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Abstract

Active involvement of local stakeholders is currently an increasingly important requirement in European environmental regulations such as the EU Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD). The same is true for economic analyses such as cost-benefit analysis (CBA). For example, the Swedish WFD implementation requires i) quantification of cost and benefits of proposed measures and ii) stakeholder involvement. How can these two requirements be integrated in practice? And can such requirements facilitate implementation of projects with a potential net benefit? This paper presents a stepwise CBA procedure with participatory elements and applies it for evaluating nutrient management options for reducing eutrophication effects in the coastal area of Himmerfjärden SW of Stockholm, Sweden. The CBA indicates a positive net benefit for a combination of options involving increased nitrogen removal at a major sewage treatment plant, creation of new wetlands and connecting a proportion of private sewers to sewage treatment plants. The procedure also illustrates how the interdisciplinary development of a coupled ecological-economic simulation model can be used as a tool for facilitating the involvement of stakeholders in a CBA.

Keywords: cost-benefit analysis, stakeholder involvement, integrated modeling, eutrophication

1. Introduction

Cost-benefit analysis (CBA) is a widely applied method for advising decision-makers by evaluation of the social profitability of projects and policies (see e.g. Boardman et al. 2011). It is used also for environmental decision-making, though practice and acceptance vary among countries (see e.g. Navrud 2004). In Europe, several EU directives that require the use of CBA are currently being implemented. For example, the Marine Strategy Framework Directive (MSFD) specifically requires cost-benefit analysis: ”*Member States /.../ shall carry out impact assessments, including cost-benefit analyses, prior to the introduction of any new measure”* (European Parliament 2008, ch. III, article 13 § 3). Another increasingly important feature of European environmental regulation is to actively involve local stakeholders. For example, the MSFD indicates that it is of importance to actively involve the general public in the establishment, implementation and updating of marine strategies (European Parliament 2008, § 36). As another example, the EU Water Framework Directive (WFD) underlines both the importance of economic analysis of water use and of securing participation of the general public (including users) by e.g. providing proper information before final decisions on management plans (European Parliament 2000). This can be further illustrated by the Swedish WFD implementation. Swedish law demands that the development of programmes of measures include a quantification of associated costs and benefits: *“..Such analysis of the consequences of the programme of measures /.../ shall contain an evaluation of both the economic and environmental consequences of the measures, in which costs and benefits shall be quantified.”* (SFS 2004:660, ch. 6 § 6), and stakeholder involvement is also promoted: *”Water authorities shall plan their work…in a way that enables and encourages participation by everyone who is affected by water quality management.”* (SFS 2004:660, ch. 2 § 4).

We conclude that there are regulatory demands both to carry out CBAs and to actively involve stakeholders. How can these two requirements be integrated in practice? This paper presents a stepwise CBA procedure with participatory elements and applies it on management options for reduced nutrient loading to the eutrophicated coastal area of Himmerfjärden, SW of Stockholm, Sweden. Our procedure illustrates how the interdisciplinary development of a coupled ecological-economic simulation model can be used as a tool for facilitating the involvement of stakeholders in developing a CBA. There is indeed a need for cooperation between ecologists and economists for making reliable predictions of environmental consequences to be monetized in a CBA. This has been repeatedly emphasized when using ecosystem services frameworks (e.g. MA 2005, SAB 2009, Söderqvist et al. 2011, TEEB 2010). Further, Hall and Mainprize (2004) argue that consultation with all stakeholders is essential for the successful implementation of an ecosystem-based approach. However, using models resulting from ecological-economic cooperation as an aid for involving stakeholders in a CBA is a relatively uncharted territory.

Earlier suggestions to involve stakeholders in CBA have emphasized that projects with a positive net present value might still fail in practice if some stakeholders perceive that their interests have not been taken into account (Grimble and Wellard 1997). We suggest that involving stakeholders in the process of developing a CBA can facilitate implementation of projects with a potential net benefit. EC (2011) advocates that such enforceability for WFD implementation is strengthened by public participation giving transparent establishment of objectives and adoption of measures and citizens´ influence on the direction of environmental protection. Behagel and Turnhout (2011) also claim that participation and involvement of the civil society in decision-making constructs democratic legitimacy when implementing the WFD. Securing support for policies by e.g. public consultation and possibilities for stakeholders to influence the policy as it is developed are factors regarded to generally speed up the process of implementation of policy (Gerrits and Edelenbos 2004). For example, Turner et al. (2007) show the importance of stakeholder involvement for successful implementation and acceptance of management plans. Further, Oen et al. (2010) emphasize the finding that stakeholder involvement is a vital determinant to improve project implementation. In addition, they observe an increase of stakeholder involvement and interactive approaches in current western policy-making through e.g. consultation and cooperation with stakeholders or citizens when developing policies.

The chances of a project to be successfully implemented also depend on identifying stakeholders adequately and recognizing how they perceive that the project's costs and benefits are distributed among them (Jenkins 1999). TEEB (2010) notes that identifying and characterizing stakeholders in economic valuation helps conflict resolution and implementation of better policies, but also that there is a risk that one or a few of the stakeholders have a disproportionate impact on the analysis. There is indeed a widespread scepticism against introducing participatory elements in a CBA because stakeholders are likely to behave strategically once they are a part of the CBA process. For example, Boardman et al. (2011) emphasize that a key feature of CBA is that it disregards the demands of stakeholders and that it is easily distorted by involvement of, for example, “guardians” aiming at minimizing net budgetary expenditure and “spenders” trying to maximize constituency support. We conclude that stakeholder involvement must not violate the pure basis of welfare economics for defining and measuring costs and benefits. Further, are the potential gains in terms of improved information, chances of gaining support for commonly developed policies and implementation of projects with a potential net benefit substantial enough to motivate testing of procedures for stakeholder involvement in CBA. Such procedure could also contribute to meet several regulative demands in current legislation.

This paper is organized as follows. Section 2 presents a 10-step CBA procedure, in which the roles of ecologists and stakeholders are highlighted. This procedure is applied to a case of mitigating eutrophication effects in the Swedish coastal area of Himmerfjärden. Section 3 provides the case study setting and section 4 describes the application. A concluding discussion is found in section 5.

2. Cost-benefit analysis as a stepwise procedure

The stepwise CBA procedure used in this paper is described in Fig. 1. Each step (1-10) is a crucial component or process of the analysis, and together they describe a complete CBA procedure. This also serves as a framework for CBA applications in which involvement of stakeholders and ecological expertise are essential components. However, cost-benefit analysts (economists) have the responsibility for ensuring a treatment adequate for CBA at each step. This requires considerable communication with stakeholders and ecologists and that their input is used without biases, such as a too restrictive selection of project alternatives due to, for example, a disproportionate impact of some stakeholders.

