Cooperating for added value

Using participatory game theory in implementing nature-based flood defences

Vreugdenhil, Heleen; Janssen, Stephanie; Hermans, Leon; Slinger, Jill

DOI
10.1016/j.ecoleng.2021.106507

Publication date
2022

Document Version
Final published version

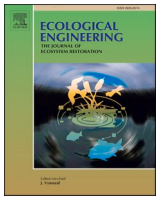
Published in
Ecological Engineering

Ecological Engineering 176 (2022) 106507

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng



Cooperating for added value: Using participatory game theory in implementing nature-based flood defences

Heleen Vreugdenhil [a,b,*], Stephanie Janssen [b], Leon Hermans [c,a], Jill Slinger [a,d]

[a] Delft University of Technology, Faculty of Technology, Policy and Management, P.O. Box 5015, 2600GA, Delft, the Netherlands
[b] Deltares, P.O. Box 177, 2600MH Delft, the Netherlands
[c] IHE Delft Institute for Water Education, Delft, the Netherlands
[d] Institute for Water Research, Rhodes University, P.O. Box 94, Grahamstown 6140, South Africa

ARTICLE INFO

Keywords:
Coalitions
Policy analysis
Nature-based solutions
Social dilemma
Participatory game theory
Wadden sea

ABSTRACT

The increasingly active role of stakeholders in the development of innovative nature-based solutions calls for appropriate instruments to support and realise added value from their involvement. In this paper we apply a newly developed instrument "Cooperation for Added Value" (Co-Add) to a study area on the Dutch coast. The instrument draws on participatory game theory and policy analysis to provide a theoretically sound structure for facilitating interactions aimed at identifying shared opportunities and potential coalitions for cooperation. The application in the case study Noard-Fryslân Bûtendyks affirmed that the Co-Add instrument systematically facilitated stakeholders in exploring potentially promising opportunities and gaining insight in the added value of engaging in diverse cooperations. Stakeholders came to understand which solutions were more achievable than others and what was needed to enable implementation in terms of collaboration, including the role of their own organization. Furthermore, social dilemmas in which a particular nature-based solution is attractive to a coalition of stakeholders but is not the most beneficial solution for a particular individual stakeholder, became clear. This represents a practical contribution to the range of participatory instruments that can be applied in societally challenging complex problems that require collaboration for their resolution.

1. Introduction

Nowadays the participation of stakeholders in the development of flood defence strategies is necessary and, in some countries, a legal obligation. Stakeholder participation is known to provide diverse contributions to a project, including the identification of values, creative solutions, new knowledge and the acknowledgement of democratic values (McEvoy et al., 2018; Begg, 2018; Paavola and Hubacek, 2013). In nature-based flood defence projects stakeholder participation is particularly important as it allows the inclusion of a diversity of opinions regarding whether and how to defend against flooding, in addition to the realization of multiple objectives through such infrastructure (Voorendt, 2017; Bark et al., 2021; Slinger et al., 2021). Nature-based flood defences fit with the idea that in a densely populated world with multi-level governance arrangements and resources distributed across multiple actors, single-objective projects potentially represent missed opportunities for achieving economically, socially and environmentally sustainable designs. Instead, flood risk management has diversified beyond the conventional engineered 'hard' defences to include mitigation, preparedness and recovery-based interventions. It is increasingly oriented to accompanying or replacing the engineered 'hard' defences such as dikes by nature-based approaches whether through the 'greening' of grey infrastructure or working with natural processes, interactions and habitats such as salt marshes from the outset (Morris et al., 2018; Slinger and Vreugdenhil, 2020). Specifically, nature-based flood defence means that the design of the flood defence takes into account the local physical context, uses naturally present type of landscapes, materials and biophysical interactions and processes and seeks to benefit and restore ecosystems where possible (Waterman, 2010; Slinger, 2015, 2016). A flood defence is viewed as an integral part of a landscape that has diverse amenity values and uses including nature, recreation, and housing. For instance, a flood defence could be a semi-permeable breakwater, a dike with vegetated foreshore, or even a dune. This implies that different authorities, and particularly those responsible for flood defence are operating in a growing network of stakeholders with large interdependencies. Moreover, legislation

* Corresponding author at: Delft University of Technology, Faculty of Technology, Policy and Management, P.O. Box 5015, 2600GA, Delft, the Netherlands.
E-mail address: heleen.vreugdenhil@deltares.nl (H. Vreugdenhil).

https://doi.org/10.1016/j.ecoleng.2021.106507
Received 30 March 2021; Received in revised form 24 November 2021; Accepted 2 December 2021
Available online 23 December 2021

increasingly supports the trend towards more cooperation between stakeholders. For instance, the European Flood Directive includes a Common Implementation Strategy on public participation (Ker Rault and Jeffrey, 2008; Thieken et al., 2014). In the Netherlands flood defence authorities have been assigned the responsibility of looking beyond their own designated area of responsibility and making agreements with neighboring authorities (MinIenM, 2015). The Dutch National Water Act (2009) also requires flood defence authorities to include the effect of foreshores in the assessment of a dike (Roode et al., 2019). So, cooperation between the different stakeholders has become desirable, a legal obligation, and indispensable to effective flood defence strategies.

At the same time, real cooperation across different authorities and with diverse stakeholders remains difficult to achieve (Pleijte et al., 2014). Interests may conflict and budgets are constrained to achieving single objectives such as flood defence or nature conservation. Furthermore, aligning different planning processes and work cultures is not easy. This makes cooperation difficult. For example, flood defence authorities in the Netherlands have expressed the impression that 'everyone wants something from the dike', but that in the end they, the authority, are faced with ensuring that certain objectives are achieved within planning and budget (Janssen and Hermans, 2017). Accordingly, the need for instruments to support and facilitate effective cooperation in flood defence planning is broadly recognized (Vinke-de Kruijf et al., 2015).

However, instruments that offer structured and practical support for such cooperation are scarce. Most existing facilitation guidelines either provide a fairly generic set of (useful) main steps and principles (Susskind and Landry, 1991; Karl et al., 2007), or a set of specific group facilitation techniques (e.g. Witte, 2007; Lynch et al., 2009). These offer a limited theoretical basis to support real collaboration that moves beyond abstract ambitions or joint vision development without associated actions. In an educational setting, Klaassen et al. (2021) trialed innovative, theoretically-informed approaches to enhance cooperation in nature-based infrastructure design, but these have not yet been applied in real cases. Accordingly, in this paper we present the design and application of a structured and practical instrument, termed 'Cooperating for Added Value' or 'Co-Add'.

