried out by authorised persons, and the measurement of impacts using scientific methods. MCA is based on political science or political economic theories and therefore democratic elements play a greater role in the study design.

Difficulties sometimes arise in recording the weightings, in the quality management of the participatory process (which depends on the expertise of the moderators. The method is not suitable for the calculation of compensation payments because of the absence of a monetary value.

7.1 Resume

An important role of the economic assessment is to make the consequences of our actions and decisions visible. Many environmental problems arise because the ecosystem services do not have a price - they cost nothing and are overused (SCHÄFER 2012). Thus monetary valuation of ES in the context of awareness-raising can be helpful by drawing the attention of policy makers to the economic importance of ecosystem services and their associated benefits (BARTON et al. 2015).

Cost-Benefit Analysis (CBA) is often at the centre of economic valuation. With the help of valuation methods, benefits from ecosystem services are determined and compared with costs in monetary units, and the advantage of the options in question is estimated from an economic point of view. Services that nature provides which are difficult or impossible to assess in monetary units are usually not taken into account in CBA. They have to be estimated using valuation methods in order to arrive at monetary values. These values often do not reflect the actual value of the benefits, but can be seen as an approximation. It is important to communicate the system boundaries in order to show what is included in the considerations.

The project shows that in practice, the identification of values is very time consuming and depends to a great extent on the availability of data. In addition, the project reflects that in many cases a evaluation through CBA has its limits. Since only monetary units are included in the evaluation, it has not been possible to include all the criteria defined at the beginning in the total CBA. Thus, no valid method could be found to represent the regulation services in monetary units. So the reduction to a single (monetary) unit did not allow a comprehensive assessment of all relevant ES.

Although the importance of ecosystem services is widely known, ideas of including practical approaches to their economic valuation in (political) decision-making are controversially discussed. There are ethical concerns as to whether it is at all justified to express the values of nature in monetary terms.

In contrast to the CBA the Multi-Criteria Analysis (MCA) considers several dimensions in different units equally and thus can also cover aspects which cannot be assessed on a monetary basis.

Although MCA requires that all the relevant dimensions of the impacts are included, the demands regarding the type of data are lower. MCA suggests that the relevant dimensions should be assessed in those units in which they occur and are usually measured. Qualitative data can also be taken into account. The MCA considers various criteria in different units on an equal basis and thus also covers aspects that cannot be assessed in monetary terms. MCA also involves an explicit separation of values (assigning different weights to different criteria) to be carried out by authorised persons, and the measurement of impacts using scientific methods. MCA is based on political science or political economic theories and therefore democratic elements as stakeholder involvement play a greater role in the study design.

The method MCA is not suitable for the calculation of compensation payments because of the absence of a monetary value.

Both methods enable decision support through the systematic comparison of options. Both methods contribute to decision-making. Which method is used depends on the issue in question and on the resources available. The question whether it is ethically justified to express nature's value in monetary terms is still a question that has to be considered before applying the method of choice to assess ecosystem services.

8. Literature

BARTON, D. N.; STANGE, E.; BLUMENTRATH, S. & VÅGNES TRAAHOLT, N. (2015): Economic valuation of ecosystem services for policy. A pilot study on green infrastructure in Oslo. NINA Report 1114.

BOYD & BANZHAF (2007): What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63: 616-626.

DE GROOT, R.; BRANDER, L.; VAN DER PLOEG, S.; COSTANZA, R.; BERNARD, F.; BRAAT, L.; CHRISTIE,M.; CROSSMAN, N.; GHERMANDI, A.; HEIN, L.; HUSSAIN, S.; KUMAR, P.; MCVITTIE, A.; PORTELA, R.; RODRIGUEZ, L.; TENBRINK, P. & VAN BEUKERING, P. (2012): Global estimates of the value of ecosystems and their services in monetary units. Ecosyst. Serv. 1: 50–61.

DIAKOULAKI, D. & KARANGELIS, F. (2007): Multi-criteria decision analysis and cost-benefit analysis of alternative scenarios for the power generation sector in Greece Renewable and Sustainable Energy Reviews 11 (2007): 716–727.

GALLAI, N., SALLES, J.M., SETTELE, J. AND VAISSIÈRE, B.E. (2009) Economic Valuation of the Vulnerability of World Agriculture Confronted with Pollinator Decline. Ecological Economics, 68, 810-821.

HANLEY, N. & SPASH, C. L. (1993): Cost-Benefit Analysis and the environment, Aldershot. pp. 8–22.

HANSJÜRGENS, B.; NEßHÖVER, C. & SCHNIEWIND, I. (2012): Der Nutzen von Ökonomie und Ökosystemleistungen für die Naturschutzpraxis. Einführung und Grundlagen. BfN Skripten 318. Bonn.

KLEIN, A. M.; VAISSIÈRE, B. E.; CANE, J. H.; STEFFAN-DEWENTER, I.; CUNNINGHAM, S. A. & KREMEN, C. (2007): Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society: Biological Sciences, 274: 303–313.

LUCKE, R. SILBERREISEN, R. UND HERBERGER, E.(1992): Obstbäume in der Landschaft. Stuttgart: Ulmer.

ÖKL – Österreichisches Kuratorium für Landtechnik (2002): Ökologische Funktionalität von Streuobstbeständen und deren betriebliche Sicherung. Im Auftrag vom Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.

PEßLER, C. (2012): Carbon Storage in Orchards. Diplomarbeit Universität für Bodenkultur Wien und Universität Hohenheim

SAARIKOSKI, H.; MUSTAJOKI, J.; BARTON, D. N.; GENELETTI, D.; LANGEMEYER, J.; BAGGETHUN, E. G.; MARTTUNEN, M.; ANTUNES, P.; KEUNEG, H. & SANTOS, R. (2016): Multi-Criteria Decision Analysis and Cost-Benefit Analysis: Comparing alternative frameworks for integrated valuation of ecosystem services. Ecosystem Services 22 (2016): 238–249.

SCHÄFER, A. (2012): Den Nutzen von Ökosystemleistungen indirekt sichtbar machen: Ersatz-, Schadens- und Vermeidungskosten. In: Hansjürgens, B.; Neßhöver, C & Schniewind, I. (EDS): Der Nutzen von Ökonomie und Ökosystemleistungen für die Naturschutzpraxis. Einführung und Grundlagen BfN Skripten 318. Bonn.

TEEB – The Economics of Ecosystems and Biodiversity (2010): Die Ökonomie von Ökosystemen und Biodiversität. Die ökonomische Bedeutung der Natur in Entscheidungsprozesse integrieren. Ansatz, Schlussfolgerungen und Empfehlungen von TEEB – Eine Synthese. ISBN 978-3-9813410-4-1.

TUDELA, A.; AKIKI, N. & CISTERNAS, R. (2006): Comparing the output of cost benefit and multi-criteria analysis. An application to urban transport investments. Transportation Research Part A 40 (2006): 414–423

UMWELTBUNDESAMT (2013): Bartel, A.; Ferner, B.; Freudenschuß, A. et al.: MUFLAN – Multifunktionale Landschaften. Reports, Bd. REP-0419. Umweltbundesamt, Wien.

ZULKA, K. P. & GÖTZL, M. (2015): Chapter 10. Ecosystem services: pest control and pollination. In: Steininger, K.; König, M.; Bednar-Friedl, B.; Kranzl, L; Loibl, W. & Prettenthaler, F. (EDS): Economic evaluation of climate change impacts. Development of a cross-sectoral framework and results for Austria. Cham, Springer: 169–189.