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Integrating ecosystem services into environmental impact assessment: An analytic–deliberative approach

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ABSTRACT

Analytic–deliberative techniques have been suggested as a promising approach to ecosystem service (ES) valuation but are still at an experimental stage. This paper contributes to the development of ES valuation in the environmental impact assessment (EIA) procedure by introducing an analytic–deliberative approach to assessing restoration options for a regulated river in Finland. Multi-criteria decision analysis (MCDA) with a value-focused approach was applied and compared with a desktop application of the ES-focused MCDA approach. We found out that the concept of ES could bring added value to the assessment process by: 1) enabling the framing and valuing especially of provisioning services — final ecosystem services, such as salmon catch in a more understandable way for the stakeholders, and 2) taking into account ecosystem processes and supporting services more precisely. However, some potential dangers of using the ES-based approach could include ES's appearing as a distant mode of thinking to affected groups and other stakeholders, and neglect of the trade-offs between ES and other relevant value and impact categories. Thus, although the ES framework is promising, it should not form a rigid 'checklist' way of making assessments but should rather be used to widen perspectives about potential issues in linking ecosystem properties to human benefits and values. It is argued that by combining the ES framework with the interactive MCDA approach, we can form a comprehensive and integrated approach to incorporating ESs into EIA.

1. Introduction

There is great demand in environmental policy making for improving and increasing the simultaneous use of analytical tools and deliberative processes. Due to a high degree of complexity, uncertainty and ambiguity, a combination of thorough analysis and informed deliberation is clearly useful and important for environmental appraisals and decision making (Dietz and Stern, 2008; Gregory et al., 2012; Renn, 2004). The combination can to lead well-structured results informed by a wide range of views. Analytic–deliberative methods, such as deliberative mapping or interactive multi-criteria decision analysis (MCDA), can be used to ensure that all sources of relevant information, including local knowledge and community values, are gathered and appropriately considered (Chilvers, 2008; Gregory et al., 2012). This is also important in the field of Environmental Impact Assessment (EIA).

The focus on the concept of ecosystem services (ES) provides a new way to approach environmental management and to connect nature and society in research and appraisals. It seems that the concept of ES is becoming mainstream at all levels of environmental decision making (Carpenter et al., 2009; Chan et al., 2012; De Groot et al., 2010; Fisher et al., 2009; Geneletti, 2011; Liu et al., 2010; Nahlik et al., 2012; UK NEA). However, it is noted that the consideration of ecosystem services within environmental assessments and decision making introduces a new level of complexity to the evaluation of what matters and why in a specific context (Chan et al., 2012; Fish, 2011).

There are still many challenges in the implementation of ecosystem services in real-life EIA projects, such as a better understanding of the trade-offs and societal preferences with regard to the full range of ESs at a specific scale (Coleby et al., 2012). In the EIA procedure, it is essential that the knowledge and values of affected and concerned groups are reflected in the various phases of the EIA. Addressing ecosystem services implies exploring the beneficiaries of the services and their characteristics (e.g., the contribution of the services to a specific group's well-being) (Geneletti, 2011). Thus, one major question for EIA is how can assessment methods be improved to include key ecosystem services, and, at the same time, take into account all other ecological, socio-cultural and economic factors and values of affected and concerned social groups.

Many recent reports and articles emphasize the need for holistic valuation of ecosystem services (Chan et al., 2012; Fish, 2011; Landsberg et al., 2011; UK NEA, 2010; Vatn, 2009). Analytical–deliberative techniques, such as interactive MCDA methods, are being increasingly applied in

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environmental assessments and planning (Fish, 2011; Liu et al., 2010; see Proctor and Dreshler, 2006), but thus far not in the incorporation of ESs into EIA. According to the UK NEA (2010), emerging methodologies that allow non-monetary values to be expressed in quantitative terms and considered alongside monetary valuation as part of a deliberative process hold much promise for systematic and integrated treatment of utilitarian, ethical and esthetic considerations. To our knowledge, only Proctor and Dreshler (2006) and Oikonomou et al. (2011) have combined the deliberative multi-criteria evaluation techniques with the ecosystem services framework but, on the other hand, their cases were not environmental impact assessment processes.

This paper contributes to the development of ecosystem services valuation within the EIA procedure by introducing an analytical–deliberative approach based on interactive MCDA. In this paper, we compare a real-life project in which interactive MCDA was applied with a desktop analysis of how the ES approach could be integrated into the MCDA approach. The comparison aims at answering the following questions:

1 Are some value or impact categories and criteria left out from EIA when applying the ES approach with MCDA in an assessment? Are some ecosystem services left out when applying the interactive MCDA approach in an assessment?
2 Can we assess and value ecosystem benefits in a more understandable way for the stakeholders and public by using the ES framework than by using the theories and practices of multi-attribute valuation? Or, does the ES approach actually introduce a new form of expert assessment which hinders public and stakeholder participation and learning in EIA?

By answering these questions, we hope to reveal potential difficulties in applying the ES approach in the context of EIA procedures.

We applied an analytic–deliberative MCDA approach to assessing restoration options – including potential ecosystem services – in the context of regulated rivers in the European Union, particularly in Finland. Restoration of the complex and dynamic socio-ecological systems of regulated rivers involves several interests and objectives, such as hydropower, fisheries, flood protection, biodiversity and tourism. Trade-offs between sociopolitical, ecological and economic impacts and potential ecosystem services should be taken into consideration (Erkinaro et al., 2011; Karjalainen and Järvikoski, 2010). Integration of conflicting objectives and scientific, in most cases uncertain, information from different disciplines demands a systematic and understandable framework.

The paper is structured as follows. First, we outline our methodological framework and the challenges in the integration of ESs into EIA. Second, we present the River Iijoki restoration case, the EIA process based on value-focused thinking (Keeney, 1992) and the decision analysis interview (DAI) approach. Third, the paper describes the results of the interactive MCDA approach applied in our case, comparing them with the results of a desktop case of the ES approach. The key question is how the value categories, criteria, alternatives and results of the assessment as well as the entire process are different in the two applications. Finally, the paper discusses the challenges and potentials regarding the parallel use of the MCDA and ES approaches in environmental assessments.