The framework involves a systems approach which is supported by ecological expertise (right box in Fig. 1). Essential stakeholder input for the framework is indicated by the left box in Fig. 1. The aim of the framework is to facilitate a structured and transparent analysis securing relevance of, and acceptance for the CBA process and its outcomes. Below we go through the steps with a focus on how collaboration with ecologists and stakeholders contributes to this aim.

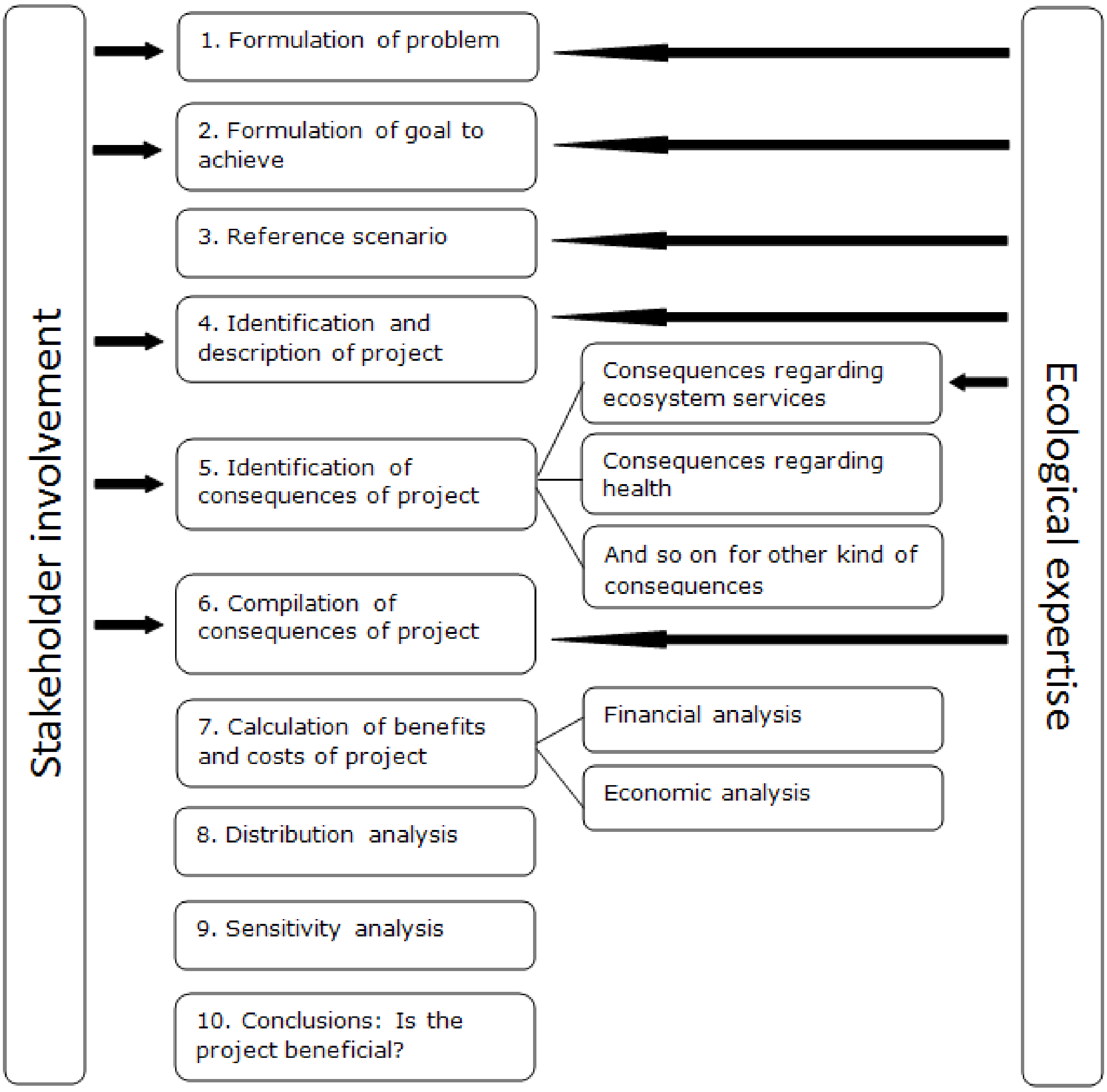

Figure 1. Cost-benefit analysis in 10 steps also indicating where the application was supported by ecological expertise and stakeholder involvement.

The CBA procedure needs ecological expertise for expressing the setting for the analysis and environmental consequences in terms of ecosystem goods and services (ecosystem services as a shorthand in the following). The typically complex and non-linear nature of ecological systems (e.g. Kemp et al. 2009, Levin 1998) necessitates a systems approach. The participation of ecologists (Fig. 1) is intended to ensure that ecological conditions are taken into account when the problem is formulated (step 1) and that realistic goals are set (step 2). Formulating the problem requires knowledge of e.g. the state of the ecosystem and its crucial external influences and internal dynamics. In the case of coastal ecosystems, the negative impacts of eutrophication include excessive phytoplankton growth, with nuisance blooms (sometimes toxic), loss of macrophytes due to the decreased water transparency, and spreading hypoxia in bottom waters, resulting in kills of fauna and changed biogeochemical cycling of nutrients (Nixon 1995, Diaz and Rosenberg 2008). The cause is usually excessive nutrient loading but this may differ between areas in for example the relative importance of point versus diffuse sources, and the nitrogen to phosphorus ratios and proportion of inorganic nutrients from these sources. Furthermore, information on composition and responses of the ecosystem and ecological thresholds are needed for setting realistic goals. For example, the growing awareness that coastal ecosystems differ from lakes in the response to increased and decreased nutrient loading is important here (Cloern 2001). Steps 1-2 are also related to ecological components of both the MSFD and WFD. Here, biological indicators are used to assess the ecological status, and near-pristine conditions and targets corresponding to "good ecological/environmental status" (GES) have to be defined (e.g. Van Hoey et al. 2010). However, other ecological indicators, more closely related to the provision of ecosystem services, may also be needed for the CBA process, like the use of ecological endpoints as links between ecological models and ecosystem services (SAB 2009).

