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Supporting collaborative policy processes with a multi-criteria discussion of costs and benefits: The case of soil subsidence in Dutch peatlands

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ABSTRACT

Collaborative policy processes are increasingly advocated to resolve management problems of social-ecological systems. To elucidate which approaches work in diverse situations, this paper demonstrates the added value of Cost-Benefit Analysis in combination with a deliberative tool as a support system a collaborative policy process in Dutch peatlands. We used quantitative models to assess the spatial and temporal physical effects of three water management strategies steering soil subsidence and land use. The stakeholders involved in the case study provided empirical economic data to link the physical effects to the ensuing economic effects, which we distributed among the stakeholder groups affected. The case study aimed for an intersubjective assessment of strategies for water management and land use planning. We therefore enhanced the discursive features of Cost-Benefit Analysis, focusing on knowledge exchange and the evaluation of equitable tradeoffs. The stakeholders participating in our case study appreciated the approach´s comprehensive assessments, and the ensuing multi-criteria discussion of the costs and benefits. We believe this result can be attributed to (a) the clear, participatory design of the CBA process, (b) a comprehensive presentation of the constituent elements of the CBA result, and (c) the abundant opportunities to deliberate the results. We discuss how our approach can increase stakeholders' capacity to understand the complexities of social-ecological systems and their ability to explore the potentialities of these systems.

1. Introduction

The Millennium Ecosystem Assessment (2005) clearly demonstrated that most of the valuable services ecosystems provide to society are degrading or are being used unsustainably. There are no panaceas for achieving a more sustainable management of social—ecological systems, because interventions often cause nonlinear changes in a complex set of interrelated environmental, political, and economic variables across multiple spatial and temporal scales (Ostrom, 2007, 2009). In response to this complexity and unpredictability, adaptive management approaches have emerged that aim to increase the resilience of social—ecological systems through a structured and iterative learning-by-doing strategy (Den Uyl and Driessen, 2015). Early versions of adaptive management approaches tended to focus on enhancing the scientific knowledge of the ecosystem being managed. Because the knowledge generated was frequently not successfully linked to management, more iterative approaches that allowed stakeholders to collaborate were designed (Scarlett, 2013). The benefits of stakeholder collaboration are legion and can be derived from (a) normative ideas and principles, e.g., the enhancement of democratic capacity or deliberation among participants, (b) a substantive rationale to improve the quality of decisions, and (c) an instrumental underpinning to generate legitimacy or resolve conflict (Glucker et al., 2013).

Although collaborative adaptive management approaches are credited with great potential to improve the management of social—ecological systems, they prove difficult to put into practice. To improve this predicament, social learning processes are advocated, aimed at "learning together to manage together" (Pahl-Wostl et al., 2007; Monroe et al., 2013). To achieve mutual understanding, Van de Riet (2003) points out that the viewpoints of researchers and practitioners must be carefully balanced. Too much focus on researchers' views may produce only "superfluous knowledge", i.e., knowledge that is scientifically valid, but irrelevant to the management problem. On the other hand, too much focus on practitioners' views may result in "negotiated nonsense", i.e., knowledge that is supported by stakeholders but is scientifically invalid.

To reconcile the viewpoints of researchers and practitioners, the integration of analytical and deliberative tools seems to be a

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prerequisite. For instance, Goosen and Vellinga (2004) promote collaborative planning platforms that include support tools for negotiation and mediation, as well as tools for the assessment of the costs and benefits of the stakeholders involved. Holman et al. (2016) found that the integration of participatory scenario development and quantitative modeling can facilitate dialog among stakeholders and a better understanding of the impacts of management choices. Chaudhury et al. (2013) discuss how participatory scenario analysis can provide the legitimacy needed to bridge disciplinary boundaries and point out that quantification of the scenarios is needed to address the credibility and salience of the knowledge. Quantification of participatory scenarios is especially important if the goal of the process is to make concrete management decisions (Bohunovsky et al., 2011).

Given the context-dependency of most management problems of social—ecological systems, it has been suggested that instead of trying to conjure up a one-size-fits-all solution, more empirical insights from projects should be captured and disseminated, to illustrate which approaches work in diverse situations (McNie, 2007; Beratan, 2014). Therefore, this paper aims to contribute to this collective understanding by demonstrating how quantitative modeling, Cost—Benefit Analysis (CBA), and a web-based discussion tool were employed to support a collaborative policy process in Dutch peatlands. Some scholars believe that the combination of CBA and deliberative tools has high potential to support collaborative policy processes (De Jong and Geerlings, 2003; Turner, 2007; Browne and Ryan, 2011; Beria et al., 2012). Yet, case studies that demonstrate the added value of such combinations remain underexposed in the scientific literature. This paper aims to fill this knowledge gap.

2. Background

2.1. Cost-Benefit analysis as a heuristic aid

CBA has proven its worth for project planning and policy analysis for many decades, with methodological origins going as far back as the definition of benefits and costs by the French economist and engineer Jules Dupuit in the mid-19th century and the stipulation of the principle that the benefits of an investment should exceed the costs (Navrud and Pruckner, 1997). Although overall societal wellbeing is improved whenever this principle is applied, this nevertheless implies that those who bear the costs will be worse off. During the 1930 s and 1940 s the works of Kaldor and Hicks justified this benefit-costs principle by stating that societal wellbeing is improved whenever the gainers can compensate the losers, regardless of whether the compensation occurs (Pearce, 1998).

Changes in wellbeing are assessed by comparing the financial and non-financial effects of a measure with the effects of a “business as usual” scenario in which the current policy remains unchanged. Financial effects are fully captured in commercial markets and can be derived from the costs of consumed goods and services and their Net Value Added (NVA) of production, i.e., the sum of producers’ income, interest, depreciation, and paid labor. Non-financial effects are not fully captured in commercial markets and require other valuation techniques. In recent decades, the valuation techniques used in CBA have gradually improved, resulting in CBAs that encompass the financial and non-financial economic values of a wide range of ecosystem services (Costanza et al., 1997; Turner et al., 2000; Robbins and Daniels, 2012).

The broad scope and the uniform monetary evaluation make CBA potentially a suitable tool to address the complexity of social—ecological systems. However, previous CBAs have encountered a variety of process-related issues that diminish its usefulness as a support tool for collaborative processes. Turner (2007) discusses how the use of CBA as a “decision rule”, i.e., the a priori identification of the optimal cost-–benefit ratio of project alternatives, often conflicts with the iterative manner of consensus building in real-world policy processes. He suggests that a better match for these processes is the use of CBA as a “heuristic aid”, i.e., a complementary component in a decision support system that aims for an intersubjective assessment of the preferred project alternative. Furthermore, both Beukers et al. (2012) and Mouter et al. (2013) found that CBA practitioners perceived misunderstandings and inadequate communication between planners and economist as a core problem in CBA processes. This predicament appears related to opposing views among the CBA practitioners on how CBA should be used. As a result, debates tend to focus on other issues than the management problem at hand, e.g., the limitations of CBA methodology, or the value assigned to CBA in the decision-making process. In addition, if some practitioners are insufficiently aware of CBA methodology, these communication deficits may even result in mistrust, if practitioners believe their values are deliberately disregarded, and the knowledge obtained by the CBA is used strategically.