2. Methodology

2.1. MCDA methods and their benefits in EIA

MCDA covers all methods seeking to explicitly take into account multiple criteria in helping individuals or groups to holistically evaluate different decision alternatives having conflicting objectives and incommensurable impacts and to explore their values in decision making (Belton and Stewart, 2002; Eisenführ et al., 2010). There is a wide range of MCDA approaches and applications covering natural resources management, environmental planning and impact assessment (for references and earlier reviews see, e.g., Hajkowick and Collins, 2007; Huang et al., 2011; Kangas et al., 2008; Keefer et al., 2004; Kiker et al., 2005). MCDA is being increasingly used in order to facilitate stakeholder involvement (e.g. Hostmann et al., 2005; Marttunen and Hämäläinen, 2008).

2.1.1. Value-focused thinking

The MCDA literature focuses strongly on the different weighting procedures and the problem structuring phase receives less attention (Belton and Stewart, 2002, p. 36). One exception is *value-focused thinking* (VFT), which is a systematic procedure to identify and structure values and objectives of decision makers (Keeney, 1992). Keeney states that the planning and assessment process often misses the discussion of the participants' objectives and proceeds too fast to the evaluation of the alternatives. However, alternatives are relevant only as means to achieve values and, therefore, the focus should first be on the values. Structuring objectives is a demanding task which can be supported and clarified by dividing the objectives into fundamental objectives, means objectives, process objectives and organizational objectives (Keeney, 2005). Value-focused decision structuring can lead to more thoughtful and better decisions and produce more innovative alternatives than the traditional approaches focusing on alternatives (Arvai et al., 2001; Gregory and Keeney, 1994). In the Iijoki project, stakeholders' objectives were identified and structured with VFT. The resulting objective hierarchy was utilized in the development of the evaluation framework for the impact assessment. Hereon we use the term value-focused MCDA to describe a decision analysis process focusing on the clarification and the use of the participants' objectives in EIA.

2.1.2. Interactive MCDA

The design and realization of interactive MCDA was based on the Decision Analysis Interview (DAI) approach developed by Marttunen and Hämäläinen (1995). The DAI approach refers to an MCDA process which is based on personal interviews with a multi-criteria model. The process consists of three major phases (Fig. 1). Framing and structuring as well as impact assessment are realized in close co-operation with all key stakeholders. The results of the impact assessment and discussions are summarized in a workbook which also contains questions for finding out the stakeholders' perceptions of the importance of the criteria. In the interviews, the answers of the participant are discussed and entered into the MCDA software. The interaction between the analyst and the interviewee is of crucial importance in order to minimize the risk of mistakes and behavioral biases (see Marttunen and Hämäläinen, 2008). The analyst ensures that the answers reflect the interviewee's views as closely as possible. An essential phase of interactive MCDA is the visual comparison of the bars depicting the overall weights of the attributes. The process is iterative and it is possible to make adjustments to criteria weights and performance values until an outcome that is acceptable for the respondent is achieved.

The MCDA software, Web-HIPRE, applied in the Iijoki project is based on *multi-attribute value theory* (MAVT) (Keeney and Raiffa, 1976). In MAVT, the alternatives are first evaluated with respect to each criterion and the criteria are then weighted according to their relative importance. As a result, one receives the overall values of the alternatives indicating their preference to the evaluator. The weights have two functions: they rescale the attributes to be comparable while at the same time pointing out the relative importance of the attributes given the range of impacts (Belton and Stewart, 2002).

Experiences from real-life cases suggest that MCDA can support EIA processes in many ways (e.g., Marttunen and Hämäläinen, 1995). A clear definition of the problem and criteria improves communication and understanding. Information on the stakeholders' attitudes is gathered in a systematic way and can be presented in a graphic mode. One of the strengths of the MCDA method in EIA is that it explicitly acknowledges that impact significance assessment contains a strong subjective element. MCDA can also be very useful in showing how stakeholders'

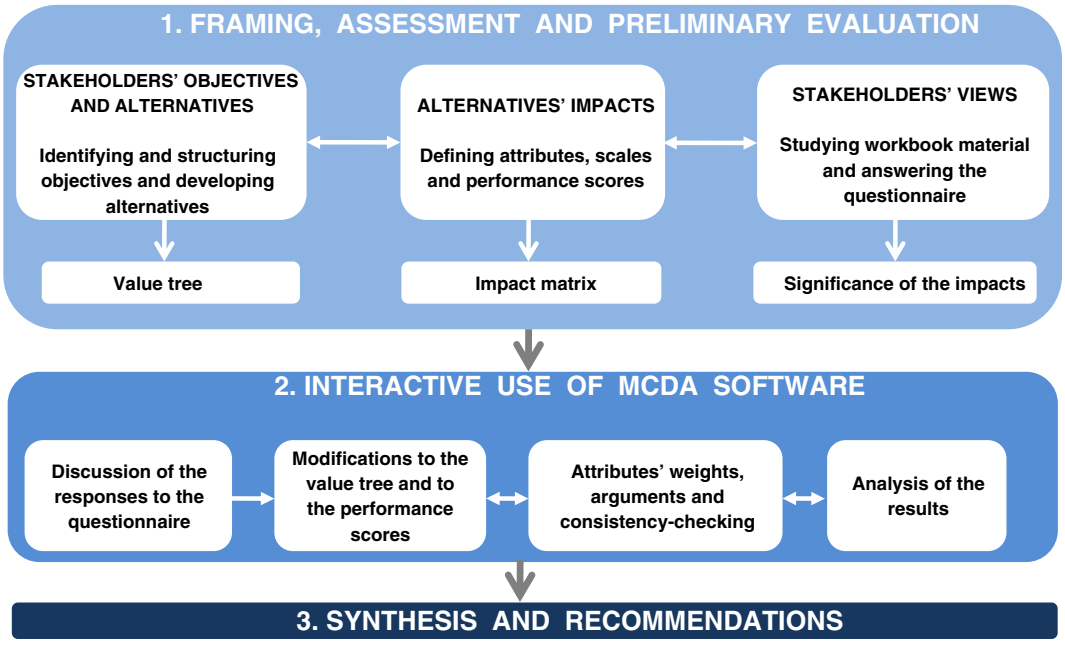

Fig. 1. The interactive MCDA process — the Decision Analysis Interview (DAI) approach.

preferences or different weighting profiles generated by experts affect the ranking of alternatives (Bagli et al., 2011; Geneletti, 2008; Marttunen and Hämäläinen, 2008; Mustajoki et al., 2011).