The definition of the reference scenario (step 3) typically needs ecological data for describing the situation today and forecasting how it will develop in the future. For coastal ecosystems this usually includes empirical information for describing the physical setting and pressures (e.g. salinity, water exchange, freshwater inflows and precipitation) and for describing the ecological state and its dynamics (e.g. nutrient and oxygen concentrations and phytoplankton biomass). In step 4, ecological expertise is important for advising on projects to be considered, to secure that they are relevant for meeting ecological standards and can achieve the goal formulated in step 2. For example, in the case of nutrient loading the response time may differ considerably between measures related to land use, where changes are slow, and measures affecting point sources in the coastal zone, where quick effects can be expected. Ecological expertise is also needed for identifying and compiling consequences of the project on the provision of ecosystem services (steps 5 and 6) in comparison to the reference scenario. Compiling consequences for the provision of ecosystem services could involve e.g. forecasting direct and/or indirect responses of ecosystems requiring ecological modeling. An example on the Baltic Sea scale is the ecological model used to propose targets for nutrient reductions and to indicate their likely ecological effects in different sea basins (Wulff et al.

2007). The compilation step should therefore be based on a systems approach integrating economic and ecological systems for determining the total and net effects of the project on ecosystem services.

As to stakeholder involvement, this is in steps 1-2 likely to increase the likelihood of a relevant formulation of the problem and the goal to achieve. Moving to step 4, it is important that concerned stakeholders accept or propose the identification and description of the project to be analyzed for facilitating the realization of a project potentially profitable to society. This step, and also steps 5-6 provide an opportunity for integrating stakeholders' local knowledge of the social-ecological system into the CBA (cf. Olsson and Folke 2002). A particular challenge is to communicate environmental consequences to stakeholders because of the often complex way in which nature responds to change, and to reach agreement on the likely consequences. Altogether a balanced involvement of local stakeholders can facilitate a formulation of the CBA relevant for both current legislation and policy demands, and including local ecological, social and economic characteristics.

Several of the initial six steps require stakeholders, ecologists and cost-benefit analysts to jointly formulate crucial problem, goal and projects (see also Fig. 1). Any step involving input from both stakeholders and ecologists requires consent on the input to the analysis. As to the remaining steps (7-10), they are mainly a task for the cost-benefit analysts although results should be communicated to stakeholders for securing an understanding and maybe even an acceptance for the analysis and its outcome. The distributional analysis (step 8) is likely to be of particular interest to the stakeholders and of help for identifying obstacles or possibilities for project implementation.

3. The case study setting

The CBA framework application described in this paper was a part of two research projects carried out in 2007-2011 and involving a multidisciplinary team of ecologists and social scientists including environmental economists as the cost-benefit analysts.[1] In the following the conditions for the application are explained covering study area, stakeholder group and organization of work.

[1] The research projects were Science and Policy Integration for Coastal System Assessment (SPICOSA, funded by EC-FP6) and Economic Assessment for the Environment (PlusMinus, funded by the Swedish Environmental Protection Agency).

The study area

The Himmerfjärden area is an elongated system of bays, of which Himmerfjärden is the largest, situated some 40 km SW of Stockholm, Sweden (Fig. 2). The local catchment of 536 km^2 (Fig. 2) is comprised of forests (57%), agricultural land (33%), urban areas (5%) and lakes (4%), and stands for ca. 32% of the fresh water inputs. Of the large total runoff from Lake Mälaren the small part diverted to Himmerfjärden stands for 49% of the freshwater inputs, 10% is from rain and 9% comes from the Himmerfjärden Sewage Treatment Plant (henceforth HSTP). The coastal areas of the brackish Baltic Sea have experienced eutrophication problems since the 19^{th} century, with more severe problems from the mid-twentieth century. In 1974, the HSTP was located in the area (Elmgren and Larsson 2001). It now serves 300 000 persons and is the third largest STP in the Stockholm region. Other nutrient sources are primarily agriculture, households with private sewers, and Lake Mälaren (Elmgren and Larsson 1997). The continuously increasing population of the Stockholm area creates a steady demand for more permanent homes, recreational housing, sewage treatment and water-related recreational activities in the surrounding area. Management of nutrients in Sweden is primarily regulated by the WFD, which requires the Himmerfjärden area to achieve GES by 2021 (Miljökvalitetsnormer 2009) and the Urban Waste-water Treatment Directive (UWTD) (European Parliament 1991).