The Co-Add instrument was developed and applied within the NWO BE SAFE research project in the period 2016 to 2019 (Vuik et al., 2019). The instrument is based on principles of cooperative game theory and previous participatory approaches drawing on systems analysis and game theory (Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014). The Co-Add instrument was applied in Noard-Fryslân Bûtendyks (NFB), an area in the north of the Netherlands on the Wadden Sea (Janssen et al., 2019). The responsible water board, Wetterskip Fryslân, needed to ensure meeting national flood defence standards both now and in the future. This meant that they needed to include foreshores in their safety assessments and potentially needed to make agreements with neighboring authorities. This represents a departure from previous practice. It requires a change from 'we don't need anyone, we are the dike authority' to 'we need each other, we would like to cooperate, and maybe this even saves us money' (POV Waddenzeedijken, 2018). This new attitude led to the decision on the part of the water board Wetterskip Fryslân to collaborate with BE SAFE researchers (particularly authors SJ and LH) in applying the instrument Co-Add. They needed to engender supportive cooperation in their flood defence planning and explore the potential for nature-based solutions such as including the wetlands along the foreshore as an integral element of the flood defence infrastructure.

Accordingly, this paper designs and applies the prototype of the Co-Add instrument and investigates the added value associated with stakeholder cooperation in nature-based flood defence planning. To what extent does the instrument facilitate going beyond increasing the mutual understanding of the constraints experienced in striving for integrated nature-based solutions? In what way does it help to overcome the single objective focus besetting flood defence authorities at present and identify cooperation opportunities? To deepen the theoretical understanding, we first introduce theory on the social dilemma in NBFD, and the potential innovative use of game theory and policy analysis to support stakeholder cooperation in Section 2. Then, we describe the flood defence study area and our action research approach, before moving on to describe the development of the Co-Add instrument in Section 3. Next, we follow Thissen and Twaalfhoven (2001) in reporting on the application of the instrument to the Noard-Fryslân Bûtendyks case in terms of both process and substantive outcomes (Section 4). The paper closes with a discussion on the potential to overcome the social dilemma and realise added value through instrument-based enhanced stakeholder cooperation in nature-based flood defence (Sections 5 and 6).

2. Theory: stakeholder participation for NBFD to increase societal benefits

2.1. A social dilemma in nature-based flood defences

The concept of Nature-Based Flood Defences (NBFD) represents an innovation in the design of flood defences (Temmerman et al., 2013; Vuik et al., 2016; Slinger and Vreugdenhil, 2020). This concept is based on the principles underlying the concepts variously termed Building with Nature, Engineering with Nature, Working with Nature, Nature-Based Solutions, Hybrid Engineering, Green Infrastructure, Working with Natural Processes (also termed Natural Flood Management) or Cyclic Floodplain Rejuvenation (Waterman, 2010; Bridges et al., 2016; Mitsch, 1996; Van Wesenbeeck et al., 2014; Browder et al., 2019; Lane, 2017; Wingfield et al., 2019; Vreugdenhil et al., 2007). This means that the design of the flood defence takes into account the local physical context, uses naturally present type of landscapes, materials and biophysical interactions and processes and seeks to benefit and restore ecosystems where possible (Waterman, 2010; Slinger, 2015, 2016). With its strong focus on flood defences, however, NBFD can be viewed as a specific approach within the broader class of such ecosystem-based management concepts. For instance, Natural Flood Management and Cyclic Floodplain Rejuvenation have the broader aim of protecting, restoring and emulating the natural functions of floodplains and rivers, even at catchment scale (Lane, 2017; Vreugdenhil et al., 2007). This entails enhancing biodiversity while ensuring safety from flooding and providing enhanced amenity value (see Wingfield et al., 2019). As such, the resulting nature-based flood defences fit multiple purposes and generate greater societal value (Bark et al., 2021; Slinger et al., 2021). However, they require thinking and designing in an integrated manner, cross-disciplinary integration, and multi-stakeholder processes in their development (Slinger and Vreugdenhil, 2020; Nesshöver et al., 2017; Giordano et al., 2020; Klaassen et al., 2021).

In practice we still see that more conventional solutions often prevail over NBFD solutions. Previous research has identified that a social dilemma precludes opting for NBFD solutions and that the potential benefits are not always realized (Janssen et al., 2020). Social dilemmas are situations in which the preferred strategy of an individual is not to the advantage of the broader interest of the group (Ostrom, 2001). Social dilemmas have also been described as "situations in which the rational pursuit of self-interest can lead to collective disaster" (Kerr, 1983). Clearly, whereas the term social dilemma can be applied loosely to mean the conflicts that arise between different groups concerned with the same issue about what the preferred strategy should be, here we use it in the strict game theoretical sense to signify a situation in which the rationally preferable strategy of an individual actor is to the disadvantage of a broader group of actors concerned with the same issue. The research of Janssen et al. (2020) showed that nature-based flood defence games are of a multi-level and nested nature in The Netherlands. There is a fragmented policy landscape which means that the choice to implement a nature-based flood defence at the project level can only be made

when it aligns with the institutional context at the policy level. For nature based flood defences, this means that games take place both at the project level around their design and construction, and at the policy level that shapes the institutional context for these projects. Social dilemmas arise with the multi-functional nature-based solutions attractive to a coalition of actors not being the most beneficial option for individual actors such as the water authority or a nature organization. Their organizational goals in relation to this issue are formulated with single objectives such as "ensure safety from flooding" or "enhance natural value". Hence, they are faced with the dilemma of opting for their maximum benefit or opting for the greater societal benefit which is less favorable to them as it can bring with it additional costs, more risks, and management complications. Accordingly, many stakeholders involved in flood defence strategies in the Netherlands, and in particular those responsible for flood protection, have a preference for mono-functional solutions related to design and construction. This has limited the routine implementation of nature based flood defences. Indeed, the mono-functional solution generates more direct value to the individual actor and better fits their designated tasks and responsibilities. Nevertheless, a multifunctional (integrated) approach could lead to added value for society as a whole.

2.2. Cooperative game theory

Game theory provides a conceptual lens to understand and resolve social dilemmas. Situations in which actors depend on each other and take decisions can be modelled using matrices or decision trees, for example (Hermans et al., 2018). Furthermore, game theory offers ways to understand and resolve games by means of logical analysis of conflict and cooperation (Straffin, 1993, p.3). It describes players, their interdependencies, the actions players can take, potential outcomes and their associated values. Game theory provides the basis of negotiation theories (Fisher et al., 1991; Raiffa et al., 2002) and forms the primary source of inspiration for the Co-Add instrument.