2.2. ES approach in EIA

Landsberg et al. (2011) have started to develop a promising framework for incorporating ecosystem services into impact assessment. Ecosystem Services Review for Impact Assessment (ESR for IA) explicitly recognizes the causal interactions between a project, human well-being and the indirect and direct drivers of ecosystem change. ESR for IA stresses the need for conducting an integrated assessment of project impacts and dependence on ecosystem services, and for a systematic implementation of the framework at the different stages of EIA (scoping, impact analysis and mitigation). Based on the literature, we can formulate a set of assumptions on how the application of the ES approach in EIA via the MCDA framework takes place.

Firstly, ecosystem service trade-offs are an essential issue in EIA in cases having an uneven distribution of costs and benefits and conflicting objectives. It is widely recognized that when management options are characterized by a high degree of stakeholder controversy and conflict, the assessment or decision process must address the values held by key participants (e.g., Gregory et al., 2012).

Secondly, the selection of ecosystem services is a crucial issue. In the scoping stage of an assessment, the different groups of beneficiaries, characterized by different needs and levels of dependence on ecosystem services, are determined (Geneletti, 2011). Also, the scale at which ecosystem services are identified impacts on what services are emphasized and what services are not recognized at all (Geneletti, 2011). We also think that the focus on the scoping stage and the identification and selection of key ecosystem services is one of the most important steps in ES-focused EIA. Overall, we see that value-focused MCDA can support the identification and valuation of ES in the EIA process. This is closely linked to stakeholder engagement and deliberation. For example, how the values (or objectives) and assessment criteria are obtained in the scoping stage — whether the process is more top-down and expert-driven or more bottom-up and collaborative.

Thirdly, one of the challenges is that the concept of 'ecosystem services' carries technological connotations (Fish, 2011) and, thus, the question is how to communicate and include the stakeholder values related to the various ESs in the assessment process. Problems may arise as the ES approach focuses on the benefits which nature produces to people and, thus, may not cover in every case all impacts of the proposed project for the community or society, such as decreasing employment (as part of well-being) in a specific sector. Results from Oikonomou et al. (2011) indicate that if the ES framework is applied in an assessment procedure, some stakeholder values or interests are left out from the analysis.

Related to the previous points, we think that it is important to clarify the distinction between final (welfare gains and/or losses to people) and intermediate (ecosystem processes) ecosystem services (Chan et al., 2012; UK NEA, 2010), as the difference in focus may have an effect on how the ES approach works in the context of the MCDA procedure in EIA. According to the UK NEA (2010), provisioning and cultural services are always classified as final ecosystem services, regulating services may be either final services or intermediate services/processes and supporting services are intermediate services/processes. Final ecosystem goods and services are easily understandable for the public without translation because they are determined by the beneficiaries (Nahlik et al., 2012; Oikonomou et al., 2011). Final ecosystem services, such as fish, wild species diversity and environmental setting, directly contribute to goods or benefits, such as food harvest, recreation and tourism, that are valued by people. Ecosystem processes or intermediate services are not directly linked to goods but they underpin the final ecosystem services.

Lastly, in the EIA procedure, it is important that ecosystem services are not only reduced to individual preferences and motivations, and that they are not discussed simply in terms of individual costs and benefits but also in terms of social rights and wrongs (Wilson and Howarth, 2002). The UK NEA (2010) calls for consideration of 'shared (social) values' – equal to economic and health values – producing well-being: ecosystem services have collective meanings and significance which include ethical arrangements guiding society's concern for nature, issues of altruism and existence value as well as esthetic considerations. Together with individual well-being values ('direct use values') we have collective shared well-being values: 'indirect use values' (societal and functional benefits), 'option values' (potential future direct and indirect use values), 'bequest values' (value of saving for future generations) and 'existence values' (value from knowledge of continued existence). The more an assessment considers these collective values, the more

qualitative and interpretative approaches to valuing ecosystem services are needed. The crucial question here is whose values are considered and how they are obtained. We think that the MCDA approach with VFT can cover different stakeholder and public values including benefits derived from ecosystems.

2.3. Comparing the value-focused approach with the ecosystem service approach

In the following chapter, we firstly present the outcomes of the applied MCDA approach, and after that, we compare them with the outcomes from a desktop analysis of applying the ES approach in the same project and process. We followed the commonly used typology of ecosystem services (provisioning, supporting, regulating and cultural services) from the MEA (2005) since this framing was also followed by Bottom et al (2009) in their typology of salmon ecosystem services in the Pacific (see Section 3.1). However, we argue that this typology might not be the best one in real-life projects involving different parties and values, while in our case we can discuss the advantages and disadvantages of this commonly used top-down categorization. Our hypothesis is that value-focused thinking encompasses stakeholders' and other societal values (in contrast to those obtained from ecosystems), interests and concerns more holistically and also more specifically than ES-focused thinking. This is important in the EIA procedure within which social or socio-economic impacts should also be taken into consideration.

In Section 4, we compare the two approaches with focus on the differences in value trees, evaluations of alternatives and the significance of impacts. The comparison is based on the researchers' expert knowledge and their project evaluation as well as the participants' feedback on the assessment process (Karjalainen et al., 2011).

3. The case — restoration of a regulated river and migratory fish populations

3.1. Ecosystem services of migratory fish

The life cycle of the anadromous Atlantic salmon (*Salmo salar*) and its management in the Baltic Sea area exemplifies the challenges facing ecosystem service valuation. Salmon ecosystems exist at varying scales, depend on habitat diversity and connectivity, and are defined here as an integrated system of people and environments that are directly linked to anadromous salmon populations or groups of populations within particular geographic areas (Bottom et al., 2009).

The Atlantic salmon once reproduced in most Baltic rivers, but various human activities have significantly decreased the number of rivers with salmon runs throughout the Baltic area. River fragmentation through damming, deteriorated water quality and overfishing are the most obvious causes of the decline (Erkinaro et al., 2011). In the Baltic Sea area, the salmon is a source of living for a relatively small number of commercial fishers and subsistence fishers (Haapasaari and Karjalainen, 2010).

According to Bottom et al. (2009), Pacific salmon populations directly provide three of the four categories of ecosystem services defined by the MEA (2005): provisioning, cultural and supporting services. In Fig. 2 (adapted from Bottom et al., 2009), these services involving two-way interactions with feedback to the salmon are described in the context of the Baltic Sea.