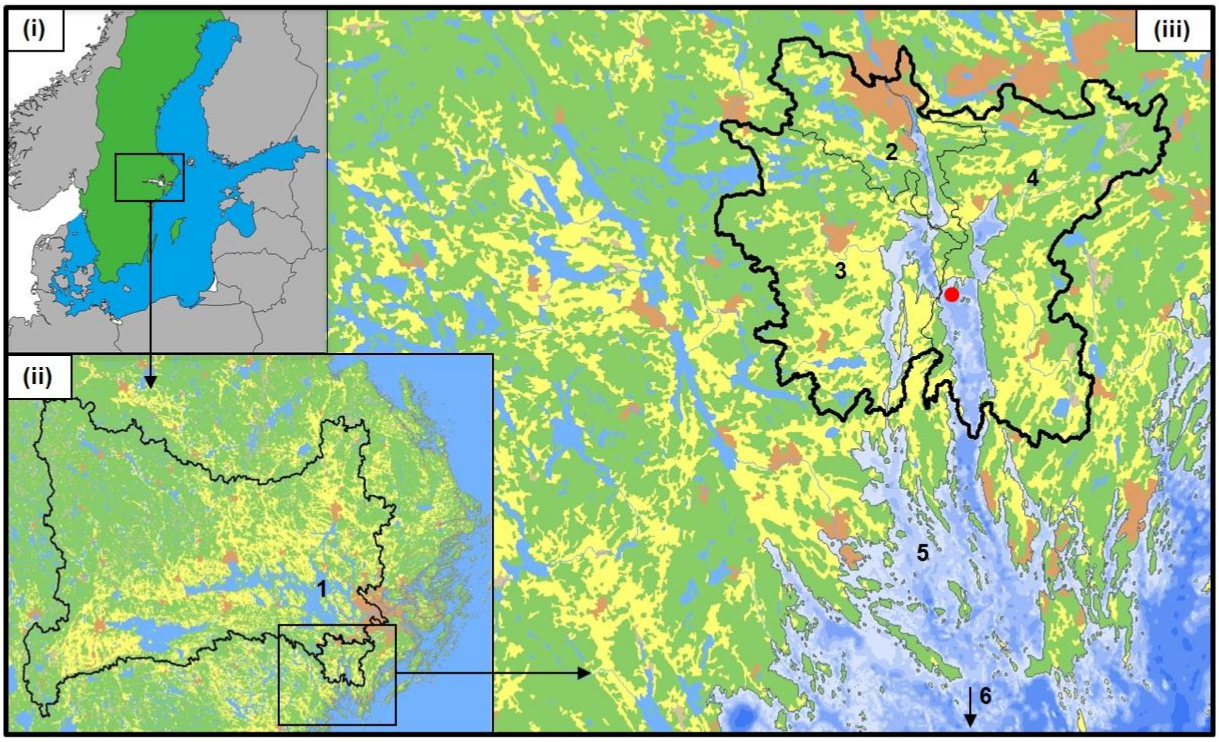

Figure 2. Location of the study site: (i) Sweden, located in the Baltic Sea; (ii) the Swedish Northern Baltic Sea River Basin District, including Lake Mälaren (1); and (iii) the Himmerfjärden study site area; divided in the model areas “Hallsfjärden” (2), “Näslandsfjärden” (3), and “Himmerfjärden proper” (4). Via "Svärdsfjärden” (5) the study site area is connected to the open Baltic Sea (6). The red circle in “Himmerfjärden proper” is the discharge point of the Himmerfjärden sewage treatment plant. The colors in the study site map indicates; blue = water (dark is deeper for marine areas), green = forest, yellow = arable land, orange = urban area (Franzén et al. 2011). © Lantmäteriet, permission I 2011/0094

Stakeholder involvement in Himmerfjärden

Stakeholder involvement in management of Himmerfjärden started with the local nature conservation society in 1974, and eutrophication research in the area since 1975 has involved recurrent contacts with local stakeholders. Institutional and stakeholder mapping of the Himmerfjärden area provided a send list for inviting potentially interested stakeholders to an initial stakeholder meeting in November 2007, co-organized with the regional Water Authority and the Stockholm County Administrative Board. At the meeting a local stakeholder group was successfully recruited, for active involvement in the research process, including a CBA for the Himmerfjärden study area. The twelve participants represented a range of local and regional stakeholders, listed in table 1. All municipalities in the area were represented, which was desirable because municipalities in Sweden are responsible for land-use planning. Many of the stakeholders also contribute to the eutrophication problems in the area through discharges of nutrients. No strong conflicts or particularly strong standpoints were noted among the stakeholders during the initial recruitment. The stakeholder group met seven times in four years (2007-2010), and at least once a year. See Franzén et al. (2011) for details on stakeholder involvement in Himmerfjärden.

Table 1. Members of the stakeholder group in the Himmerfjärden study area (Franzén et al. 2011).

Representing	Position	Comment
Stockholm County Administrative Board	Official (Environmental analyst)	Changed representative 2008
Södertälje Municipality	Official (Ecologist)	2 representatives; 1 after the 3rd meeting
Botkyrka Municipality	Official (Environmental analyst)	2 representatives
Nynäshamn Municipality	Official (Environmental investigator)	Dropped out 2008 due to reorganization of the municipality
Himmerfjärden sewage treatment plant	Process manager	
Astra Zeneca sewage treatment plant	Process engineer	2 representatives
Land-owner	Owner of Mörkö Manor	Also farmer
The Swedish Farmers Union	Representative of local chapter	Dropped out 2009 due to lack of time
Himmerfjärden Nature Conservation Society	Chairman of the Society	

Organization of work

A crucial task for the researchers was to build an integrated quantitative model facilitating both stakeholder involvement and assessment of management options selected together with the stakeholders. A simulation model rather than an optimization model was judged to be the most suitable choice. The ecologists focused on developing conceptual ecological models, modelling the ecological system of the study area, linking the quantitative ecological model to the corresponding economic model and supporting the analysis during the stakeholder group meetings. The social scientists first worked on a socioeconomic conceptual model that was later developed into the quantitative model described below.

4. Applying the framework

In the following we describe how the framework presented in section 2 was applied to the case of Himmerfjärden by going through each of the CBA steps of Fig. 1, resulting in a complete CBA. A specific focus is on describing the implications for the CBA of the input from ecologists and stakeholders. These implications are later discussed in section 5.

Step 1: Formulation of problem

A dialogue with the stakeholder group about problems of the marine environment in the study area indicated their concern for low water quality, loss of marine biodiversity, algal blooms and negative effects on ecosystem services due to nutrient loadings. The stakeholders agreed that eutrophication was the most urgent environmental problem in the area. Ecologists in the research team confirmed eutrophication to be a major issue in the study area and also helped limiting the scope of the analysis by modifying the focus to nitrogen management. Phosphorus loads in Himmerfjärden are dominated by import from the open sea, and hence can be little influenced by management measures in the study area.

The formulation of the problem also required examination of its causes. The ecologists supported the description of the physical conditions and causes of the problem. Eutrophication is due to mainly heavy loadings of nitrogen in the study area. This is a problem common to many coastal areas of the Baltic Sea proper, where large, mainly anthropogenic, nitrogen loadings may cause local phosphorus limitation in some areas. The stakeholder group considered the HSTP to be the single most important source of nitrogen, which was confirmed by the ecologists. To also include agriculture and private sewers in the study area as sources of nitrogen were particularly requested by some stakeholder representatives. Although agriculture and private sewers have much less effects on the overall coastal ecological system in the study area, they may have impact on a more local level, including lakes and streams in the watershed. Including these nitrogen sources also have distributional implications for managing nitrogen loadings in the area.

Step 2: Formulation of goal to achieve

The goal chosen for the CBA was formulated as improving water quality in the study area by undertaking relevant management measures. Both the stakeholder group and the ecologists viewed this goal as desirable. This goal corresponds well to the WFD and the MSFD where water quality aspects such as water transparency are indicators for assessing GES (Commission decision 2010/477/EU and European Parliament 2000). Hence, the goal formulated for the study area also has policy relevance.

Step 3: Reference scenario

"Business as usual" was recommended by the ecologists as the reference scenario. This requires the HSTP to satisfy the basic UWTD requirements of an effluent nitrogen concentration below 10 mg/l. Local small-scale projects in both agriculture and private sewers are going on in the study area. For agriculture, business as usual assumes no new specific measures, such as additional wetland creation. The approximate number of private sewers of various constructions in each of the three drainage areas of the study area are 1050 (Himmerfjärden, model area 4 in Fig. 2), 2600 (Näslandsfjärden, model area 3 in Fig. 2) and 660 (Hallsfjärden, model area 2 in Fig. 2), i.e. 4310 in total (J. Holmström, personal communication, 4 December 2008 and S. Jonsson, personal communication, 2 December 2008). The reference scenario assumes no change in number or technology of private sewers. See table 2 for a summary of the reference scenario.