Game theory has two main streams: non-cooperative game theory and cooperative game theory. Non-cooperative game theory is useful in analyzing stakeholder dynamics: how do the players (stakeholders) depend on each other, how do they compete, and what are logical outcomes? This helps to identify social dilemmas (see Janssen et al., 2020). Cooperative game theory focuses on cooperation: what can players achieve together and how can they share the benefits? An underlying precept of game theory is that the players seek to optimize the value accruing to them. Cooperative game theory seeks to analyze whether and how players can accrue added value by forming coalitions, that is cooperating, with other players (Hermans et al., 2018).

Traditionally, game theory is oriented more towards conceptualizing, modelling and analyzing decision making situations and less towards applying the models practically in problem solving (Cunningham et al., 2014). This makes game theory a powerful approach in identifying strategic situations and dilemmas, but also means that game theory easily falls short in representing more complex real-world contexts that include a wide range of actors, interacting in different settings (Hermans et al., 2014). In real-world games, factors such as identity, culture, experience and knowledge exert a large influence. Similarly, the capriciousness, dynamics and unpredictable events that characterize real-world decision-making are difficult to capture in an analytical model. All this means that the use of game theory to analyze "games real actors play" is not straightforward (Scharpf, 1997). Game theory offers analytical forms to analyze multi-actor decision situations, but it does not offer tools to link these abstract models to real-world games. To address this critical element for real-world applications, a combination with policy analysis methods is useful.

2.3. Policy analysis

In contrast to game theory, the field of policy analysis places the complexity of real-world decision-making processes centrally (Thissen and Walker, 2013), aiming to assist decision makers in choosing which interventions to make in complex problem situations. Policy analysis adopts a wide problem focus, applying a structured approach to conceptualise the problem situation as a multi-actor system (Walker, 2000; Enserink et al., 2010). It employs a range of methods to elicit differences in values, diverse perceptions of the problem, alternative interventions, and the trade-offs amongst the outcomes of the interventions (Walker, 2000; Enserink et al., 2010). The role of process in co-determining the substantive outcomes of policy analytic activities is distinguished (Thissen and Twaalfhoven, 2001) and uncertainties in the outcomes of interventions are explicitly taken into account in the analysis as is the strategic position of the decision maker in relation to other actors. This means that policy analysis and game theory are potentially complementary.

2.4. Combining policy analysis and game theory for stakeholder participation

Recent innovations in participation processes have drawn on policy analysis theory (Enserink et al., 2010; Mayer et al., 2004; Thissen and Walker, 2013) in conjunction with game theory to design and structure the engagement between stakeholders. These innovations include the game structuring approach of Cunningham et al. (2014), an evaluative framework for assessing the outcomes of collaborative planning activities nested within an overarching decision-making process (McEvoy et al., 2019), and the design of collaborative activities for developing nature-based interventions in the coastal zone (d'Hont, 2020). Within these approaches, workshops or collaborative activities now have a theory-based agenda designed to enhance cooperation and the substantive quality of the outcomes. These methods differ from many of the stakeholder engagement methods applied in flood risk management in that they neither focus on enhancing the understanding of flood risk of stakeholders nor improving flood risk communication (see Fleischhauer et al., 2012; Meyer et al., 2012; Bradford et al., 2012; O'Sullivan et al., 2012; Thieken et al., 2014); they are not targeted at improving the information base for community engagement in flood risk management, nor are they intended to support management practice in a flood-prone system. Instead, they each represent a systematic theoretically-informed exploration of new collaborative arrangements amongst the stakeholders concerned with the nature-based planning or design issue. The closest comparable approaches are those focusing on supporting dialogue about mutual gains, such as strategic stakeholder management (e.g. Susskind and Landry, 1991) although these types of approaches are not commonly applied to flood risk management. They are characterized by a strong focus on coalition forming and qualitative evaluation of the benefits deriving to the stakeholders involved. In contrast, the many collaborative modelling approaches undertaken with the aim of supporting decision making tend to focus on generating understanding of the consequences of interventions in the biophysical system and supporting dialogue on these (see Evers et al., 2012) rather than on developing coherent implementable sets of policies or forming coalitions for nature-based solutions.

Nowadays game theory approaches are increasingly used in conjunction with policy analysis in designing participatory activities that focus on identifying the values of different actors by identifying multiple perspectives on the past, present and future in interactive workshop settings (see Slinger et al., 2014; d'Hont, 2020). However, while these methods supported successful development of shared problem perspectives and visions, neither joint development of coherent sets of policy options, nor joint assessment of (dis)benefits for individual stakeholders and for all of the stakeholders together has been achieved. Clearly, this represents the next step in applying game theory and policy analysis-based instruments to identify and realise the added value of cooperation. The Co-Add instrument supports making this step.

This is particularly applicable to nature-based flood defence

strategies that require the social dilemma to be overcome for their realization and forms the focus of this paper.

3. Methods

3.1. The Noard-Fryslân Bûtendyks study area

The majority of the coastal area of Fryslân is protected by sea dikes, which undergo regular testing as required by Dutch law. During the flood defence assessment of 2011, Wetterskip Fryslân identified five dike trajectories that failed to meet the flood defence standards (see Fig. 2) and needed reinforcement. Wetterskip Fryslân initiated dike improvements along these trajectories in 2017 (Wetterskip Fryslân, 2016). Our case study focuses on one of these trajectories, Noard Fryslân Bûtendyks, which consists of a sea dike with a 4200 ha foreshore comprising of salt marshes and polders. When the foreshores are included in a flood risk reduction strategy, it becomes a nature-based flood defence, as the foreshore vegetation and the dimensions of the foreshore play a role in decreasing wave energy on the dike (van Loon-Steensma, 2015). Such an approach could potentially greatly reduce dike construction efforts and associated costs. Furthermore, Wetterskip Fryslân has the ambition to execute the reinforcement in a stakeholder-inclusive manner. This created the opportunity to test the Co-Add instrument in the province of Fryslân in 2018.

The foreshore polders and the salt marshes have high natural value and are used for cattle grazing and recreational activities. A large part of the area is owned by nature conservation organization 'It Fryske Gea' which in turn leases land to farmers for cattle grazing.