The salmon has shaped the way of living and thinking of a large number of people especially in the northern parts of the Baltic Sea area. Thus, people living in coastal areas and river valleys owe the salmon a large part of their pride, identity and cultural heritage. Recreational activities, such as recreational salmon fishing, and the supply of esthetic values derived from the free-flowing river are seen today as a benefit for local dwellers as well as a source of income for nature-based or fishing tourism. In the northern parts of the Nordic countries, tourism is given special governmental emphasis in the local and regional economic development (Haapasaari and Karjalainen, 2010; Kauppila and Karjalainen, 2012). Overall, the focus of the above-mentioned benefits derived from the salmon is shifting from the sea to estuaries and rivers and, thus, from provisioning services, such as commercial harvesting, to cultural services, such as recreational opportunities.

3.2. The River Iijoki — a regulated and potential river for migratory fish

The River Iijoki is the sixth largest river in Finland. Until its damming for hydropower production between 1961 and 1971, it was one of Finland's famous salmon rivers. For several decades, five hydropower dams in the lower course have blocked the passage of migratory fish to their reproduction areas. Most of the upstream areas suitable for salmonids have been restored after the cessation of timber floating. Since the damming in the 1960s, salmon and sea trout stocks have been maintained in the River Iijoki through a broodstock program where the stocks are renewed using eggs stripped from returning fish and their genetic diversity is monitored (Erkinaro et al., 2011).

The EU is reorganizing Baltic salmon fisheries by proposing a new plan that heavily stresses natural production (instead of stocking which has been stressed in the past) in wild salmon rivers and also in potential regulated rivers. In addition, there are concurrent policy initiatives (such as the EU Water Framework Directive, WFD) to restore the multi-functionality of riverine ecosystems and landscapes (Sigel et al., 2010). On the other hand, there are also plans aiming to increase the use of European and northern rivers for hydroelectric power production to meet the obligations of international climate agreements and to gain profit therefrom (Karjalainen and Järvikoski, 2010).

In the case of heavily modified rivers, such as the River Iijoki, restoration is inevitably a lengthy process, and long-term commitment of different parties to the project is necessary. Therefore, smooth co-operation and communication as well as mutual understanding between planners, authorities, stakeholder groups and citizens are of vital importance. Thus, there is definite demand for approaches that can evaluate multiple issues, interests and values as well as integrate stakeholder and community concerns into the assessment and decision-making processes of river restoration.

The main objective of the project *Migratory fish return into the River Iijoki* (2008–2010) was to create a concrete program for restoring migratory fish. In order to support this objective, an environmental impact assessment was launched applying the interactive MCDA approach, aiming to find an ecologically, socially and economically sustainable way to return migratory fish stocks into the River Iijoki.

3.3. The case study process

The impact assessment process in the River Iijoki case was coordinated by a project group of researchers, key stakeholders from fishing co-operatives, a hydropower company, a local environmental association as well as officials from the environmental and fishing administration. The project group had altogether six different meetings or workshops where the MCDA and EIA work was processed. The smaller expert group, which coordinated the research for the impact assessment, consisted of researchers from the University of Oulu, the Finnish Environment Institute and the Finnish Game and Fisheries Research Institute. Fig. 1 describes the main phases of the assessment process. The whole EIA process lasted one year.

The MCDA process provided a framework and a tool for integrating the different work packages, disciplines, studies and phases of the research and for collecting, processing, organizing and analyzing the information gathered from stakeholders, experts and scientists. The participants' evaluation of the process and approach (through a feedback questionnaire) was positive: they thought that different viewpoints and alternatives were found and systematically analyzed (Karjalainen et al., 2011).

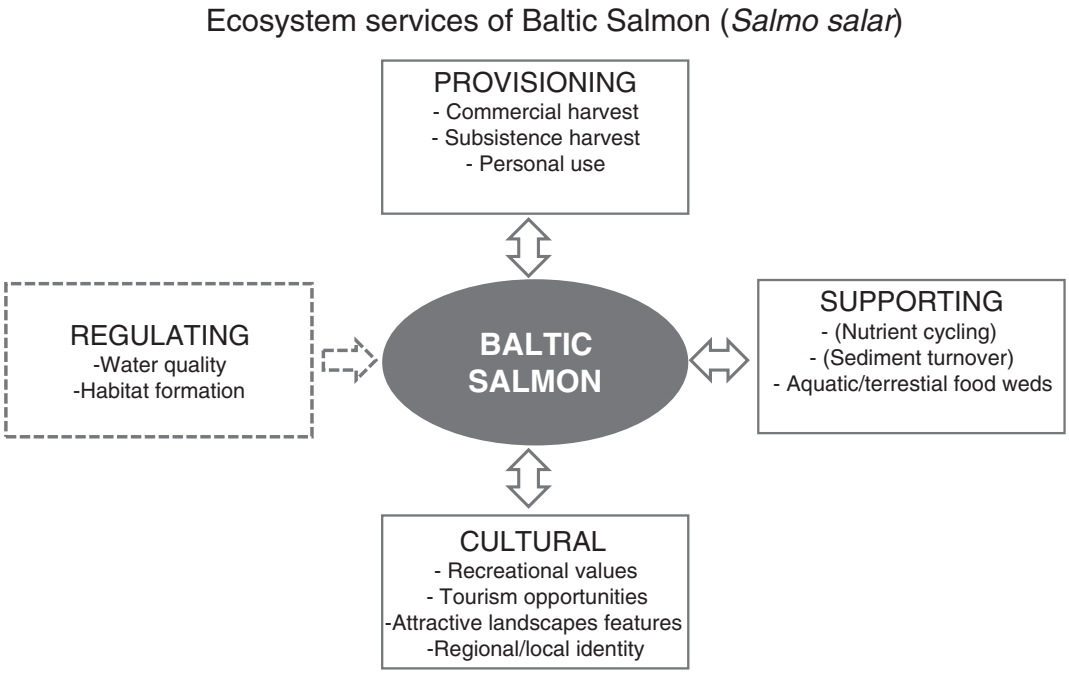

Fig. 2. Salmon population in the Baltic Sea provides provisioning, cultural and supporting ecosystem services that benefit people. These services involve two-way interactions with feedback to the salmon (adapted from Bottom et al., 2009).

3.3.1. Problem definition and structuring of the value tree

In the first project group meeting, it was agreed that the rehabilitation of migratory fish populations into a regulated river in the presence of multiple interests (such as hydropower, recreational and amenity values, nature conservation and tourism) would be complex and span a considerable period of time. It was accepted that a time scale of 50 years would be an appropriate period for all the measures to have taken effect. There was also discussion about existing uncertainties, e.g., the future state of the Baltic Sea and its effect on the migration and rearing of salmons.