In terms of eutrophication effects, the ecological model predicts a mean summer Secchi depth of 3.1 m in Himmerfjärden for the reference scenario. This means that the study area has poor ecological status according to the WFD status classification (SEPA, 2007).

Step 4: Identification and description of project

Several management options to improve local water status by reducing loadings from each of the three local sources of nitrogen were proposed by stakeholders and ecologists. The HSTP representative helped in selecting possible options for the HSTP, mainly involving different levels of effluent nitrogen concentration. Two options for the HSTP also included moving the present discharge point from below to above the summer thermocline, which would reduce transport of released nitrogen northwards in the receiving area. The local nature conservation society has long wanted to examine moving the HSTP outlet to the open sea 25 km south of Himmerfjärden, an option previously dismissed as unrealistic due to high costs. New requirements caused by WFD implementation may change this, and including this management option allowed simulating Himmerfjärden as a coastal area without the impact of a large STP. Different management options for agriculture such as catch crop cultivation and wetland creation were proposed by the stakeholder group. Stakeholders also requested management options for private sewers, for which a main option is to connect them to existing STPs with higher nitrogen removal.

The options were limited to measures that decrease the main nitrogen sources in the study area, i.e. HSTP, agriculture and private sewers. That is, the effects of measures taken elsewhere, e.g. in the Lake Mälaren catchment, were assumed to be fixed at today's level. The management options identified for the main sources of nitrogen in Himmerfjärden are summarized in table 2.

Table 2. Management options for Himmerfjärden study area. Reference scenario in italics and main scenario in bold. Pipeline scenario corresponds to the main scenario but with the pipeline option for the HSTP.

Sources of nitrogen and management options		
Management options for HSTP (effluent nitrogen concentration and point of outfall)	**Management options for agriculture (wetland creation or catch crop creation)**	**Management options for private sewers (share of private sewers connected to an STP)**
▪ *10 mg/l and no change in point of outfall* ▪ **4 mg/l and no change in point of outfall** ▪ 4 mg/l + move point of outfall upwards ▪ 10 mg/l + move point of outfall upwards ▪ 4 mg/l + move point of outfall to the open Baltic Sea by building a pipeline	▪ *No additional measures* ▪ **Wetlands (25 hectares)** ▪ Catch crops – large area sown ▪ Catch crops – small area sown	▪ *No additional measures* ▪ **25 % connected to STP** ▪ 50 % connected to STP ▪ 100 % connected to STP

Different combinations of management options (henceforth referred to as scenarios), were discussed and agreed on in discussions with the stakeholder group and the ecologists. Of the many combinations discussed, the one chosen as the main scenario for the analysis is indicated with text in bold for each source of nitrogen in table 2. The main scenario entails management options for all sources of nitrogen, with measures distributed over the study area. The main scenario has maximized nitrogen reduction effort in the HSTP. For agriculture creation of 25 hectares wetland was chosen, a measure that is particularly interesting for the Näslandsfjärden drainage area, where the most intense agriculture is found (model area 3 in Fig. 2). Parts of this area were also pointed out as of high interest for wetland creation by the Stockholm County Administrative Board, and an information project about wetland creation was established in the area during 2009 and 2010 (Stockholm County Administrative Board 2009). For private sewers the main scenario assumes that 25% (or approximately 1100) of the private sewers in the study area are connected to an STP. This might seem like a small share but is in effect ambitious considering the current situation of the private sewer systems in the area, all of them not yet mapped or known. The exact location is important when choosing management options for private sewers, since it has a considerable impact on the costs of connection to an STP. Connecting a private sewer situated far from an STP is probably not feasible due to very high cost. Improved private sewage treatment might therefore be a better option in many cases. However, both stakeholders and ecologists agreed that the main scenario was still the most likely one for implementation, and therefore the analysis did not include private sewage treatment options. To broaden the analysis the so called "pipeline" scenario was also assessed. This is equivalent to the main scenario, plus moving the outlet of the HSTP to the open Baltic Sea. Thus, the main scenario and the pipeline scenario were the projects chosen for the analysis and the major output from step 4.

Step 5: Identification of consequences of the project

A systems approach was followed for illustrating, discussing and assessing scenarios for nitrogen management. The main instrument for accomplishing this and to facilitate communication with stakeholders was an integrated quantitative coastal zone simulation model including ecological and economic dimensions. Its construction was based on a conceptual model, developed through discussions with the stakeholder group (steps 1-4).

Setting up the conceptual model involved identification and compilation of consequences of the scenarios relative to the reference scenario (corresponding to steps 5 and 6 in Fig. 1). This step required a broad scope when identifying consequences and explaining the likely causal relationships through conceptual sub-models of ecological as well as economic systems. Identification of ecological consequences of the selected management options was supported by ecologists and stakeholders. Positive effects of improved water quality on ecosystem goods and services were recognised, with e.g. increased biodiversity and less intense algal blooms as indicators. Possible economic effects of this were increased demand for recreation (including recreational fishing, sunbathing and boating), increased number of visitors and increased real estate prices. Stakeholders also brought up distributional issues such as the high costs for reducing nitrogen emissions from private sewers and farmland.

Step 6: Compilation of consequences of project

The ecological modeling entailed evaluating likely consequences for the marine ecosystem of the management options, using quantitative indicators such as Secchi depth (water transparency) and chlorophyll *a* concentration. These ecological indicators summarize several ecological attributes and facilitated communication of the ecological consequences of a scenario to the stakeholder group. The ecological water quality indicators could also be linked to the analyses of the economic consequences, which mainly have a non-market character. However, improved water quality can also be expected to increase the demand for water-related recreational activities and recreational housing in the study area which might affect the local economy if e.g. the number of visitors to the area increases. It would also require investments in sewage treatment. Compilation of the consequences suggested a refinement of the conceptual model to that in Fig. 3. The main economic and ecological consequences perceived by the stakeholders within the borders of the study area are included in this model. As shown by Fig. 3, this conceptual model consists of a block of management options for the sources of nitrogen, ecological and economic components, where Secchi depth is the crucial link, for assessing identified consequences of the chosen scenarios and a final block summarizing outputs.