3.2. Participatory action research in a nature-based flood defence planning process

The authors undertook action research in the project Noard-Fryslân Bûtendyks (Section 2.2) to test the Co-Add instrument and support the exploratory planning process (Baum et al., 2006).

The authors first tested the suitability of the Co-Add instrument, which is the preparation step of the instrument (step 0, see below). Indeed, Janssen and Hermans (2017) concluded from 8 interviews and a literature study that cooperation could be improved and that all parties had positive expectations of applying the Co-Add instrument. Potential areas for cooperation were identified to include summer polders, recreation, ecology, land tenure, salt marsh development, cultural history, and grazing cattle on the dike. Accordingly, the decision was made to apply the Co-Add instrument in 2 workshop sessions in the fall of 2018. Five organisations related to the areas of interest were invited to send 1 or 2 people to participate in the two sessions. The five organisations represented national and regional water management, cultural and landscape interest groups, farming and the municipality. The joint objective was defined as: "parties on and around the foreshore get to know each other better and the opportunities for and value of possible cooperation are identified' (Janssen, pers. com. 2018).

To evaluate the functioning of the Co-Add instrument we follow Thissen and Twaalfhoven (2001). With the help of their framework the effects of a policy analytic activity can be evaluated by examining the input, the process followed and the substantive content, and how this may lead to effects, results and use. Based on this framework, McEvoy et al. (2020) identified evaluation criteria on learning that we use in the evaluation of the application of the Co-Add instrument in the case study. After each workshop the participants filled out an evaluation form to identify their perception on the process of the instrument, their learning for practice and content level. They scored 14 statemements on a likert scale from 1 to 5. This included their perception on input, process, content, effects, results and use. Table 1 provides an overview of the evaluation statements and their characterization.

Table 1
Evaluation of the Co-add workshops by participants in response to a questionnaire applying a 5-point Likert scale from totally disagree (1) through neutral (3) to totally agree (5). The scores of the participants are averaged and characterized following McEvoy et al. (2020).

	Questionnaire statements	Characterization
Workshop 1	The workshop was useful	Results (value and relevance of results to the planning process and stakeholders)
	Other stakeholders understand your role and ambitions better	Effects (effects on learning)
	You were able to share your ideas about foreshore management with others	Effects (effects on learning)
	You were able to build new, or deepen existing, relationships with other stakeholders	Effects (effects on learning)
	You have a deeper understanding of opportunities to cooperate in foreshore management	Effects (effects on learning)
	You have changed your opinion in regard to (future) foreshore management	Effects (effects on learning)
	You have a deeper understanding of the management challenges relating to the foreshore	Effects (effects on learning)
	Cooperation related to the foreshore has changed or will change owing to the workshop	Use (direct use of results)
	The goals of the workshop were clear	Input (aim and role of workshop (s))
	The expectations of you as participant were clear	Process (communication)
	The visualisation support by artists contributed significantly to the workshop	Process (way of working)
	The teamwork during the brainstorm session was good	Process (workshop structure and procedures)
	You had sufficient information to participate in the brainstorm session	Content (quality and type of information and data used)
	All relevant issues were discussed	Content (depth and breadth of content)
Workshop 2	The workshop was useful	Results (value and relevance of results to the planning process and stakeholders)
	You have a deeper understanding of the added value of cooperating with others	Results (value and relevance of results to the planning process and stakeholders); Effects (effects on learning)
	The analysis 'Added Value of Cooperation' supports vision development	Content (quality and type of information and data used)
	The analysis 'Added Value of Cooperation' supports exploring pilot project development	Content (quality and type of information and data used)
	Workshop 2 builds upon the results of Workshop 1	Input (aim and role of workshop (s))
	Today we took a step towards developing a pilot project	Use (direct use of results)
	Today we took a step in developing a vision related to a 'Dike with Vegetated Foreshore'	Use (direct use of results)
	A step has been taken in translating ideas into practice	Use (direct use of results)
	The goals of the workshop were clear	Input (aim and role of workshop)
	The expectations of you as participant were clear	Process (communication)
	You had sufficient information to participate in the brainstorm session	Content (quality and type of information and data used)
	All relevant issues were discussed	Content (depth and breadth of content)

3.3. The instrument Cooperating for Added value (Co-Add)

The instrument 'Cooperating for Added Value' or 'Co-Add' aims to help stakeholders to resolve social dilemmas, understand the added value of cooperation, and the conditions under which cooperation can occur. Adopting the commonly applied and pragmatic 'scan, focus, act' sequence (see MG Taylor Corporation, 1997, Capgemini Consulting, 2013), we distinguish six steps based on cooperative game theory. This requires that the players are first identified and what they could do together and the value that this would generate compared to their current activities or situation are then explored. More specifically, the steps include (0) Preparation, (1) Getting to know each other and the context, (2) Identifying opportunities for cooperation, (3) Valuing opportunities for cooperation, (4) Determining the added value of cooperation, and (5) Committing to cooperative action. Fig. 1 depicts the composite steps, which are described in detail thereafter. The activities typically associated with each of the steps are depicted in the bars below each step.

Step 0: Preparation.

In the preparation step, the suitability of the instrument for the problem situation is assessed. Necessary characteristics of the problem situation are:

- The presence of a social dilemma (Janssen et al., 2020). This means that there is the potential to achieve added value through cooperation, rather than only achieving single actor objectives.
- The willingness of the stakeholders to participate (Ker Rault et al., 2013).

Determining whether these characteristics are met takes place in consultation with the client or problem owner, and with key stakeholders. Once it is established that the characteristics are present, a wider stakeholder engagement process can be designed. The design includes determining the overall goal of the participative process, demarcating the problem situation or determining the problem scope, inviting the relevant stakeholders, and arranging the practicalities such as financing, dates and locations of meetings.

Step 1: Getting to know each other and the context

Given the complexity of the problem situation and the involvement of multiple actors, the first step in applying Co-Add with a group of stakeholders is getting to know each other and the context. This step aims to increase mutual trust and the preparedness to work together, to increase understanding of the different parties involved and the diversity of their interests, and to create a shared knowledge basis. There are many ways to get to know one another and the area under consideration, for example by undertaking field trips together. Beside the personal element, it is important to learn about each other's working processes and interests. This can help in identifying opportunities to cooperate (step 2) and in understanding why one actor values a particular opportunity more or less than another actor (step 3). Furthermore, sharing relevant research insights and information can increase the knowledge base. Consultants or researchers are therefore explicitly part of the process to support this. Techniques to support this include Joint Fact Finding (Karl et al., 2007), Group Model Building (Basco-Carrera et al., 2017; McEvoy et al., 2018), and Modelling in the Muddled Middle (Clifford-Holmes et al., 2018).