In the second meeting of the project group, the main theme was to clarify all the objectives of the stakeholders and the different policies for the restoration project. As a result of the meeting, the list of objectives described in Table 1 was identified:

Based on this listing of objectives, the expert group developed the initial proposal for the value tree. A starting point was to take three dimensions of sustainability (ecological, economic and social, including cultural aspects) as the upper level of criteria. All other criteria were classified as subcriteria under these main criteria. Several iterative modifications within the expert and project group resulted in a value tree which was accepted by all stakeholder groups (Fig. 3).

3.3.2. Development of the alternatives

The possible set of restoration alternatives was considered and discussed while structuring the value tree. The set of alternatives was initially developed by the expert group and discussed and revised in the two project group meetings. The alternatives developed reflect the main objectives and interests as well as issues of conflict, such as how much the current fishing rights and regulations are to be revised, and how much water is to be allocated for fish ladders. The relevance of each alternative was discussed in the project group meetings. It was ensured that the stakeholders can state their preferences from the different alternatives and agreed that all alternatives could be realizable if the costs of building the fish ladders (total sum circa 15 million Euros), operating and maintaining them could be shared between the different actors. The following set of alternatives (besides the status quo) was accepted in the third project group meeting:

1 Transporting fish over the dams. This alternative is based on the idea of transporting adult fish (600 salmon and 300 sea trout) over the hydropower dams and not building any fish ladders. Fishing rights and regulations are kept in general in the status quo. This

Table 1
The list and description of objectives obtained in stakeholder meetings.

Objectives		Description
Ecological objectives	To rehabilitate of migratory fish populations and natural life cycle (salmon, sea trout, white fish, and lamprey)	*The original salmon, sea trout and white fish populations of the River Iijoki will survive and strengthen, and they will increase the overall natural production in the Baltic Sea area.*
Economic objectives	To enhance regional economic prosperity and well-being.	*The attractiveness of river valley and tourism activities will increase.* *Minimization of the loss for the hydropower production.* *The conditions of commercial fishing will improve and incomes from fishing licenses will increase.*
Social objectives	To improve the quality and amenity of residential and recreational environment	*Local identity will strengthen.* *Fishing and other recreational possibilities (incl. landscape features) will improve.*
Process and strategic objectives	Environmental justice	*To fairly acknowledge different parties, division of costs, the fishing rights are. To compensate for the detriments of river regulation and to equalize the distribution of losses and gains*
	To achieve the objectives of the River Basin Management Plan (WFD)	*To improve ecological status of the river.* *To allow free passage of aquatic organisms.*

alternative minimizes the losses for the current fisheries in the estuary area, for hydropower and for fish farming.
2 Fishways and stocking. Fish ladders are built in every dam, and salmon and trout are stocked into the river in order to build up naturally reproducing populations. In this option, fishing regulations are stricter than in Alternative 1 in the river mouth because the majority of the migrating fish is presumed to enter the fish ladder.
3 Fishways and a wide range of measures. This alternative comprises the same measures as Alternative 2. However, they are realized on a wider scale: the number of restocked juveniles and the amount of water allocated for fish ladders are larger, the restoration efforts wider and the fishing regulations stricter. This alternative maximizes the gains or benefits for ecological values, tourism, local identity and recreational fishing (especially concerning the fishing experience). The focus is on potential ecosystem services.

3.3.3. Evaluating the impacts of the alternatives

Evaluation of the performance of the alternatives was mainly carried out as expert work by the project group. The attributes for measuring the performance of the alternatives were defined while structuring the value tree. The evaluation work was based on existent literature, expert evaluations and three new studies specifically conducted for this assessment: a salmon life cycle model for assessing the number of fish in different stages of life and migration (from sea to river) by the Finnish Fisheries and Game Research Institute, a specific study on the economic value of fishing tourism on the River Iijoki (Kauppila and Karjalainen, 2012), and a study on the social impacts of the restoration work (Karjalainen et al., 2011).

The natural attributes are recommended by the literature (e.g., Keeney and Gregory, 2005), and we managed to find them for most of the attributes (see Table 2). For some criteria, natural measurable attributes could not be found and, therefore, constructed attributes were utilized. We applied a scale from + + + (considerable positive effects) to − − − (considerable negative effects) with 0 meaning no effect to the following criteria: whitefish (state of stock), local identity and fishing experience.

3.3.4. Eliciting weights for the criteria

Stakeholder preferences were included in the MCDA model by means of decision analysis interviews. A stakeholder workshop was organized for the selected interviewees where the results of the impact assessment were presented and the framework, as well as the decision analysis interview process, was described. In the same meeting, the interviewees were handed a questionnaire for the interview and an information package in order to provide them with background information about the case, the decision analytical approach and the interviewing process. The 38 page package also described in detail the applied value tree including the grounds for the alternatives, criteria and measurement value estimates.

Interviews were conducted by three researchers in September and October 2010. Altogether 25 representatives of different stakeholder groups were interviewed. Thus, altogether 25 different weighting profiles and evaluations of the model reflecting the preferences of the interviewees were gathered. We used local scales (as attribute measurement values on a 0–1 value scale), as then the end points are truly realistic values. Thus, for each criterion, the lowest attribute value among our alternative set was mapped onto the value 0, the highest attribute value onto the value 1, and the other attribute values were mapped linearly onto this scale (Belton and Stewart, 2002). For eliciting the weights for the criteria, the Swing method (von Winterfeldt and Edwards, 1986) was used. In this method, an interviewee is first asked to allocate 100 points to the most important criterion, i.e., the criterion whose value he/she most preferably would like to change from its lowest possible level to its highest level. After this, the decision maker is asked to allocate 0–100 points to every other criteria to indicate the importance of value change in this criterion in relation to the value change in the most important criterion. The actual weights are obtained by normalizing the sum of the given points to 1.

The interviewees' preferences were entered into the model using the decision analysis software Web-HIPRE (Mustajoki and Hämäläinen, 2000). The results were analyzed and discussed with the respondents. In a few cases where the respondent thought that the outcome did not fully match with his opinion, the criteria weightings were refined.