Remarkably, the CBA practitioners that perceived the processes-related issues still believed CBA should be used in the appraisal process of a project, because it provides valuable information about the usefulness, necessity and design of a project (Mouter et al., 2013). However, to maximize the impact of these advantages, the process-related issues must be dealt with. The suggested solution by some scholars is that CBA should refrain from presenting final verdicts based on decision rules but should instead be used as a method for collecting, organizing, and discussing information relevant to interactive policy making, embedding the analytic analyses in deliberative processes aimed at revealing preferences and settling arguments (De Jong and Geerlings, 2003; Robinson and Hammitt, 2011). To achieve this, many authors propose a combination of CBA and Multi-Criteria Decision Analysis (MCDA), either by complementing CBA with a MCDA of non-financial values, or by using CBA as one component of a wider MCDA (Turner, 2007; Browne and Ryan, 2011; Beria et al., 2012).

2.2. Water management and land use planning in Dutch peatlands

In the research area (Fig. 1) the predominant land uses are dairy farming and built-up areas, and there are some small marshland nature reserves. The area lies in the delta of the river Rhine; its elevation ranges from 1 m above to 2.5 m below sea level. This low elevation requires manipulation of the drainage to prevent the soil from becoming waterlogged. To achieve this, during the Middle Ages artificial catchments called polders were created, with a dense network of several thousand km of watercourses. At present the drainage base levels of the watercourses are maintained at 30–70 cm below ground. Drainage

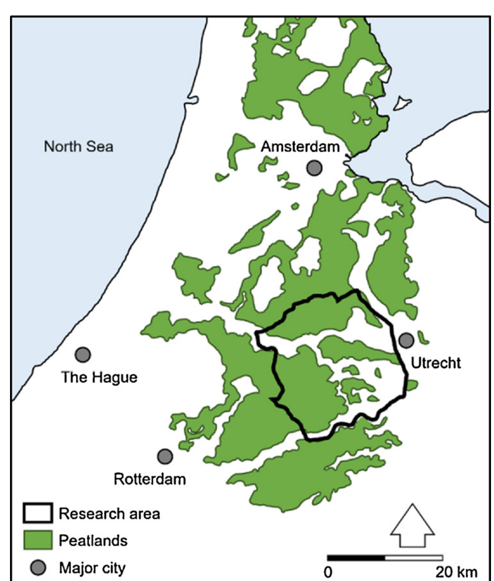

Fig. 1. Location of the research area in the western part of the Netherlands.

causes the peat soil to oxidize, shrink, and compact, which in the research area results in average soil subsidence rates of 5–10 mm.y^{-1}. To compensate for this soil subsidence, the drainage base levels must be lowered periodically, so they remain at the same depth relative to ground level. The soil subsidence results in high management costs for roads, sewers, and the waterways. Furthermore, real estate foundations are prone to damage, and the peat soils emit greenhouse gases and nutrients as they subside. All these effects can be diminished by setting higher drainage base levels, which would result in higher groundwater tables and therefore reduce the soil subsidence rates. However, the revenues of dairy farmers would fall.

For many years, the long-term objective of local governments was to raise the drainage base levels of the watercourses. This objective was fueled by a CBA performed by the national government, which claimed that raising drainage base levels would decrease the soil subsidence rates. Although profitable dairy farming would no longer be possible and large-scale transitions from dairy farming to nature restoration would be necessary, this disadvantage would be outweighed by a decrease of management costs (Van Brouwers-Haven and Lokker, 2010). However, projects aimed at a top—down implementation of the transition in land use met with resistance from agricultural stakeholders. A lock-in situation developed, which made government organizations aware that more effective stakeholder collaboration was needed to produce legitimate results and develop viable management strategies. To aid this resolve, an assemblage of stakeholders (see Appendix A) initiated a collaborative policy process to explore the effects of other strategies for water management and land use planning. To support this endeavor, they opted for a CBA as a heuristic aid, underpinned by quantitative modelling, and supplemented by a web-based discussion tool. In this paper, we use this case to demonstrate the added value of CBA in combination with a deliberative tool as a support system for collaborative policy processes.

3. Methods

3.1. Outline of research

The research approach of the current study reflects the basic outline suggested by Dutch CBA guidelines. To some extent, the CBA practice in the Netherlands reflects a symbiosis of CBA and MCDA that allows for multiple evaluative endpoints. The reason for this is a comprehensive CBA guideline issued by the Dutch government at the turn of the century (Eijgenraam et al., 2000). Unlike traditional CBA, this guideline aimed not to present final cost–benefit ratios of project alternatives, but to give an overview of societal welfare effects. Some authors even remarked that “it functions more as a scorecard method for all relevant impacts than as a CBA” (De Jong and Geerlings, 2003). In subsequent years, the guideline was proceeded with several refinements and additions (e.g. Faber and Mulder, 2012; Romijn and Renes 2013). Although each guideline is slightly different, the basic approach consists of (a) a problem analysis, (b) the definition of project alternatives, (c) the assessment of costs and benefits, and (d) a clear presentation and interpretation of the results. All guidelines stress the importance of including an uncertainty analysis and a distribution of the effects among the affected stakeholder groups. In addition, some guidelines also stress the importance of including non-monetary effects and indirect effects, i.e., the wider economic effects for producers and consumers caused by the direct effects of a project alternative.

From the Dutch CBA guidelines, we derived a CBA approach of three consecutive phases, which we embedded in the deliberative decision-making process of the case study. The first phase reflects steps (a) and (b) of the CBA guidelines. We engaged researchers and practitioners to collaboratively define water management strategies and the timeframe of the assessments. The second phase reflects step (c) of the CBA guidelines. We used an integrated modeling framework to assess the physical effects of the management strategies. Subsequently, we assessed the ensuing costs and benefits, and distributed these effects to the stakeholder groups affected. We elaborated upon the suggestions of the guidelines by further redistributing the effects of the governmental stakeholders to all tax-payers in proportion to the taxes they pay. The third phase reflects step (d) of the CBA guidelines. We discussed all results with the advisory boards of the participating governmental organizations. We elaborated upon the suggestions of the guidelines by presenting trends in annual values in addition to Net Present Values (NPVs). Complementary to this, we used a deliberative web-based tool to evaluate the added value of our approach. In addition, we discussed options for follow-up strategies at several meetings attended by a broad range of stakeholders involved in peatland management. All meetings in the third phase focused on knowledge exchange between stakeholders and governments, culminating in a reconnaissance of shared interests.