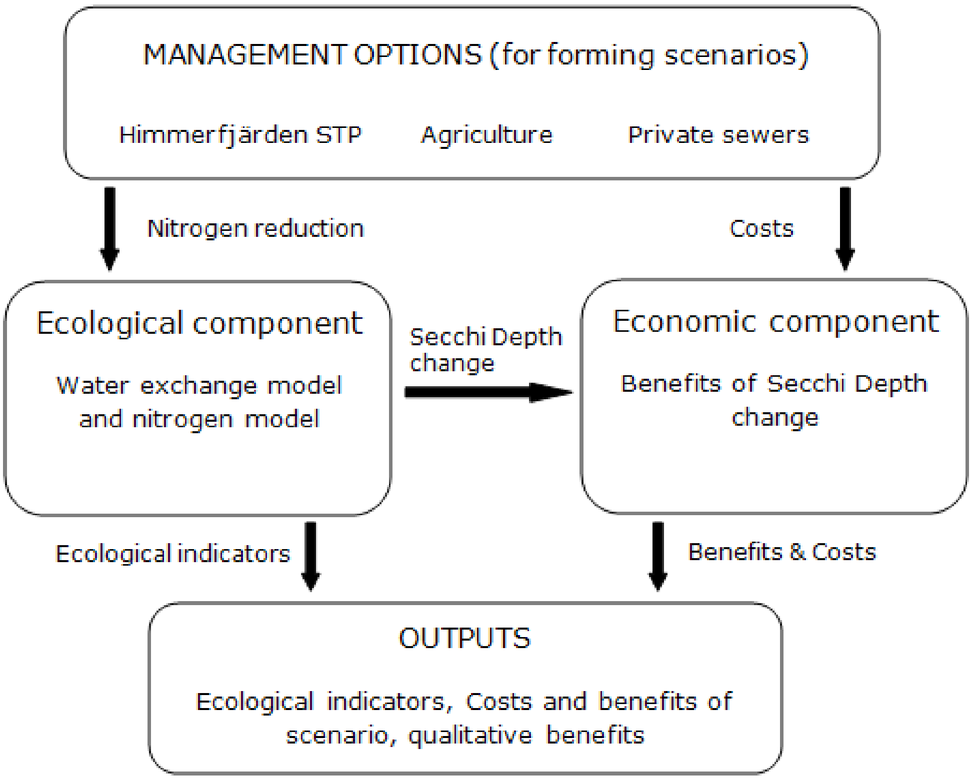

Figure 3. A conceptual model of Himmerfjärden study area.

Step 7: Calculations of benefits and costs

Expressing the identified consequences in monetary terms required several sub-steps, including setting up a quantitative simulation model based on the conceptual model in Fig. 3.

A complex ecological model (describing growth rate of phytoplankton and cyanobacteria, sedimentation, grazing losses, and sediment nutrient remineralisation) was condensed to a nitrogen loading-nitrogen concentration-Secchi depth model based on water exchange and an empirical relationship between nitrogen concentration and Secchi depth. Secchi depth is an indicator of water quality that typically affects people's well-being and recreational demand (Egan et al. 2009, Frykblom et al. 2005, Moore et al. 2011). Its summer average therefore serves as a link to the economic component. The ecological model produced results in reasonable agreement with field measurements for the reference scenario and had the advantage of being easily understood and communicated to stakeholders, see Franzén et al. (2011) for details. The economic component involved estimating the benefits of a Secchi depth improvement and the costs of the chosen scenarios, as detailed in the next two subsections.

Benefits of an improved Secchi depth in Himmerfjärden

We estimated benefits from the results of a stated preference study by Östberg et al. (2011). They applied a choice experiment for valuing several environmental attributes of Himmerfjärden, including one water quality attribute based on the WFD ecological status classification, which is correlated with Secchi depth. Data were collected from a web-panel consisting of randomly selected adults (18 years or older) from two different populations: (1) 102 000 residents in parishes bordering to Himmerfjärden ("locals") and (2) 828 000 residents in areas within 30 km of Himmerfjärden but not "locals" (i.e. "non-locals") (Statistics Sweden 2010). The average response rate was 31 per cent. To minimize problems that occur in stated preference studies due to the hypothetical situation (e.g. over or under estimation of willingness to pay, henceforth WTP), a commonly recognised method (cheap-talk script) were used (Östberg et al. 2011).

The mean monthly WTP for a one-class and a two-class water quality improvement was estimated for locals to about 390 and 490 SEK per household, respectively.[2] The payment

[2] These WTP estimates are based on a model using socioeconomic variables for which publicly available data exist: gender, income, age, university education, place of birth in Sweden or abroad. Östberg et al. (2011) also used a model with an extensive set of variables collected in the survey (including e.g. socioeconomic variables, experience of the current environmental problem, and connections to the area) and found that the mean WTP estimates from the two models were not statistically different.

vehicle used was a monthly fee to be paid for 20 years to a government fund established for achieving these environmental improvements.

The water quality descriptions used by Östberg et al. (2011) indicate that a one-class improvement involves a Secchi depth increase of about 2 meters. Assuming a linear relationship between Secchi depth increase and the WTP for a one-class improvement give a mean monthly WTP per decimeter increased Secchi depth amounting to 390/20≈20 SEK per household. The corresponding WTP based on a two-class improvement is 490/40≈12 SEK since the Secchi depth increase would be about 4 meters in this case. The lower WTP per unit improvement for a larger total improvement, i.e. a diminishing marginal utility of Secchi depth improvement, is a plausible finding. Because the Secchi depth increase caused by the selected management options does not exceed 2 meters, we use the 20 SEK per decimeter estimate. This estimate corresponds to 20/1.95 or about 10 SEK per person and month, where 1.95 is the average number of adults in Swedish households (Statistics Sweden 2011). This means that total WTP per month (TWTP) for a Secchi depth improvement can be computed as follows:

$$TWTP = (\text{SecchiDepthChange in dm})*WTP_{\text{Respondents}}*(p_{\text{Respondents}}*N) + (\text{SecchiDepthChange in dm})*WTP_{\text{Non-respondents}}*(p_{\text{Non-respondents}}*N), \qquad \text{(Equation 1)}$$

where WTP denotes mean monthly willingness to pay per person, p refer to the proportion of respondents and non-respondents respectively and N is the population size.