Step 2: Identifying opportunities for cooperation

The objective of this step is to identify a range of opportunities for cooperation between parties. This is an important divergent phase of the first workshop in the process and there are multiple ways to achieve this. For example, involving stakeholders in brainstorm sessions in which a broad initial scope is exercised, and ideas are not judged nor prioritized, can be a useful means to identify opportunities. By considering multiple topics and linking issues the search for synergies or opportunities can be expedited (Van Popering-Verkerk and Van Buuren, 2017). Opportunities for cooperation and the associated coalitions of stakeholders are then identified by focusing on the most relevant problem issues and their related stakeholders. This choice of focus exemplifies the combination of policy analysis with its practical problem structuring orientation and game theory with its decision modelling and strategic orientation (Mingers and Rosenhead, 2004; Enserink et al., 2010; Kelly, 2003). Conceptual models and drawings as well as reflections from the researchers may be helpful in identifying and depicting cooperative opportunities and the associated coalitions. So in this step the focus lies on the practical relevance of a cooperative arrangement for the problem situation. The focus is not on all possible coalitions that could theoretically be achieved, as detailing these becomes practically impossible for more than three parties.

Step 3: Valuing opportunities for cooperation

The objective of this step is to determine the value accruing per opportunity to each stakeholder. This is the convergent step in the first workshop resulting in an overview of the value distribution amongst stakeholders for each opportunity. It provides insight into who gains or who loses when a specific opportunity is realized. In principle this step is undertaken during workshop 1 by preference voting using stickers, rank-ordering the opportunities or completing a multi-criteria table (Slinger et al., 2014; Cunningham et al., 2015; d'Hont, 2020). However, it could also be part of a desk study if participants are asked to undertake this assessment through an online questionnaire. The output of all such methods, whether qualitative or quantitative, can be synthesized into a table similar to Table 1 in which the value accruing to each stakeholder from the identified cooperation opportunities is indicated.

Step 4: Determining the added value of cooperating

In this desktop analysis, undertaken by involved researchers or analysts using tabulated information from Step 3 of the first workshop, the overall added value of cooperating is identified. First, the cooperative opportunities are characterized using the dominance concept of game theory (e.g. Colman and Bacharach, 1997). Promising opportunities are those where everyone wins compared with the current situation and nobody has a better alternative. Non-promising opportunities are those where everyone loses compared with the current situation or alternative solutions. Potentially promising opportunities lie in between and require further investigation. Second, to identify the added value accruing to cooperation, the potential added value of cooperating is identified for each cooperation opportunity, as well as the maximum added value for the group as a whole (the grand coalition, in cooperative game theory). This is simply the sum of the values assigned to each cooperation opportunity and represents the potential added value of full cooperation. It determines what could be achieved in theory if full cooperation were possible. If there are multiple mutually exclusive possible solutions to a particular problem, the solution with highest value is taken into account.

If this step indicates that there is added value to cooperation, it does not necessarily mean that the added value can be realized. Whether the total identified added value can emerge depends on the distribution of gains amongst the stakeholders. For instance, if one stakeholder gains greatly but all others are neutral this cooperation realization is uncertain, particularly when critical stakeholders are not likely to benefit. In this step, therefore, analytical preparations are made to support discussions on potential cooperation in the next step to ensure that the interests of stakeholders are addressed.

Step 5: Committing to cooperative action

The results of the analyses undertaken in step 3 and step 4 are discussed with the stakeholders. The focus lies on whether the analysis is understood and is recognized and accepted as representing their perspectives on cooperation regarding nature-based solutions. During the discussion the analysis can be nuanced. For example, if different employees of the same organization value cooperation opportunities differently this means that the original valuation could shift somewhat and the results change slightly. The influence of such shifts have usually already been explored in the preparatory analysis of Step 4. If not, further supportive analysis may be required. The outcome of Step 5 is the identification of follow up actions to support cooperation. The results and the discussion may help participants to agree on compensation

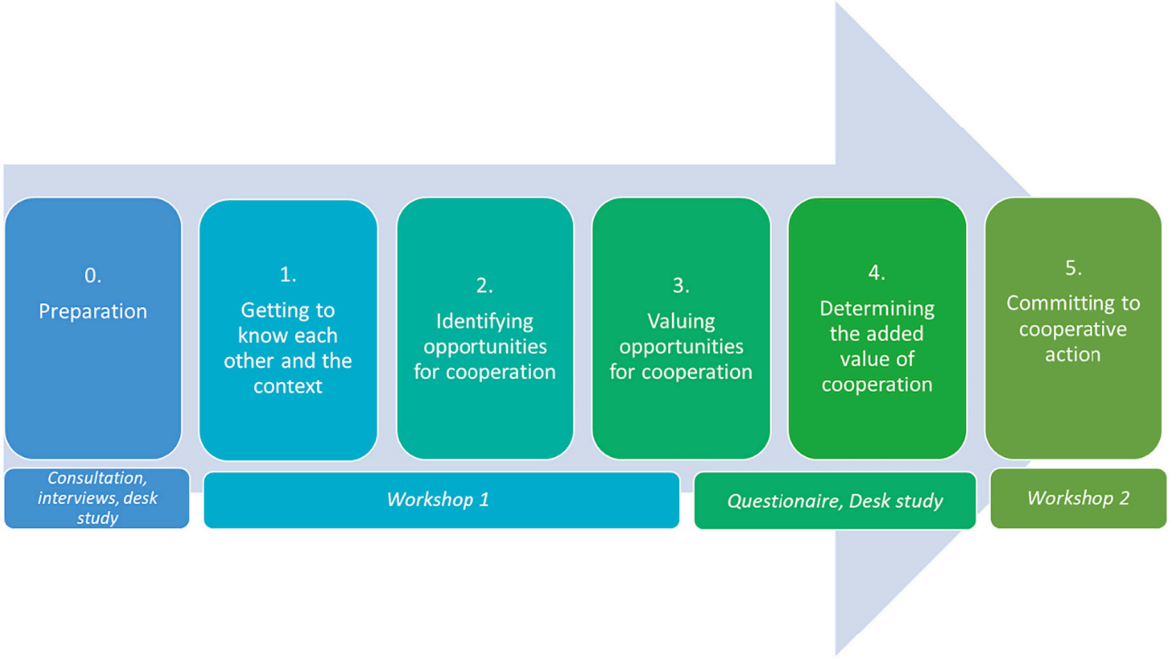


Fig. 1. The steps and activities of the Cooperating for Added Value (Co-Add) instrument.