3.2. Defining management strategies

In the first phase, the initiators of the policy process organized small-scale meetings to discuss peatland dynamics and plausible management alternatives with several organizations of researchers and stakeholders (see Appendix A). In the final meeting, all participants jointly defined three water management strategies and the “business as usual” scenario (strategy 0) in which the current management is continued unchanged:

1 Current surface water levels. The drainage base levels of the watercourses are maintained at the same level relative to the ground surface, to facilitate the current land use. This means that the absolute surface water levels must be lowered periodically, to compensate for the soil subsidence. This management strategy reflects the present policy.
2 Progressively higher surface water levels. The drainage base levels of the watercourses are maintained at the same absolute level. This implies that as soil subsidence progresses, the drainage base levels rise relative to the ground surface. This management strategy was chosen because it reflects the former top—down approach to achieve a transition in land use.
3 Lower surface water levels. The drainage base levels in the watercourses are maintained at 90 cm below ground, to optimize conditions for agricultural land use. To achieve this, absolute surface water levels must be lowered periodically to compensate for the progressive soil subsidence. This management strategy was chosen because it facilitates current agricultural land use, regardless of future impacts on other interests, and is the opposite of strategy 1.
4 Current surface water levels, with field drains installed at depths below the surface water level. During wet periods the drains result in lower groundwater levels, because the water drains away faster. During dry periods, the drains supply water to the soil, resulting in higher groundwater tables. These drain-dependent groundwater tables have been reported to increase agricultural production and to retard soil subsidence (Querner et al., 2012). This management strategy was chosen as an alternative to higher drainage base levels.

We considered a timeframe from 2010 to 2100, including predicted climate change. Because predictions for climate change diverge substantially, we used an uncertainty range with a lower boundary at which no change occurs and an upper boundary according to the W^+ scenario of the Royal Netherlands Meteorological Institute, which is the most extreme regional projection of climate change for the Netherlands (Van den Hurk et al., 2006). Regarding demography and urbanization, we assumed the population and the extent of built-up areas would remain the same as in 2010.

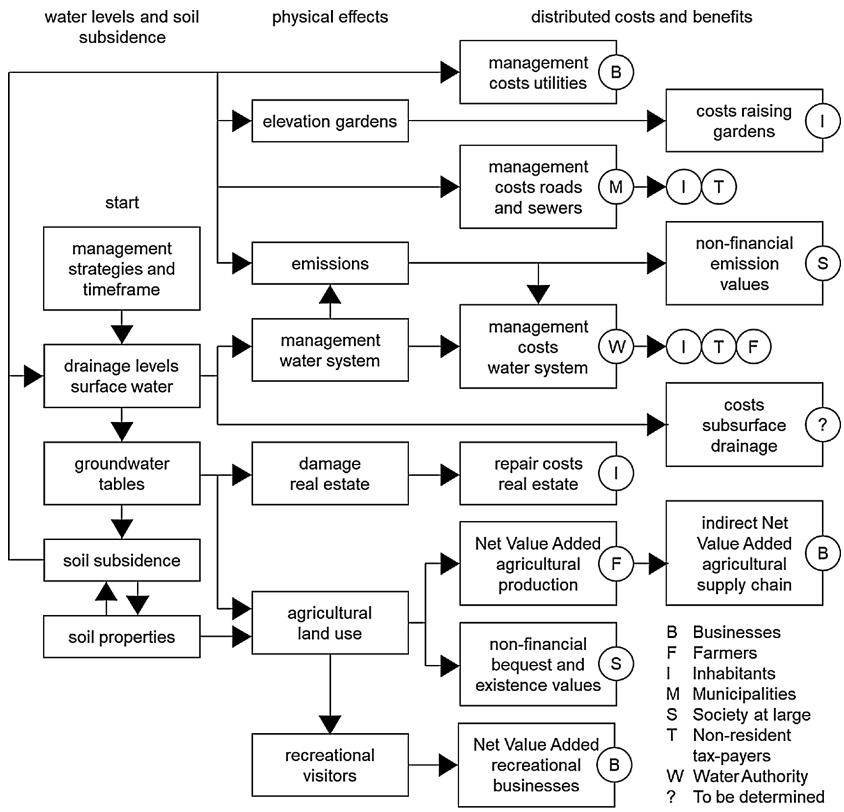

Fig. 2. Flow chart of the effects assessed in the current study. Arrows indicate the direction of the sequence. Circles indicate the stakeholders to whom the costs and benefits are distributed. The costs incurred by municipalities and the water authority are redistributed to the other stakeholders in proportion to their share of taxes.

3.3. Assessing the effects of management strategies

In the second phase, the physical effects of the water management scenarios and the ensuing costs and benefits were assessed (Fig. 2). Once again this required a joint effort, with researchers making the assessments and practitioners providing GIS input data and empirical knowledge. We used a spatially and temporally explicit modeling framework that simulates the interrelated dynamics of surface water levels, groundwater tables, and soil subsidence, as well as the ensuing effects on gardens, CO_2 emissions, the water system, real estate, agricultural land use, and recreational visitors (Van Hardeveld et al., 2017).

The modeling framework assessed soil subsidence as a function of soil composition and groundwater tables, using an empirical equation adapted from Van den Akker et al. (2008). After each time step of five years, the amount of soil subsidence (in cm) was subtracted from the thickness of the top of the peat soil. Next, the drainage base levels in the watercourses were adjusted, to restore them to the same level relative to the ground surface. The altered elevation of the soil surface and the drainage base levels were used to calculate the change in groundwater tables.

The impacts on the emissions of CO_2 were assessed by relating the calculated soil subsidence to average peat soil properties in the research area (Van den Akker et al., 2008). Additionally, using empirical knowledge obtained from the regional water authority, the emission of CO_2 from the diesel-powered pumps that drain the watercourses was estimated. The calculated surface water levels combined with empirical knowledge of the regional water authority were used to assess the impacts on the management of the water system, i.e., the weirs, embankments, fish ladders, and pumping discharge required. Using the calculated groundwater tables combined with empirical data on foundations, the real estate damage was assessed by comparing the change in groundwater table since the year a house was built with the threshold for damage resulting from a change in the groundwater table assigned to the foundation type of the house. The calculated groundwater tables and soil properties were used to estimate the decline in crop and dairy yields. Above a certain threshold of yield loss, dairy farming was assumed to be replaced by biomass crops for energy production and ultimately by marshland. Subsequently, the number of recreational visitors was derived by combining the assessed land uses with empirical data on the number of recreational visitors for these land uses.