4. Results

4.1. Comparison of the value tree

In the structuring process of the applied MCDA framework, we emphasized the importance of careful planning for producing an operationally functional value tree representing all dimensions and values obtained in the collaborative work. We think that the criteria in the final value tree fulfill the requirements of completeness, value relevance, balance and understandability quite well (Belton and

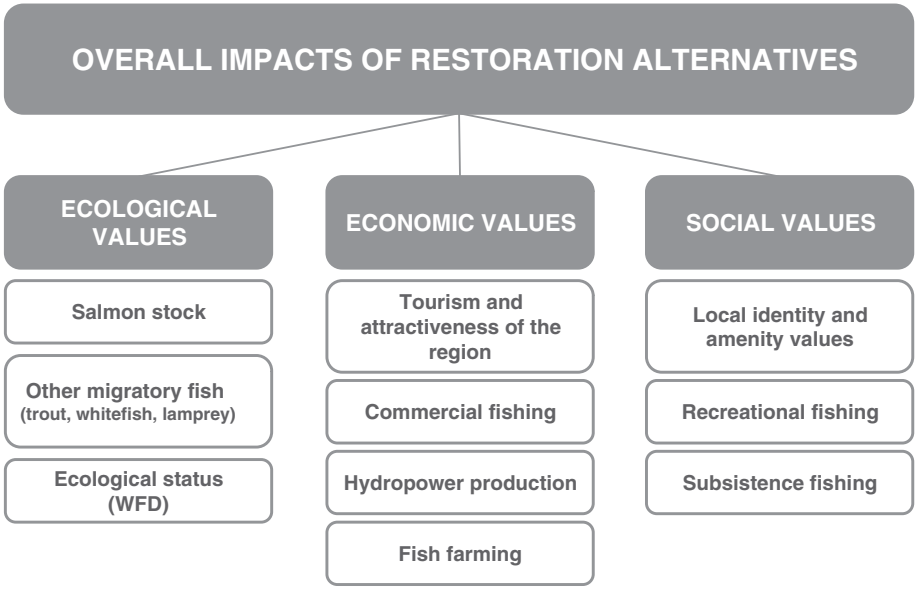

Fig. 3. Value tree in the River Iijoki project — value-focused approach.

Table 2
Impact matrix of different restoration alternatives.

	Criteria	Present state	Transporting	Fishways and stocking	Fishways and a wide range of measures
		Alt 0	Alt A	Alt B	Alt C
Ecological	Salmon (smolts from natural production)	0	20,000–35,000	70,000–120,000	150,000–260,000
	Sea trout (smolts)	0	7000	20,000	38,000
	Whitefish (state of the stock)	0	0	+	++
	Ecological status	Moderate	Moderate	Good	Good
Economic	Tourism income (direct)/year	1.16 M€	1.28 M€	1.68 M€	1.97 M€
	Man-years, direct	6.4	7.0	9.2	10.7
	Commercial fishing (man-years)	4.64	4.14	3.64	3.64
	Hydropower				
	Output of electricity/year	825 GWh/y	825 GWh/y	821.3 GWh/y	818.5 GWh/y
	Value/€/year	38.8 M€	38.8 M€	38.6 M€ (−176,000 €)	38.4 M€ (−304,000 €)
	Fish farming				
	Number of employees	20	20	18.5	17
	Risk of fish disease	0	− −	−	−
Social	Local identity	0	+	+	++
	Recreational fishing — downstream				
	Sale of fishing licenses	900–1000	975–1075	1050–1150	1200–1300
	Fishing experience		+/−0	+	++
	Recreational fishing — mid- and upstream				
	Sale of fishing licenses	9000	9450	10,800	11,700
	Fishing experience		+	++	++
	Subsistence fishing — downstream				
	Number of fishing days	15,200	13,700	9100	5300
	Number of fishers	290	260	120	100
	Subsistence fishing — mid- and upstream				
	Number of fishing days	232,000	208,800	185,600	185,600

Stewart, 2002; Gregory et al., 2012). In our case, the assessment criteria were closely linked to the values of the different interest groups, each of whom may have internally conflicting goals as well. Here the valuation represents all who have a legitimate stake in or who are affected by the case project.

Following the MEA typology of ecosystem services, we obtained the different criteria for the assessment (Fig. 4). The most obvious role of salmon ecosystems is the provisioning service, providing various fisheries (commercial and subsistence) with highly valued food products (Fig. 2). In the case of provisioning services, the main focus is on the amount of direct use values (outputs that can be consumed directly) and 'final ecosystem services', goods – in this case, the harvest of fish – that directly deliver welfare gains for different fisherman groups. These can be considered individual well-being values. In the applied value-focused MCDA framework, the number of salmon smolts (in ecological values, see Table 2) was considered a good attribute for the criterion of salmon stock and its changes. It can be considered an indirect use value (societal or functional benefits) as part of other shared well-being values. The number of salmon smolts can be considered to include existence value (value from the knowledge of continued existence) and bequest value (value of saving for future generations) because it inherently takes into account the state of the stock and reveals information about the ecological sustainability of the considered alternatives in the future. The ES approach focused more on provisional services while the real-life approach captured the value not via final services but via salmon smolts.

In the value-focused MCDA process, supporting services were not included into the analysis. Overall, most ecological values are considered differently by the ES approach. Nutrient cycling or food webs were not considered at all in the MDCA framework for two reasons. First, when stressing the objectives and values of local stakeholders, such as fishing co-operatives and hydropower, focus was given to socio-economic issues, whereas such issues regarding ecosystem services where expert knowledge is required were not emphasized. With the ES approach, supporting services are put more explicitly on the agenda also in the interactive process (see Coleby et al., 2012; Oikonomou et al., 2011). Secondly, a fish biologist (pers. comm.) who participated in the project group expressed afterwards that, in this particular case, the issue of supporting services is not very clear. For example, several thousand spawning adult salmon in a large river do not lead to significant sediment turnover or nutrient cycling.

However, in the project feedback, major criticism was directed at the fact that in Finland, the river pearl mussel (*Margaritana margaritifera*) existing in the catchment area is an endangered species (Valovirta, 1998) but it was not taken into account. The salmon and the sea trout are the host animals for the mussel in its early stages of life and the rehabilitation of the salmon and sea trout stocks could enhance the mussel population (Bauer, 1987). In summary, more ecological expertise is used in applying the ES approach, and evidently, the whole process of selecting the key ecosystem services and assessment criteria would be more expert-driven and better take into account ecosystem characteristics, such as the relationship between mussel and salmon management (Table 3).

In cultural services, the same criteria could be found: local identity and amenity values, tourism and recreational values (mainly recreational fishing) should be identical to some criteria of the economic and social values in the value tree of MCDA. These criteria are evident without stakeholder engagement since they are clearly part of cultural ecosystem thinking (e.g., MEA, 2005).