Fig. 2. Location of the study area in the Netherlands and Fryslân. The blue line indicates the dike trajectories along the Frisian coast that will not meet the Dutch flood safety standards over the next 50 years without reinforcement; the green circle indicates the location of the case study site NFB (Adapted from Wetterskip Fryslân, https://www.wetterskipfryslan.nl/projecten/koehool#h2_1;) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

or mitigatory measures, or on meaningful steps in a phased process. These commitments are captured in an action plan.

4. Application and outcomes of the Co-Add instrument in Noard-Fryslân Bûtendyks

4.1. Preparation step (step 0)

First, the suitability of Co-Add in the Noard-Fryslân Bûtendyks situation was established. The complexity of the stakeholder network that needs to be involved in these dike reinforcement trajectories has increased in recent years. For instance, the waterboard is nowadays obliged by law to make agreements with land owners and managers of areas adjacent to the flood defences and to take the foreshore into account (POV Waddenzeedijken, 2018). In addition, the waterboard has a desire for more cooperation as indicated in the project plan, as it was thought that enhanced cooperation would lead to increased mutual understanding and a better public image for the waterboard. Lastly, a nature-based approach involving vegetated foreshores, requires a collaborative approach with foreshore stakeholders.

4.2. Introduction and getting to know one another in Noard-Fryslân Bûtendyks (step 1)

The introduction to the Noard-Fryslân Bûtendyks area comprised an introductory round, a site visit (Fig. 3) and an explanation of recent studies done under the auspices of Wetterskip Fryslân. The first workshop was attended by 7 participants from four organisations. The municipality was not represented at this event. Two people from the research team facilitated the workshops. They were supported by

Fig. 3. The Noard-Fryslân Bûtendyks field visit.

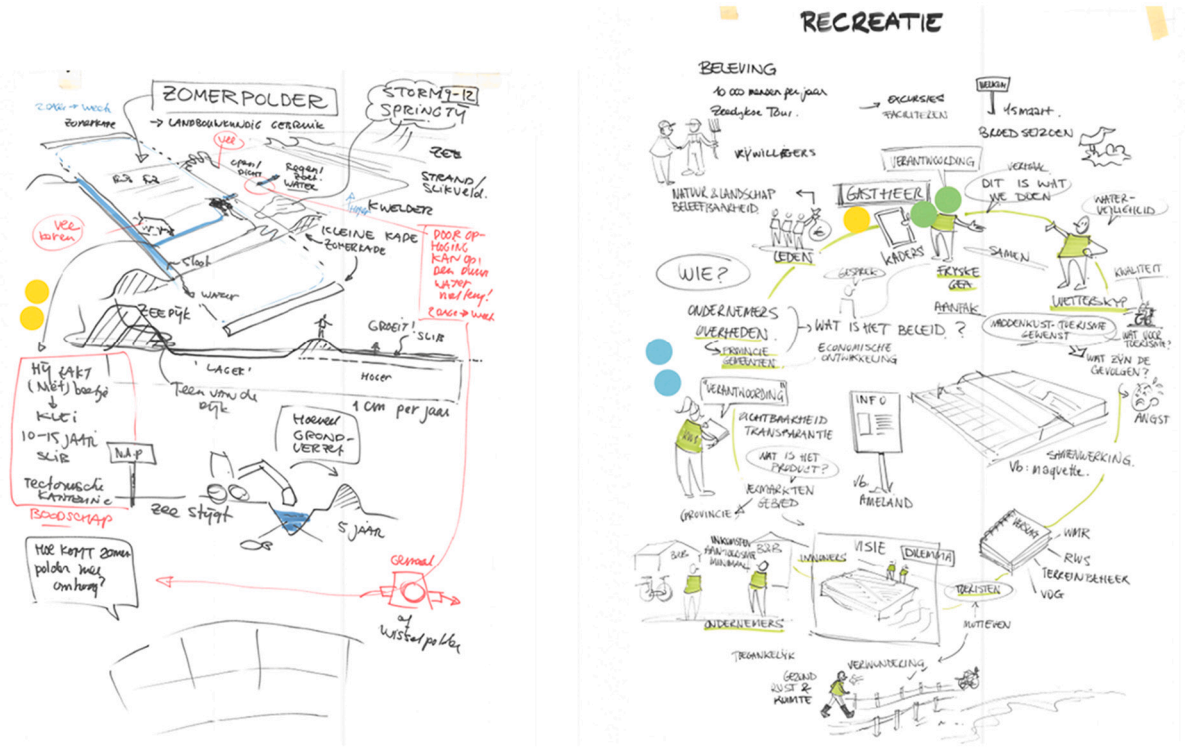


Fig. 4. Depicting opportunities for cooperation in visual format: examples of 'summer polders' and 'recreation'.

technical experts providing input for the discussion. These people were not involved in designing solutions or voting. Furthermore, during the first workshop illustrators were present to capture the discussion. During the introductory round the participants explained who they were, what their role is in the area and with whom they currently cooperate. After the site visit the group gathered at the workshop venue where a representative of each organization presented the current way of working, the ambitions and goals of the organization.

4.3. Identifying opportunities for cooperation in Noard-Fryslân Bûtendyks (Step 2)

The potential areas of cooperation identified in the preparatory phase (step 0) were introduced and discussed with the group. These included summer polders, recreation, ecology, land tenure, salt marsh development, cultural history, and grazing cattle on the dike. The choice was made to explore four topics further, namely summer polders, recreation, salt marsh development, and grazing cattle on the dike.

The group was divided into four smaller groups to address the following questions: What is the issue at hand? Can this be solved? And, who is needed to solve the problems? The latter question is designed to help in identifying potential coalitions. Eight opportunities for cooperation were identified and depicted by an illustrator (see Fig. 4). The eight opportunities are:

- Raising the summer polders[1] using natural processes

[1] 'Summer polders' are the foreshore areas protected from flooding during summer by low dikes. These areas are subject to flooding during heavy winter storms. Natural subsidence of these pastures occurs as the supply of sediment is limited. This results in problems with natural dewatering after rainfall.