Using the results from the integrated modeling framework and empirical financial data, we determined the investment sums and maintenance costs required for (a) gardens, (b) utility cables, (c) roads and sewers, (d) the water system, (e) field drainage, (f) real estate, (g) the NVA of agricultural production, (h) the NVA of the agricultural supply chain, and (i) the NVA of recreational businesses. Assuming an interest rate of 4% we derived the annual management costs, which equal the sum of interest, depreciation, and maintenance. If the management costs calculated for the present situation did not correspond to actual government management budgets, we adjusted the empirical cost indicators to obtain a better fit. Moreover, if the empirical indicators provided converged, we used an uncertainty range, with the resulting mean annual management costs corresponding to actual government management budgets and a range of approximately 20% between the lower and upper boundaries. In addition, we assumed price levels would remain fixed at the average for the years 2009–2012. We were unable to obtain sound regional agricultural projections because long-term developments in global agricultural markets and the Common Agricultural Policy of the European Union are too uncertain, so instead of defining an arbitrary uncertainty range for the NVA, we assumed that market conditions would remain unchanged.

The effects on the agricultural supply chain are indirect effects of the management strategies, which, according to CBA literature, can only be included if they result in additional welfare effects, for instance by reducing costs due to market imperfections (SACTRA, 1999; Eijgenraam et al., 2000; Vickerman, 2007). However, it is very difficult to assess the degree to which market imperfections occur and additional welfare is generated (Rouwendal, 2002; Hof et al., 2011). We therefore included the full scope of the indirect agricultural effects and assigned the task of delineation to the participants in the policy process. However, because it is not clear to what extent the indirect effects generate welfare, we presented them separately from the direct effects. In addition, indirect effects that clearly do not result in additional welfare effects were excluded. For instance, indirect benefits for government contractors equal the costs of government investments. Incorporating them would have meant they would have been valued twice, which is methodologically unsound and decreases the transparency of the CBA.

The non-financial values of the emission of CO_2 were derived by combining the calculated emissions with the rounded average price of CO_2 credits in the years 2009–2012. The non-financial bequest and existence values were derived with Willingness to Pay estimates. Using the guidelines for valid benefit transfer of Brouwers and Spanink (1999) and Bos (2007) we transferred the Willingness to Pay estimates obtained by a survey used for a similar policy process, i.e., an appraisal of a similar range of land use categories in the peatlands to the north of Amsterdam. In accordance with Bateman et al. (2006) we estimated the number of residents willing to pay as 47% of the residents within a radius of 10 km from the research area.

We derived the economic effects of the management strategies, i.e., the generated societal wellbeing, by comparing the assessed costs and benefits of the management strategies and the "business as usual scenario" (strategy 0). Many CBA guidelines recommend distributing the economic effects to assess the goal of social fairness (e.g. Eijgenraam et al., 2000; Romijn and Renes, 2013). This is especially relevant if the preferred management strategy is not enforceable by the central government but instead requires a collaborative effort from multiple stakeholders. We therefore heeded the recommendations of the guidelines and distributed all economic effects to the stakeholder groups affected.

Because government management costs are funded from taxes, the economic effects for the regional water authority and the municipalities were redistributed to all tax-payers in proportion to the taxes they pay: farmers (4% of the water management costs), residents (33% of the water management costs and 76% of the management costs of roads and sewers), and tax-payers who do not reside in the peatlands but elsewhere in the area administered by the regional water authority or municipalities (63% of the water management costs and 24% of the management costs of roads and sewers). Because businesses do not pay taxes for the management costs considered, they were excluded from this redistribution. Note that farmers are residents too, but were considered a separate group because they have different stakes than the non-agricultural residents and pay extra tax to the regional water authority. The costs of field drainage were not assigned to any group, because these costs are usually paid for jointly by several groups of stakeholders, in varying ratios. Because all non-financial values are virtual values that do not result in monetary transactions, these values were assigned to society in general.

Traditionally, a CBA discounts all present and future economic effects at a positive constant rate, resulting in the NPV of all present and future values combined. Costs and benefits that do not occur within a few decades therefore seem inconsequential. However, collaborative policy processes entail multiple perspectives (in the sense of time horizons). Each collaborating stakeholder will value future developments from their own perspective. Whatever discount rate is chosen, most likely there will always be another discount rate that would have better reflected the perspective of some of the stakeholders. Therefore, we not only presented NPVs, but also trends in annual values, as this allows each collaborating stakeholder to interpret the information from their own perspective.

3.4. Discussing the results

In the third phase, we presented the balance of the effects of the management strategies, along with all constituent assessments. We discussed the results on four separate occasions with advisory boards of the initiators of the policy process, in the presence of approximately 100 people who represented governmental organizations and organized interest groups (see Appendix A). Afterwards, we asked those who participated in the meeting to reflect on the results. We used a web-based tool to evaluate their agreement to statements regarding (a) the quality of the analyses, (b) the added value of the overall approach, (c) the use of annual values instead of NPVs, (d) the distribution of values, (e) the assessment of indirect economic effects for the agricultural supply chain, and (f) the added value of the economic valuation of non-financial effects. In addition, we inquired about the perceived need for a collaborative effort to implement adaptations in the follow-up phase, because this idea was frequently mentioned in the meetings. For comparison, we normalized their responses to a scale ranging from 0 to 1. We also included several open follow-up questions, to elicit the reasons for their opinions. The tool also allowed them to reflect on responses of other respondents and to discuss various opinions. From their responses we derived an overview of the most frequently mentioned reasons for positive and negative opinions about the statements.

We discussed the combined results of our assessments and the evaluation on eight separate occasions, which were attended by approximately 100 employees and board members of the participating organizations, and 40 representatives of other governmental organizations and organized interest groups involved in peatland management. At all meetings in the third phase, we deliberately did not draw specific conclusions from the CBA, but left the participants free to make their own tradeoffs between all criteria. Furthermore, we guided the discussions toward an exchange of standpoints and a reconnaissance of shared interests, instead of delivering verdicts on the management strategies.

4. Results

4.1. Effects of the management strategies

We found that the soil subsidence is highly dependent on the soil composition and the groundwater table, with limited subsidence at locations with high groundwater tables or sandy crevasse deposits but maximum subsidence exceeding 1 m at locations with low groundwater tables and peat soil (Fig. 3). The differences in soil subsidence result in pronounced physical effects. For instance, the lower surface water levels make it necessary to construct 301–304 km of additional embankment, whereas progressively higher surface water levels result in no change at all, because the drainage base levels of the watercourses remain at the same absolute level. Another striking example is the area of dairy farming that is converted to biomass crops. Progressively higher surface water levels result in a conversion of 17–76 km^2, whereas lower surface water levels result in only 1–3 km^2. On both accounts the other water management strategies result in intermediate physical effects.