We then computed a total WTP for the locals. This is a conservative approach minimizing the risk of scope bias, based on a hypothesis that non-locals might be considerably more inclined to have taken also other coastal areas than Himmerfjärden into account when responding to the survey. Also our treatment of non-respondents is conservative: their WTP is assumed to be zero. This means that the present value of total WTP summed over 20 years is calculated according to equation 2.

$$\text{Summed present value of } TWTP_{\text{Locals}} \text{ over 20 years} = (\text{SecchiDepthChange in dm})* WTP_{\text{Locals\_Respondents}}*(p_{\text{Respondents}}*N_{\text{Locals}}) *12*13.59, \qquad \text{(Equation 2)}$$

where 12 is conversion from month to year and 13.59 is the summed present value factor for a social discount rate of 4 % over 20 years.[3]

For a 1-meter Secchi depth improvement, Eq. 2 estimates total benefits to 516 MSEK. Based on the local sample, this corresponds to a mean annual WTP of 372 SEK per person for the local population. This is slightly higher (18 %) than the default monetary value for any 1-metre Secchi depth improvement in Swedish coastal waters suggested in SEPA (2010), based on four earlier non-market valuation studies carried out in the Stockholm archipelago.

Costs of scenarios

Table 3 gives an overview of scenarios and associated management options and their costs. Costs for HSTP measures are given as additional costs relative to the reference scenario. Consistent with Eq. 2, summed present values of costs are computed based on a social discount rate of 4%. For the main scenario the costs of the management option for HSTP is calculated as the operating costs over 20 years. The connection costs for 1 100 private sewers and the construction costs for 25 hectares of wetlands are assumed to be financed by loan and the cost is calculated as an evenly distributed annual installment over 20 years and an annual interest rate on the loan of 6.5 % (Greppa Näringen 2003, Hasselström 2007, SIKA 2009 and P. Stålnacke, personal communication, 30 October 2008). In addition, an operating cost is calculated for the wetlands over 20 years. Costs for connecting private sewers to a larger STP include an annual operating cost and a yearly saving because of avoided maintenance and operating costs for the replaced sewer construction (Hasselström 2007). Operating costs minus savings are calculated for 20 years and added to the investment cost. The cost calculation for the “pipeline” scenario has the same operating costs as the main scenario and an additional cost for building the pipeline. The pipeline is also assumed to be financed by loan and calculated like the loans above (J. Bosander, personal communication, 13 August 2008). The time horizon for all measures is the same as that for benefits, i.e. 20 years. However, an actual technical life span of measures exceeding 20 years is more probable than a shorter one, especially for constructions for connecting private sewers to an STP and the pipeline construction.

[3] A social discount rate of 4% is recommended by Swedish authorities, see SEPA (2003) and SIKA (2009).

Table 3. Three scenarios (including the reference scenario), management options within each scenario, costs and costs calculations for each management option (Greppa Näringen 2003, Hasselström 2007, P. Stålnacke personal communication, 30 October 2008, J. Bosander personal communication, 13 August 2008, J. Holmström personal communication, 4 December 2008 and S. Jonsson personal communication, 2 December 2008). * calculated to present values using a social discount rate of 4% over 20 years. ** Yearly cost of the reference scenario. *** Costs of the reference scenario are seen as given in a CBA and costs of the analyzed scenarios are calculated as the costs exceeding those of the reference scenario.

SOURCE OF NITROGEN		**REFERENCE SCENARIO**	**MAIN SCENARIO**	**"PIPELINE" SCENARIO**
HSTP, effluent nitrogen concentration		**10 mg/l**	**4 mg/l**	**4 mg/l + offshore outfall**
Costs for HSTP	Investment cost	35 MSEK	35-35** = 0	360 – 35** = 325 MSEK
	Yearly cost	5.8 MSEK (operating cost)	7.7 – 5.8** = 1.9 MSEK (extra operating cost for lower effluent nitrogen concentration)	1.9 MSEK (operating cost for lower effluent nitrogen concentration)
	Summed cost*	-***	25.8 MSEK	405.7 MSEK + 25.8 MSEK = 431.5 MSEK
Agriculture		**No additional measures**	**Wetland creation (25 hectares)**	
Costs for Agriculture	Investment cost	-	160 000 SEK per hectare	
	Yearly cost	-	1 100 SEK per hectare (operating cost)	
	Summed cost*	-	5 MSEK + 0.4 MSEK= 5.4 MSEK	
Private sewers connected to STP		**0 % (no additional measures)**	**25 % (1 100 private sewers)**	
Cost for private sewers	Investment cost	-	85 000 SEK per household	
	Yearly cost	-	2400 SEK (operating cost) – 3400 SEK (yearly savings due to new investment)= -1 000 SEK per household	
	Summed cost*	-	116.7 MSEK – 14.9 MSEK = 101.8 MSEK	

Comparing costs and benefits

The principal results of the cost-benefit analyses of the main scenario and the pipeline scenario are given in table 4, which corresponds to the output box in the conceptual model in Fig. 3. Recall from step 3 that the mean summer Secchi depth for the reference scenario is 3.1 m. The simulation model predicts the main and "pipeline" scenarios to result in Secchi depths of 3.7 and 4.1 meters, respectively. Despite the major measure undertaken in the pipeline scenario the additional increase in Secchi depth is smaller compared to the improvement associated with the main scenario. The total benefits of these Secchi depth improvements as well as the costs associated with each scenario are given in table 4. The main scenario improves the Secchi depth by 0.6 m and has a clear positive net benefit. The “pipeline” scenario improves the Secch depth by 1 meter, but its higher benefit estimate is still outweighed by the substantial cost of building a 25 km pipeline, resulting in a negative net benefit. However, the difference between benefits and costs is not substantial for the pipeline scenario when considering the long time horizons, i.e. the costs and benefits have been calculated over 20 years.

The benefits have been estimated conservatively by assuming zero WTP for non-locals and non-respondents. The costs are less likely to be underestimated since we assume a total loan financing for all investment costs. Further, in both scenarios, non-monetized benefits such as increased biodiversity are not included in the analysis. Also, there are potential positive effects such as increased demand for recreation and increased real estate values that are not included in this analysis. It is noteworthy that neither of the scenarios attains a Secchi depth consistent with GES, corresponding to about 6- 7 meters for the study area according to the WFD status classification (SEPA 2007).

Table 4. Secchi depth and its change, costs, benefits and net benefits for the studied scenarios.