On the other hand, we might argue that in applying the ES approach, we do not explicitly consider ecosystem 'disservices' (Coleby et al., 2012) or 'disbenefits' (UK NEA, 2010). In our case, this means that the social and economic costs or losses that can be caused by the restoration alternatives have not been explicitly considered. The most obvious of these are the losses for hydropower (water allocated for fish ladders) and fish farming (the replacement of natural populations with stocked populations affecting local employment). If, in an assessment, focus is only given to the benefits – without considering the costs and trade-offs needed to achieve new ecosystem goods or services – negative economic impacts may be underestimated and there is a risk that economically inefficient and, for some groups, unacceptable alternatives are preferred. This is especially the case when considering such highly-managed environments as regulated rivers often are.

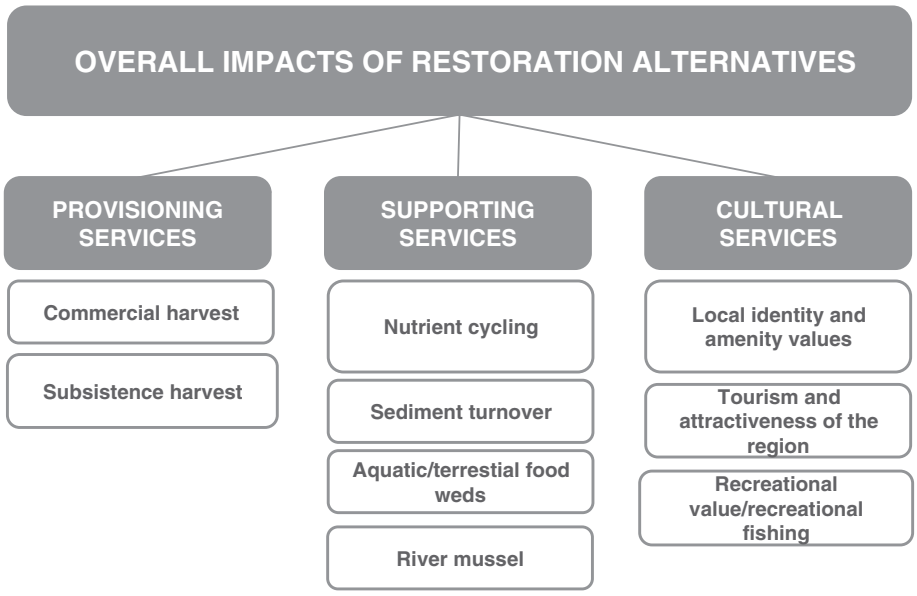

Fig. 4. Value tree of the ES-focused approach.

4.2. Evaluating the alternatives

The ecosystem service focused approach could have emphasized the possibility of applying the Payments for Ecosystem Services (PES) practice (Milder et al., 2010) in formulating the alternatives. In this case, the idea of PES would consist of, for example, financial support for transporting fish over the dams or for purchasing water from the hydropower company for fish ladders. Money for these purposes can be collected from fishing licenses and from changing the fisheries' obligatory fees toward supporting the restoration of a new wild stock instead of stocking. Thus, it can be seen that the ES approach would go further than the applied approach in introducing explicit mechanisms for enhancing social equity resulting from the alternatives.

In the ES framework, three of the listed supporting services (nutrient cycling, sediment turnover and food webs) would probably be measured using constructed attributes (see Table 3). The number of river pearl mussels could have been evaluated based on a model calculating the number of adult sea trout migrating in a particular river area. The river pearl mussel is a highly endangered species and the value of a specimen has been assessed by the Ministry of the Environment at 589 Euros per mussel.

The economic value of the salmon stock is more evident within the ES approach when the catch value for commercial and subsistence fishing can be calculated by means of life cycle modeling. The number of fish and evaluated catch values would be explicitly presented. This would probably be more acceptable for some stakeholders; a large amount of criticism has been leveled against the expert evaluation of the applied framework concerning the impact to commercial fishing (i.e., decreasing man-years in all alternatives). This expert evaluation was based on the assumption that stricter fishing regulations in the estuary would have a negative effect on commercial fishers and their fishing efforts. A more accurate estimate of fish and catch values (compared to the number of smolts) could have given a more realistic and objective picture of how changes in the fisheries would affect the fishermen's incomes.

Table 3
Comparison of value-focused and ES approach with regard to assessment criteria and attributes.

Value-focused approach			ES approach		
Value category	Criterion	Attribute	Criterion	Attribute	Type of service
Ecological values	Salmon stock	Number of smolts	Nutrient cycling	Constructed scale	Supporting
	Other migratory fish	Number of smolts/state of the stock	Sediment turnover	Constructed scale	Supporting
	Ecological status	Constructed scale (bad…excellent)	Food webs	Constructed scale	Supporting
			River mussel	€/mussel	Supporting
Economic values			Commercial harvest	Catch value (€)	Provisioning
			Subsistence harvest	Catch value (€)	Provisioning
	Fishing tourism	Direct income (€)	Fishing tourism	Direct income (€)	Cultural
		Man-years, direct		Man-years, direct	
	Commercial fishing	Man-years, direct			
	Hydropower	Output of electricity			
		Value/€/year			
	Fish farming	Number of employees			
		Risk of disease (constructed)			
Social values	Local identity	Constructed scale (− − −…+ + +)	Local identity	Constructed scale	Cultural
	Recreational fishing	Number of sold fishing licenses	Recreational fishing	Willingness to pay, € (a salmon management fee to restore the salmon stock)	Cultural
		Fishing experience			
		Constructed scale			
	Subsistence fishing	Number of fishing days			
		Number of fishers			

4.3. The significance of the impacts

As the results (Fig. 5) show, the most important issue for the interviewed stakeholders was the ecological impact of the alternatives. Most of the interviewees considered the state of migratory fish stocks as the basic unit when measuring the success of the restoration efforts. One should, however, note that the given weights indicate the importance of the criteria only within this particular alternative set and context. The importance of the criteria in this case depends both on facts and values (preferences): an interviewee is asked to consider both the impact range of the alternatives (e.g., spatial scale and temporal scale) and the importance of the objective considered (in the context of this project) from the evaluator's point of view. Thus, one cannot make general conclusions about the preference for the criteria, as some of the variation originates from seeing the effects of the alternatives differently. For example, those who saw little difference between the alternatives in their effects on hydropower production accordingly assigned this a low weighting, even if they might generally regard the continuation and feasibility of hydropower as highly important — overall, the losses of hydropower were considered insignificant in proportion to the total electricity production on the River Iijoki.