The economic effects over time differ regarding the management strategies and the affected stakeholders (Fig. 4 and Table 1; see Appendix B for the non-distributed economic effects). Progressively higher water levels (strategy 1) result in a fall in revenues from dairy farming. Therefore, the economic effects for farmers (4D) and indirectly for businesses (4 F) are negative. Simultaneously, the soil subsidence is diminished, which results in positive economic effects for all other stakeholders. For inhabitants (4B) and non-resident tax-payers (4C), this welcome outcome is mainly due to a reduction in management costs for the water system, the roads, and the sewers, which constitute the lion's share of the economic effects for these stakeholder groups. Society at large (4 A) also profits, because emissions decrease, and bequest and existence values increase. The lower water levels (strategy 2) have the opposite effect: revenues for dairy farming and soil subsidence both increase, whereas species abundance decreases. For both

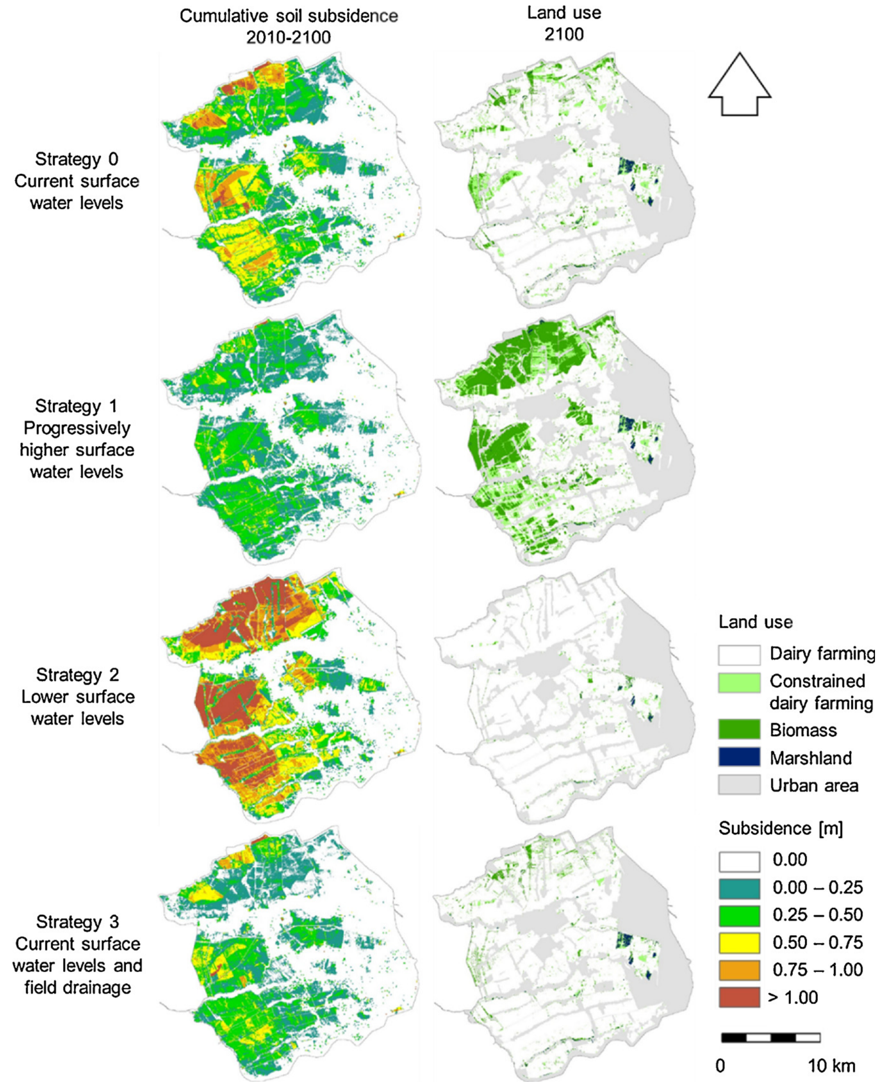

Fig. 3. Cumulative soil subsidence in 2010–2100 and agricultural land use in the research area in 2100. Note that soil subsidence only occurs at locations with peat soil. At locations where the groundwater tables have risen, the land use has changed successively from dairy farming to constrained dairy farming (i.e. more than 20% fall in crop yields), biomass crops, and, ultimately, marshland.

management strategies the direct effect for businesses (4E) is small because the average spending of recreational visitors in the area is relatively low and the predicted land use changes have a limited impact on the number of such visitors.

The effects of current water levels with field drainage (strategy 3) are more evenly distributed, with positive economic effects for all stakeholders. However, to implement this management strategy the negative economic effects of field drainage itself also need to be offset, which will diminish the overall economic effect of the affected stakeholders. It is noteworthy that although all stakeholders profit from this management strategy, only the positive indirect effects for businesses outweigh the negative effects of field drainage itself. Therefore, for most stakeholders it is not economically viable to implement this management strategy without the aid of other stakeholders.

4.2. Discussion of the results

23 attendees of the four meetings with the advisory boards (see Appendix A) evaluated the quality of the analyses, the added value of the approach and its constituent elements, and the need for collaborative adaptations. Collectively, they issued 153 responses, which we grouped into 28 statements that elucidate their opinions (Table 2). Most viewed the CBA approach and its constituent elements favorably. The mean opinion score for the quality of the analyses was 69 out of 100. They frequently praised the approach's relevant and comprehensive assessments, i.e., the simultaneous assessment of multiple effects, all of which were underpinned by quantitative modeling. Criticism mostly concerned the scope of the scenarios and various minor flaws and omissions in the assessments. In addition, they frequently mentioned the difficulty of evaluating uncertain future developments and the effects of novel adaptations. The mean score for their opinion of the added value of the overall approach was 77 out of 100. They especially appreciated the support given to the policy process. Most constituent elements of the approach were viewed favorably as well, with mean opinion scores ranging from 63 to 83 out of 100. The topic receiving the most positive response was the assessments of indirect economic effects, because this improved the comprehensiveness of the assessments. Because the main agricultural processor in the Dutch peatlands is a dairy cooperative to which many of the farmers belong, the farmers' interests are better captured by including the indirect benefits for agricultural processors in the CBA. The topic receiving the most negative response was the economic valuation of non-financial effects, with a mean opinion score of 25. The most frequently mentioned statement to elucidate the low opinion reflects the difficulty of interpreting these