	REFERENCE SCENARIO	**MAIN SCENARIO**	**“PIPELINE” SCENARIO**
Mean summer Secchi depth (m)	3.1	3.7	4.1
Secchi depth change (m)	-	0.6	1
Benefits of Secchi depth improvement	-	309 MSEK	516 MSEK
Costs of scenario	-	133 MSEK	539 MSEK
Net benefit	-	176 MSEK	-23 MSEK

Step 8: Distribution analysis

Recall from steps 5 and 6 that the benefits of improved water quality in Himmerfjärden are mainly of a non-market character. Hence, the benefits are primarily allocated to people living permanently or seasonally in the area and attributable to recreational use.

The costs for reducing the nitrogen load to Himmerfjärden are allocated to the three major sources of nitrogen in the area. In the main scenario most costs are allocated to the public (e.g. summer house owners), since the management option for private sewers is costly. The main scenario also imposes relatively large costs on the HSTP, which are likely to in the end be paid by residents in the municipalities whose sewage systems are connected to the HSTP. In the pipeline scenario the extra costs for the HSTP are substantial. Although the costs for wetland creation are relatively small, they can still be large for an individual farmer.

From this analysis we conclude that farmers and owners of houses with private sewers belong to the group benefiting from both scenarios to the extent that they use Himmerfjärden for recreation, but they will also carry a relatively large share of the costs for the scenarios.

Step 9: Sensitivity analysis

Table 5. Costs and benefits of the main and pipeline scenario respectively calculated with discount rates of 2, 4, and 6 percent.

Discount rate	Benefits Main scenario (MSEK)	Costs Main scenario (MSEK)	*Net benefit Main scenario (MSEK)*	Benefits Pipeline scenario (MSEK)	Costs Pipeline scenario (MSEK)	*Net benefit Pipeline scenario (MSEK)*
2 %	372	154	**218**	620	621	**- 1**
4 %	309	133	**176**	516	539	**- 23**
6 %	261	117	**144**	435	473	**- 38**

Calculating costs and benefits using different discount rates is one way of testing the robustness of the main results from table 4, see table 5 for results. Recall that a discount rate of 4 % was used for the calculation in table 3 and 4. Table 5 shows that the main scenario has a positive net benefit regardless of whether the discount rate is lower (2 %) or higher (6 %). The net benefit of the main scenario is however sensitive for a changed discount rate and rises (falls) with a lower (higher) discount rate. The pipeline scenario shows a negative net benefit for all three discount rates. However, when using a discount rate of 2 % the pipeline scenario is close to break-even.

Another parameter affecting the calculation of both benefits and costs is the time horizon. Benefits usually occur in the long run, whereas costs are immediate. This also depends on the calculations of costs and benefits, in table 3 costs are assumed to be financed by loans. Further, the costs are calculated as annual installments evenly distributed over 20 years which means that the costs and benefits occur simultaneously in the current analysis.

Step 10: Is the project beneficial to society?

Table 4 shows that the main scenario has a positive net benefit when calculated over 20 years with a 4 per cent discount rate. However, from step 8 it is also clear that this may not be true for those individuals who would pay for wetlands creation or for connecting a private sewer to an STP. Finally, step 9 implies that the results are sensitive to changes in the discount rate. However, that the main scenario entails a positive net benefit is a stable result. This is also true for the negative net benefits of the pipeline scenario. However, it has to be kept in mind that benefits were computed conservatively.

5. Concluding discussion

Participation by stakeholders and ecologists are essential components of the proposed framework in Fig. 1. Our case study indicated that such participation can provide essential input for CBA. Ecologists strengthen the analysis by, for example, making the scope operational, describing the reference scenario and, not the least, in developing the model. Stakeholders contributed constructively with local knowledge and by suggesting relevant management options. By transforming a complex ecological sub-model to a less detailed version ecologists made integration with the economic sub-model possible. The development of the integrated model supported understanding of environmental problems by making the complex system comprehensible. Hence, the model provided an important tool for communicating with the stakeholders. Active involvement of local stakeholder in turn resulted in additional value to the CBA developed for Himmerfjärden study area. This added value depended primarily on the stakeholders' acknowledgement of the process as such and their ability to agree on central issues in early stages of the process.

The stakeholders provided important input by suggesting inclusion of agriculture and private sewers as sources of nitrogen. They also identified additional management options such as moving the HSTP outfall outside Himmerfjärden, an option that added a valuable perspective to the study. The disconcerting result that even radical local measures may be insufficient for reaching GES in Himmerfjärden in accordance with WFD requirements could indicate that the definition of GES is too strict with respect to Secchi depth in the case of Himmerfjärden, but it also underlines the need for measures causing a general improvement in the water quality of Lake Mälaren and the open Baltic Sea. Presenting results from the final simulation to the stakeholder group brought up questions on technical issues but did not result in specific objections.

Participation by stakeholders in a CBA process provides both opportunities and challenges. For example, Human and Davies (2010) argue that involving stakeholders in early phases of management programmes or prioritization of research questions, could imply problems caused by stakeholders' lack of knowledge about complex ecosystems, or poor collaboration and consistency between stakeholders. The existence of e.g. clash of interests, underlying conflicts or difficulties of finding a common language could also result in severe difficulties for the suggested CBA framework. However, the lack of strong underlying conflicts in the stakeholder group and only small disparity of recognition of the important issues probably explains the constructive stakeholder involvement in this application. Contradictory opinions and explicit dissention among the stakeholder groups decreased during the process, suggesting that it fostered consensus-building among in stakeholder group. Whether this is a strength or a weakness of the process can be debated, since it could either support or prevent implementation of a project with potential net benefits.

Our study showed that stakeholder involvement in CBA can be rewarding. We believe that the usefulness of a CBA is increased if the focus and process of the CBA is relevant to and accepted by both stakeholders and ecologists. Following the ten steps in Fig. 1 seems to be a way to create such relevance and acceptance. The general agreement between stakeholder groups and ecologists on fundamental issues, such as formulation of the problem, probably facilitated the successful CBA process for Himmerfjärden. The long history of stakeholder consultation in the area may also have helped. It is also important to note that a process like the one proposed in this paper is influenced by culture and tradition, and that consensus-building historically has been typical for Swedish decision-making (Lewin 1998). The consensus in the present stakeholder group might also be explained by the inclusion of management options for reducing all major local nitrogen sources mentioned by the stakeholders in the simulation model. Finally all stakeholders groups shared a concern for the marine environment and were aware of current regulatory demands in the area. Thus, the main scenario evaluated in the present CBA might imply good conditions for implementation in practice in the study area. However, considering the fact that the main scenario does not reach GES in Himmerfjärden in accordance with WFD requirements could indicate that other and more substantial management options are needed.

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