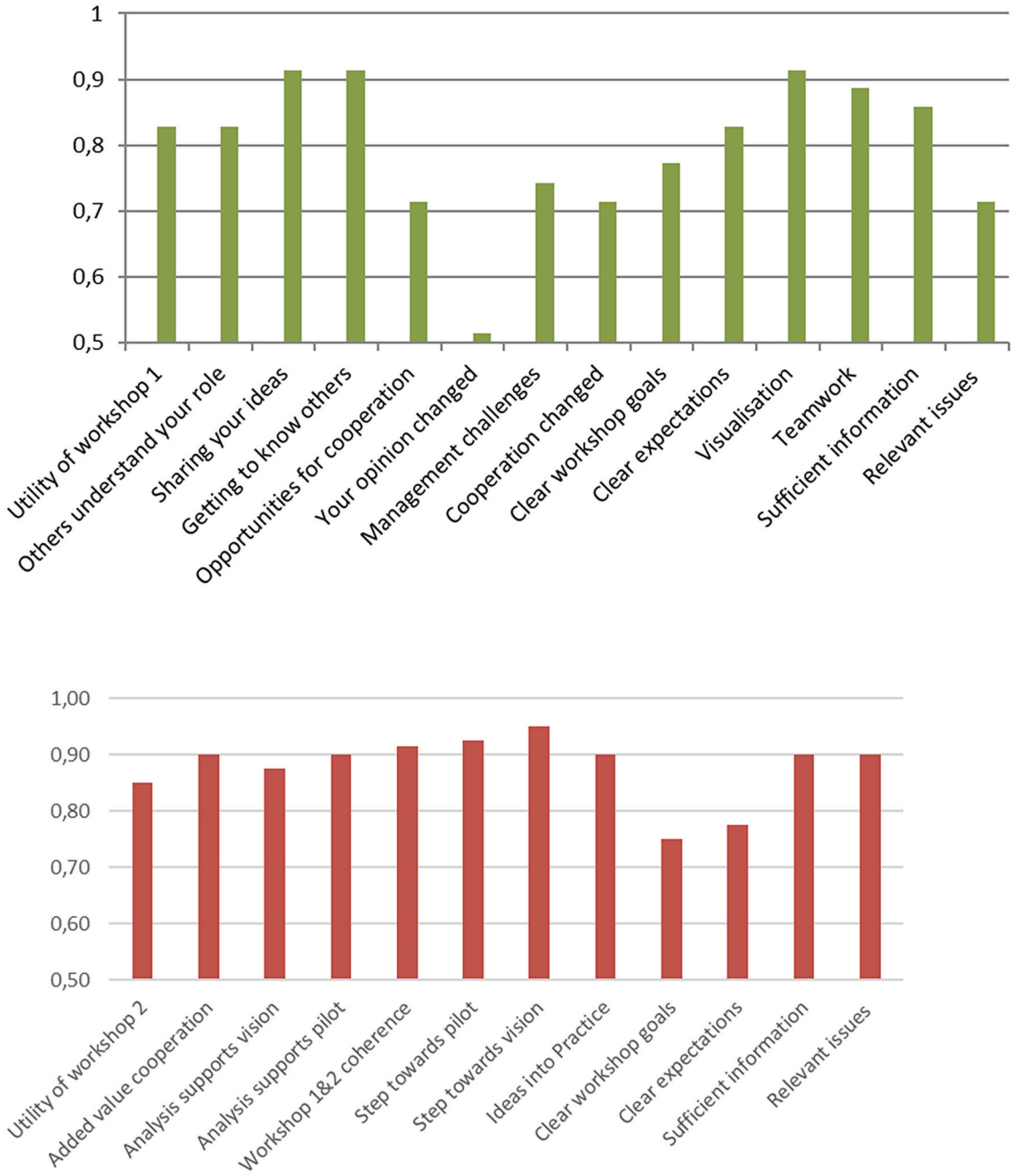


Fig. 5. Evaluation results of Workshop day 1 (Fig. 5a) and Workshop day 2 (Figs. 5b) by the participants.

- Raising the summer polders using material dredged from the navigation channel
- Raising the summer polders using material from the nearby salt marshes
- Allowing recreational activities
- Designing green dike variants (gentle slope or wide green dike)
- Developing joint coastline vision
- Tackling the thistle problem together
- Expanding the grazing season[2]

4.4. Valuing opportunities per stakeholder in Noard-Fryslân Bûtendyks (Step 3)

The participants were then asked to value the opportunities by determining the degree to which an opportunity contributed to achieving the stakeholders' interest or specific goals. Each participant was allocated 20 stickers to divide over the eight opportunities. However, owing to the limited time at the end of the day and the challenge of comparing very diverse cooperation opportunities, the results were of insufficient quality for further analysis. So, an online questionnaire was designed in Survio (www.survio.com) to identify the value assigned to each of the cooperation opportunities per stakeholder. Two questions were asked per identified opportunity, namely:

[2] Breeding by birds in spring and the danger of flooding in October serve to constrain grazing on the foreshore.

- Question 1: Compared to current practice, achieving the goals of your organization by implementing this opportunity will be made *difficult or impossible (−3), much more difficult (−2), a little more difficult (−1), neutral (0), slightly easier (+1), much easier (+2), very easy (+3)*
- Question 2: How critical is your organization to this solution? *Critical, Non critical*

These questions were designed to establish the extent the opportunity contributes to the goals of the different stakeholders, and to identify which coalition of stakeholders would be needed to realise a cooperation opportunity. Note that the participants were not asked to indicate whether other stakeholders were critical to realise the identified cooperation opportunities. Instead, the questions focus on each stakeholder's own point of view. After each question the participants could provide an explanation of their answer. Six participants representing four stakeholders responded to the questionnaire. When more than one participant from the same organization responded the scores were averaged. The results are presented in Table 2. It shows how each of the eight cooperation opportunities are valued by the stakeholders, and who are the critical stakeholders. The cooperation opportunities are ranked according to their total valuation.

4.5. Determining the added value of cooperating in Noard-Fryslân Bûtendyks (Step 4)

The cooperation opportunities identified through the first two steps of the Co-Add process are potentially feasible. However, the valuation per stakeholder (Step 3) indicates that are some are more promising than others. The most promising are those opportunities that deliver high value to the stakeholders involved. However, for a promising opportunity to be realized it is also particularly important that critical stakeholders benefit from it. A stakeholder is considered critical when they control resources without which the project cannot be realized, or if they have power to block the realization of a project (Enserink et al., 2010).