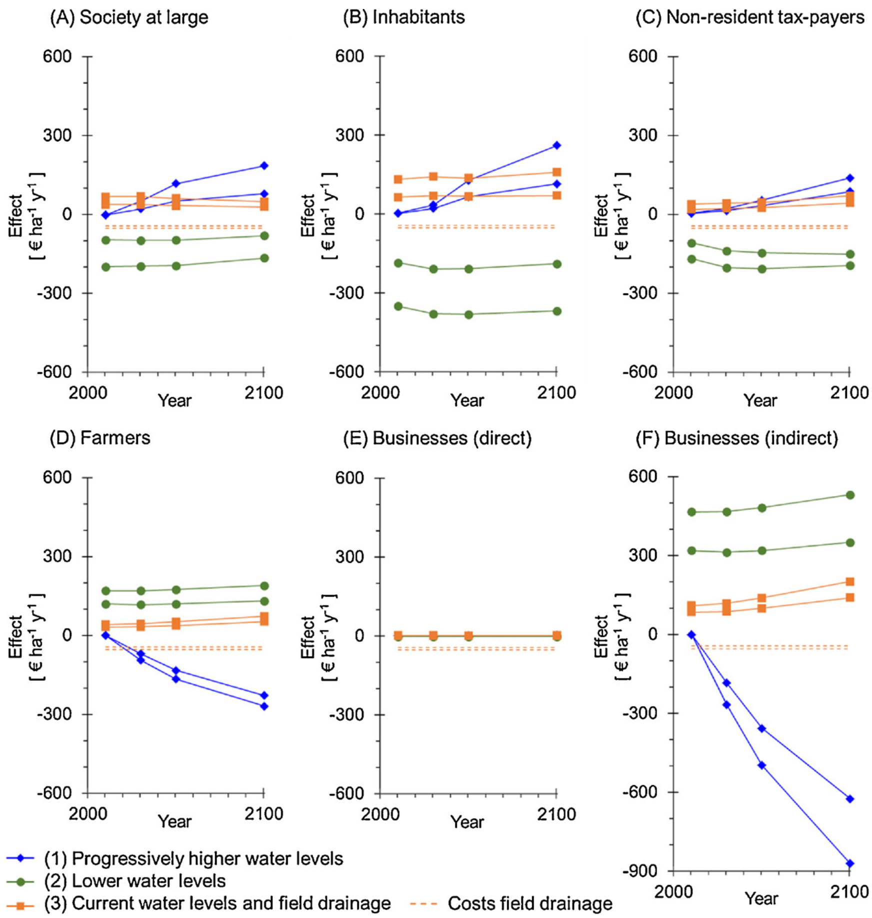

Fig. 4. Distributed economic effects of the management strategies, i.e., the differences compared with strategy 0. Both upper and lower limits to the range of values are shown. Note that the costs of field drainage are shown separately in all graphs, and the uncertainty regarding agricultural markets is not reflected in the results (D and F).

Table 1
Distributed Net Present Values (million euro). Both upper and lower limits to the range of values are shown. Note that the uncertainty regarding agricultural markets is not reflected in the results. Non-monetary values that could not be assigned to a clear stakeholder group were left undistributed, i.e. assigned to "Society at large".

Management strategy	1	2	3
Society at large	11 −28	−121 to −55	18 −36
Inhabitants	17 −33	−279 to −151	50 −104
Non-resident tax-payers	12 −18	−148 to −101	17 −32
Farmers	−55 to −43	90 −129	26 −34
Businesses (direct)	0	−2 to −1	0 −1
Field drainage	0	0	−41 to −33
Total	**−2 to 24**	**−421 to −217**	**78 −166**
Businesses (indirect)	−114 to −162	240 −357	68 −91

effects. Many practitioners suggested employing non-financial indicators and using multiple evaluative endpoints instead of a single economic endpoint. The mean opinion score for the need for collaborative adaptations was 73 out of 100. The need for a context-specific follow-up was stressed, but a complementary generic top–down approach was deemed necessary too.

We discussed the results of our assessments and the evaluation on eight separate occasions, which were attended by approximately 140 people involved in peatland management. These meetings guided the participating organizations in their design of peatland management strategies. Collectively, they decided that the former top—down approach to raise water levels and achieve a transition in land use (strategy 1) was not viable, because gains and losses were unequally distributed. Instead, the participating organizations decided to embark on several context-specific follow-up processes primarily aimed at applications of field drainage (strategy 3), in which the management costs were shared collectively by the participating stakeholder groups.

5. Discussion

5.1. Added value of the approach

As stated in the introductory section, several scholars believe the combination of CBA and deliberative tools has high potential to support collaborative policy processes (De Jong and Geerlings, 2003; Turner, 2007; Browne and Ryan, 2011; Beria et al., 2012). However, the effectiveness of these combinations depends on their ability to overcome process-related issues associated with CBA: such as misunderstandings and inadequate communication between CBA practitioners. In this section, we discuss to what extent these process-related issues were dealt with in the case study, and which limitations of the approach we perceive. In addition, we will present some limitations of our approach and suggestions for further research.

In the case study, the CBA results were deliberated at length. The participants predominantly regarded the research and its constituent elements favorably (Table 2), which we believe is a clear indication of a successful CBA process. A further indication that process-related issues were handled adequately is the nature of the discussions. Although many statements were issued about methodological limitations (Table 2), these issues did not dominate the discussions or kindle a sense of mistrust among the participants. Instead, the discussions focused on the management problem at hand, propagating the need for collaborative adaptations and context-specific follow-up processes.

Beside the abundant opportunities to deliberate results, we perceive two main reasons for the successfulness of the CBA process: (1) the design of the process and (2) the presentation of the results. The

Table 2
Overview of the participants' opinions of the research, and the statements they gave to elucidate their opinions. Opinions are normalized to scores ranging from 0 (low) to 100 (high). Beside the mean score, the standard deviation is given in parentheses. The number in parentheses after each statement indicates how many participants issued that statement.

Topic	Opinion score	Participants' statements to elucidate low opinions	Participants' statements to elucidate high opinions
Quality of the analyses	69 (± 19)	• The assessments need improvements (8) • The scenarios need a broader scope (8) • The uncertainty of long-term developments is difficult to interpret (7) • More knowledge is needed on the effects of adaptations (7) • A comparison is needed with other locations (3) • The transparency needs improvements (3)	• The great comprehensiveness of the assessments is good (7) • The transparency is good (2)
Added value of the overall approach	77 (± 29)	• Not all elements are equally important (3)	• The process is supported by stakeholders (5) • The discussion of standpoints is stimulated (2)
Added value of trends in annual values	63 (± 35)	• Net Present Values are also useful (3)	• Improved understanding of long-term developments (6)
Added value of distributed values	76 (± 31)	• Questions the fairness of the taxes levied (8) • Distracts from overall societal wellbeing (1)	• Is relevant for a discussion on tradeoffs (9)
Added value of indirect economic effects	83 (± 24)	• The assessment of indirect effects needs a broader scope (7) • The assumptions of indirect effects are uncertain (7)	• The comprehensiveness of the assessment is improved (5)
Added value of the economic value of non-financial effects	25 (± 30)	• The interpretation is difficult (10) • Non-financial effects are important (9) • Separate indicators are needed for non-financial effects (7)	• Economic values are easy to compare (4)
Need for collaborative adaptations	73 (± 22)	• A generic top–down approach is also needed (6) • Conservative stances are problematic (2) • The setting must feel safe for collaboration (1)	• A context-specific follow-up is needed (9) • A collaborative approach is needed (4)

Table A1
Participants in the case study.