Overall, there are quite a lot differences in the given criteria weights (Fig. 5). Although some agreement regarding the preferences could be found among stakeholders, detailed analysis of the stakeholders' interviews and weighting profiles revealed that disagreement occurs concerning the effects of the different alternatives and the importance of the criteria. In the analysis, we found four different stakeholder viewpoints (defined as the critical, environmental, administrative and local economy views) (Karjalainen et al., 2011).

The most important difference in valuation between the applied value-focused framework and the ES framework is the presence of trade-offs: In the ES approach, trade-offs between potential ecosystem services and evident losses (in hydropower production) are not, in principle, considered — unless hydropower is also considered an ecosystem service. This can have a major impact on the overall value and ranking of the alternatives when the alternatives containing a wide range of restoration efforts would clearly compete with the alternatives taking the losses into account.

5. Discussion and conclusions

The successful implementation of the ecosystem service approach in EIA requires understanding of stakeholder preferences and different trade-offs between the benefits obtained from ecosystem services and the 'disbenefits', including costs and losses, produced by the alternative projects. ES frameworks (e.g. MEA, 2005) suggest that there are often trade-offs between different services and not every service can be maximized without sacrificing another. The application of interactive MCDA as a systematic tool and participatory practice has promising potential in focusing on these issues. In this paper, we compared a real-life interactive value-focused MCDA case with a desktop case of ES-focused MCDA in EIA in regard to assessing restoration options in the context of a regulated river.

In our view, the value-focused MCDA approach is useful for considering the trade-offs required for achieving benefits from ecosystem services and goods. With this kind of approach, negative economic impacts (e.g., losses in hydropower production) are included into the analysis, lowering the risk that economically inefficient and, for some groups, unacceptable alternatives are preferred. In addition, the results from a study by Oikonomou et al. (2011) indicate that the ES typologies neglect some stakeholders' values and concerns.

However, the explicit consideration of ecosystem services within the MCDA framework would enable the framing and valuing of provisioning services in particular – in our case, commercial and subsistence harvesting of salmon – in a more meaningful way for some stakeholders. It is important to notice that, in our case, the ES approach evidently concentrates on direct use values (catch value) in the valuation of the improvement of migratory fish stock, whereas in the applied approach, the state of the stocks (the number of wild salmon smolts) represents use values which are more indirect, i.e., societal and functional benefits. On the other hand, if supporting services and the river pearl mussel are taken into consideration, emphasis can be given to indirect use and existence values.

The applied value-focused approach is appropriate and flexible in working with stakeholders and their often conflicting values and goals because it takes trade-offs into account in EIA. It focuses on the scoping stage where the key objectives and values of stakeholders are defined, and where the key ecosystem services can also be selected. To avoid the top-down process of identifying and valuating ecosystem services and important objectives, analytic–deliberative methods could foster a bottom-up way of forming value categories, including key ecosystem services and assessment criteria. Applying value-focused thinking during the scoping stage enables the identification of priority ESs according to the significance of the project's impact on each of them. In the EIA process, determining the impact's significance is recognized as a crucial, highly complex and little-understood activity.

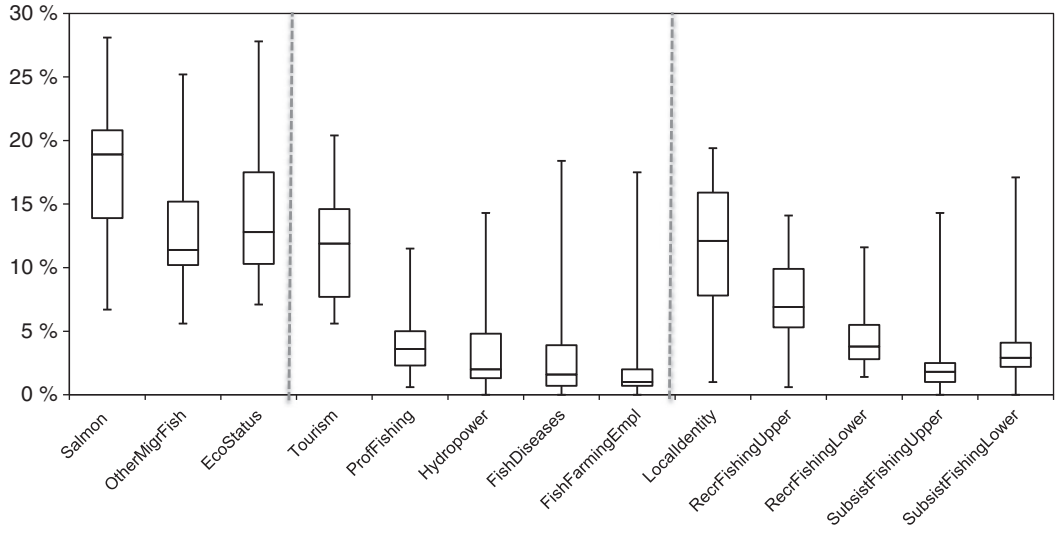

Fig. 5. The importance weights of the criteria in the River Iijoki case given by the interviewed stakeholders (min, median, 75th percentile, and max).

In expert assessments, the identification of ESs may seem to be a mode of thinking that is distant to stakeholders. Particularly, when working with lay people, it is important to use terms which people are familiar with. Expert judgments regarding ecosystem services might shadow the fact that there are values and decisions hidden in the expert assessments of ESs. However, the selection of key ecosystem services depends on the definition of ES and the kind of collaborative approach that is selected. If ESs are considered simply in terms of benefits provided by the ecosystem, stakeholders could also have had their say in the identification of the ecosystem services. The ES approach can include the detailed identification of beneficiaries: who are losing, who are gaining and where are they located (Turner et al., 2010).

We argue that the interactive MCDA approach can be used as an integrated impact assessment framework within which all dimensions of value could be considered, including ecological, socio-cultural and economic dimensions as well as the different costs and benefits. The ecosystem service approach can have an additional value within this framework in EIA focusing on ecological structures and functions providing services and benefits for people. Thus, applying ESs in an EIA process may help to develop more rigid links between ecosystem characteristics and benefits for people. However, it should not form a rigid 'checklist' way of making assessments but it should rather widen horizons about potential issues in linking ecosystem properties to human benefits and values. Some values, economic costs or 'disbenefits' do not fit naturally into the ES approach, and it is important that these are not dismissed as hidden externalities but are also acknowledged.

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