Organization	Background	Role in policy process
Copernicus Institute of Sustainable Development	Utrecht University institute for sustainability research and teaching	Researcher (advisor approach)
LEI	Wageningen University institute for agricultural research	Researcher (advisor on assessment of physical and economic effects; supplier of input data)
Grontmij	Consultancy company	Researcher (advisor on assessment of soil subsidence)
Water authority "Hoogheemraadschap De Stichtse Rijnlanden"	Regional government organization for water management in the research area	Practitioner (initiator of process; supplier of input data)
Provinces of Utrecht and South Holland	Regional government organizations for spatial planning and environmental quality in part of the research area	Practitioner (initiator of process)
Regional Committee "Stuurgroep Groene Hart"	Boundary organization for government organizations and societal stakeholders in the peatlands, aimed at supporting initiatives that strengthen the vitality and sustainability of the peatlands	Practitioner (initiator of process)
Municipalities of Woerden, Bodegraven–Reeuwijk, Gouda, De Bilt, and Wijk bij Duurstede	Local government organizations within or near the research area	Practitioner (supplier of input data)

assembled organizations that initiated the process were very clear from the start that they intended to use the CBA as a heuristic aid. Such explicit communication about the envisioned role of CBA in a decision-making process is believed to contribute to the prevention of process-related issues (Mouter et al., 2013). In addition, a participatory approach for designing management strategies was used. Also, empirical economic data from the stakeholders were used for the assessments. We believe these design characteristics of the CBA process increased the support of the participants, which was the most frequently stated reason for the added value of the overall approach (Table 2).

Regarding the presentation of results, we aimed to increase the transparency of the assessments by unraveling the composite CBA result, i.e., the cumulative NPVs of the management strategies. Beside the cumulative NPVs, we also presented the results from the quantitative modeling framework that we used to underpin the CBA (Fig. 3), trends of annual values in time (Fig. 4), and distributed values (Fig. 4 and Table 1). Consequently, our approach presents costs and benefits as multiple evaluative criteria. For instance, beside the cost–benefit ratio of direct effects, our approach also considers a cost–benefit ratio for indirect effects. Furthermore, the emphasis on distributed values and trends in annual values allows the user to weigh the constituent components of the cost–benefit ratios. Arguably, this is key to ensure strong support for collaborative policy processes. The Kaldor–Hicks compensation principle implies that from the perspective of overall societal wellbeing it suffices to draw conclusions from the cumulative NPVs of management strategies, regardless of whether the gainers compensate the losers. But if the preferred management strategy requires a collaborative effort from multiple stakeholders, we argue that a prerequisite for a successful policy process is a discussion on equitable tradeoffs. We therefore allowed the participants to exchange standpoints on how they value the future developments, which opportunities they perceive for improving wellbeing by means of indirect economic effects, and which distribution of costs and benefits they regard as fair.

5.2. Limitations of the approach and suggestions for further research

Even though the overall approach was judged favorably by the participants of the case study, several limitations emerged as well. The

Table A2
Background of the participants that evaluated the approach.

Background	Organization
Water authorities in peatland areas	• Hoogheemraadschap De Stichtse Rijnlanden • Hoogheemraadschap van Delfland • Hoogheemraadschap van Rijnland • Hoogheemraadschap van Schieland en de Krimpenerwaard • Rijkswaterstaat • Waterschap Vallei en Veluwe • Wetterskip Fryslân
Other government organizations in peatland areas	• Province of Friesland • Province of North Holland • Province of South Holland • Municipality of Woerden • Environmental agency "Milieudienst Rijnmond"
Organized interest groups	• Village Committee of Oud-Kamerik • Dutch Federation of Agriculture and Horticulture • Interest group for municipalities in peatlands "Platform Slappe Bodem" • Interest group for peatland residents "Stichting Groene Hart" • Ecological interest group "Initiatiefgroep natuurbeheer Delft" • Cultural heritage interest group "Bond Heemschut" • Peatland Innovation Center • Freelance advisor on landscape quality

Table B1
Net Present Values of the effects of the management strategies (million euro). Both upper and lower limits to the range of values are shown. Note that the uncertainty regarding agricultural markets is not reflected in the results.

Management strategy	1	2	3
Water system	13 −16	−124 to −103	6 −8
Roads and sewers	13 −28	−262 to −127	51 −107
Real estate	1 −2	−6 to −3	2 −6
Gardens	2 −4	−35 to −18	8 −15
Agricultural production	−55 to −43	90 −129	26 −34
Utilities	0	−3 to −1	0 −1
Recreational businesses	0	0	0
Emission values	5 −10	−80 to −40	18 −37
Bequest and existence values	7 −19	−40 to −15	−1 −0
Field drainage	0	0	−41 to −33
Total	**−2 −24**	**−421 to −217**	**78 −166**
Agricultural supply chain	−114 to −162	240 −357	68 −91

most notable limitation was the assessment of the economic value of non-financial effects. The participants clearly stated that these effects were difficult to interpret (Table 2). Their opinions reflect previous critiques that such valuations narrow down non-financial values to current individual preferences and instrumental utility maximization goals (e.g. Costanza, 2006). Therefore, CBA and/or MCDA should have a broader, more holistic scope, including less tangible and indirect impacts (Browne and Ryan, 2011; Beria et al., 2012). We endorse this suggestion, because the participants in our case study clearly expressed a preference for separate indicators for non-financial effects (Table 2). In view of these results, we suggest that further research should aim to capitalize upon these revealed preferences.

A further research suggestion is the enhancement of the collaborative interpretation of the results. In our case study, we witnessed how the participants increased their capacity to understand the complexities of the peatlands and their ability to explore its potentialities by exchanging knowledge among themselves and with researchers. However, the participants often found it difficult to interpret the uncertainty caused by various assumptions and future developments (Table 2). This predicament can easily result in methodological debates that distract from the management problem at hand, creating the process-related issues that have been reported in previous CBAs (Beukers et al., 2012; Mouter et al., 2013). To avoid this pitfall, we believe it necessary to further increase the transparency of the approach, as well as its ability to handle uncertainty in information-rich context-specific processes similar to those in our case study. In this regard, we specifically draw attention to virtual learning platforms and geo-technology, which are designed to analyze large amounts of data, and have been shown to enhance knowledge co-production and learning (Medema et al., 2014; Pelzer et al., 2016).

The question remains what the added value of our approach would be in other settings. In the case study, most participants were co-operative throughout the entire process, because they all had recently experienced the drawbacks of a non-participatory top-down approach to water management and land use planning in Dutch peatlands. However, a few propagandists of the former top-down strategy used the results strategically, by discrediting the transparency of assessments which results did not match their agenda and refusing any further discussion of the subject. Strategic use of knowledge like this by non-cooperative stakeholders is a commonly reported problem in science-

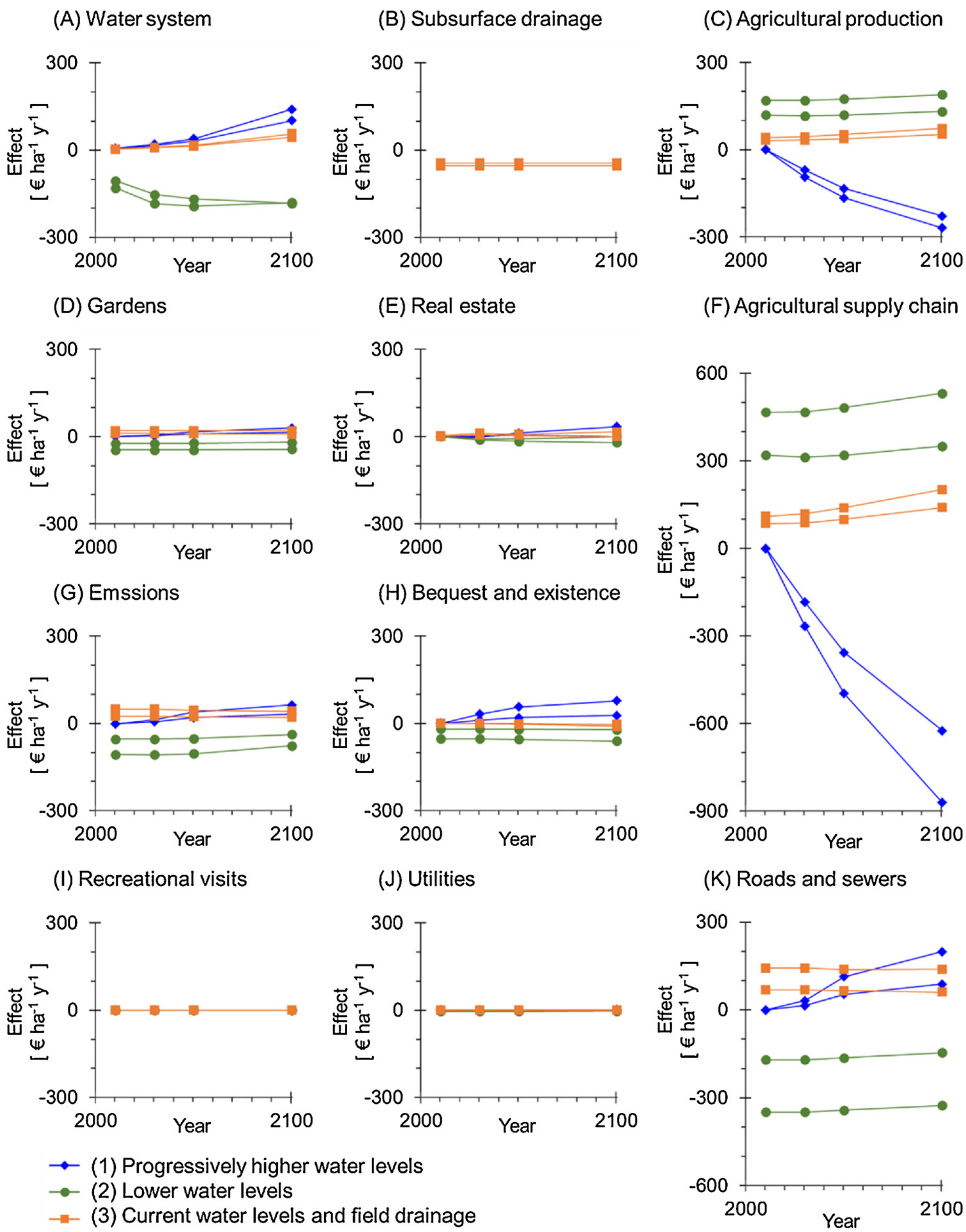

Fig. B1. Economic effects of the management strategies, i.e., the differences compared with strategy 0. Both upper and lower limits to the range of values are shown. Note that the uncertainty regarding agricultural markets is not reflected in the results (C and F).

policy interactions (Van Enst et al., 2014). If more participants would behave non-cooperatively like this, a deadlock would occur where each participant advances their own arguments without listening to those of others, a so-called "dialogue of the deaf" (Van Eeten, 1999). Arguably, it is unlikely that our approach would be effective in such settings, where non-cooperative attitudes of participants persist regardless of opportunities to exchange opinions with other participants. In those settings, we would suggest a combination of CBA (or other analytical tools) with tools aimed at mediation instead of deliberation (Driessen and Vermeulen, 1995).

6. Conclusion

To contribute to our collective understanding which tools can support the management of social—ecological systems in diverse situations, we demonstrated how quantitative modeling, CBA, and a web-based discussion tool were employed to support a collaborative policy process in Dutch peatlands. We did not use CBA as a decision-rule, to determine the optimal cost–benefit ratio of project alternatives, but as a heuristic aid, aiming for an intersubjective assessment of the preferred project alternative.

The stakeholders participating in our case study appreciated the approach's relevant and comprehensive assessments, and the ensuing multi-criteria discussion of costs and benefits. In the case study, we witnessed how our approach increased the capacity of the participants to understand the complexities of the peatlands and their ability to explore its potentialities. The analytical merits of CBA, underpinned by quantitative modelling, exposed that the former top—down approach to raise water levels and achieve a transition in land use was not viable, because gains and losses were unequally distributed. Although the participants perceived many methodological limitations, these issues did not dominate the discussions or kindle a sense of mistrust among them. Instead, their discussions focused on the management problem at hand, propagating the need for collaborative adaptations and context-specific follow-up processes. We believe this result can be attributed to (a) the clear, participatory design of the CBA process, (b) a comprehensive presentation of the constituent elements of the CBA result, and (c) the abundant opportunities to deliberate the results.

Although our case study demonstrates that the combination of CBA with a deliberative tool can support the reconnoitering phase of a policy process with cooperative participants, we do not propagate our approach as a one-size-fits-all solution for the support of the management of social—ecological systems. Arguably, it is unlikely that our approach would be effective in settings with non-cooperative stakeholders. Therefore, we call on other researches to share empirical insights that demonstrate which tools can support the management of social—ecological systems in those situations.

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Appendix A. Background of the participants in the policy process

The policy process was initiated by an assemblage of a regional water authority, two provinces, and a steering committee for the peatlands. They received input from two scientific research institutes, a consultancy company, and five municipalities. Table A1 provides some background on these organizations, including their role in the policy process. Table A2 provides an overview of the backgrounds of the participants that evaluated the approach.

Appendix B. Additional results

See Table B1 and Fig. B1.

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