In the analysis, undertaken in step 4 by the authors prior to the second workshop, the eight cooperative opportunities are first characterized using the dominance concept. When there are mutually exclusive cooperation opportunities, the opportunity with highest value is retained. This means that opportunity (6) 'raising summer polders using material dredged from the navigation channel' and opportunity (7) 'raising summer polders using material from the nearby salt marshes' are deemed of less value (see Table 1) and excluded from further analysis as they are dominated by the more promising opportunity 'raising summer polders using natural processes'. This leaves six potential cooperation opportunities for further exploration.

Despite the positive added value that can be obtained, cooperating on all six remaining opportunities is practically challenging, so the analysis proceeds by identifying the feasibility of the opportunities. Cooperation opportunity (1) 'developing joint coastline vision' has a high total value across the actors and delivers positive value to *all* critical actors. This is therefore viewed as the most promising cooperation opportunity. Opportunity (2) 'Tackling the thistle problem together' is rated positive by the critical actors and as such seems a highly promising opportunity as well. The opportunities (3) 'designing green dike variants' and (4) 'expanding the grazing season' are rated positive or neutral by the critical actors. As such, investigation is needed whether the neutral critical actors are willing to participate here. Likewise, cooperation opportunity (5) 'Raising the summer polders using natural processes' seems more complicated. This opportunity generates (high) value for three actors, but it is rated negatively by stakeholder 4 who is critical to its realization. Lastly, cooperation opportunity (8) 'allowing recreational activities' provides the lowest total value across the actors and is valued negatively by one of the critical stakeholders (stakeholder 4). This makes it the least promising alternative for further exploration.

This analysis of the value of the identified cooperation opportunities provides the grounds for discussion in the second workshop session.

4.6. Committing to cooperative action in Noard-Fryslân Bûtendyks (Step 5)

The second workshop on 31 October 2018 was attended by 5 participants from the previous 4 organisations complemented by a participant from the municipality. During this workshop, further technical analyses on the flood safety effects of nature-based flood defences were presented by engineering consultants. This was followed by a presentation of the analysis of the added value of cooperation. No adjustments to the analysis were required as the participants considered it to reflect the value accruing to them through cooperation on each of the opportunities.

The validated analysis formed the starting point for further discussions regarding which cooperative opportunities would be interesting to develop further. The choice was made to initiate a process to develop a coastline vision, i.e. to realise the most promising cooperative opportunity. As stakeholders in addition to those present at the workshop sessions are needed in developing a shared vision for the coastal area, this decision represents a first commitment to action step.

The rest of the discussion focused on cooperation opportunities that could be achieved through collaboration with the organisations represented in the room. For instance, the farmers' concerns regarding the implications of raising the summer polders were discussed. The participants came to understand what actions would be necessary on the part of others in realizing the different opportunities. The participants considered that pilot projects would provide an effective step towards realization. Accordingly, pilot projects related to the most promising cooperation opportunities were identified, namely 'raising summer polders using natural processes' and 'tackling the thistle problem together'.

The participants indicated that consideration of tourism opportunities could be included in the coastline vision development. They were

Table 2
The results of the online valuation of the identified cooperation opportunities ranked according to the total value accruing to the stakeholders. The stakeholders who considered themselves critical to the realization of each opportunity are listed in the last column.

Cooperation Opportunity	Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4	Total Valuation	Critical Stakeholder
(1) Developing joint coastline vision	3	2	2	2	**9**	1,2,3
(2) Tackling the thistle problem together	1	1.5	0	2	**4.5**	1,4
(3) Designing green dike variants (gentle slope or wide green dike)	1	1.5	1	0	**3.5**	1,3,4
(4) Expanding the grazing season	1	0	0	2	**3**	1,3,4
(5) Raising the summer polders using natural processes	3	1.5	1	−2	**3.5**	1,3,4
(6) Raising the summer polders using material from the nearby saltmarshes	1	1.5	0.5	−1	**2**	1,3,4
(7) Raising the summer polders using material dredged from the navigation channel	1	1.5	0.5	−2	**1**	1,3,4
(8) Allowing recreational activities	1	0.5	0	−1	**0.5**	1,4

also aware that a wide green dike was already being tested elsewhere in the Netherlands and so this opportunity was not given priority.

The identification of the opportunities 'raising summer polders using natural processes' and 'tackling the thistle problem together' and the priority given to the development of a coastline vision that incorporates the foreshore as an essential element in the coastal defence, represents the commitment to action arising from the Co-Add application. These choices indicate that the stakeholders recognize the value that the cooperation opportunities hold for their organisations and for others, i.e. they recognize the added value of collaboration.

5. Discussion

5.1. Discussion of the case study outcome

In developing and testing the instrument, we have used the framework of Thissen and Twaalfhoven (2001) in combination with the evaluation criteria of McEvoy et al. (2020) to reflect on the outcome. The results of the evaluation with the participants is shown in Fig. 5. Fig. 5a shows the results after workshop 1, and Fig. 5b the results after workshop 2. The scores of the participants have been normalized.

The evaluation results of workshop 1 show that in general the stakeholders were positive about the utility of the workshop (result), with major effects getting to know each other and the area better. They could share their ideas and to a lesser extent could identify opportunities for cooperation (effects). At the same time their opinions did not change. Despite the relative low clarity on workshop goals and expectations (input and process), the content and results of workshop 2 were similarly highly valued. A next step in effects and use was achieved, including added value on cooperation (effect), steps towards vision and pilot (use). The evaluation did not cover the selection, number and representative nature of the participants in the workshop.

During the workshops the participants discussed joint concerns and practical issues related to the point of view of each stakeholder and then ranked the collaboration opportunities from most to least promising. The stakeholders used the results by selecting three opportunities. Two of these were without a social dilemma, which aligns with the findings of Janssen et al. (2020) that actors prefer solutions without a social dilemma. The social dilemma related to the selected cooperation opportunity 'raising the summer polders using natural processes' was addressed within the Co-Add environment. The affected stakeholders could air their concerns, and the coalition committed to addressing these concerns.

The longer term effects of using the instrument to date are that new choices are made, such as developing a joint coastline vision along with tangible activities around the raising of summer polders and thistle-management. Arguably, choosing for a joint coastline vision is not an outcome that distinguishes Co-Add from other participatory exercises. Through the Co-Add process, however, short-term and practical cooperative activities can be fed into the joint visioning process, potentially strengthening it. Another longer-term effect is the participation of the involved organisations in a new follow-up NWO research project called 'Living Dikes'. So, the example of Noard-Fryslân Bûtendyks indicates that the designed Co-Add instrument could be applied in practice and it shows that it has the potential to facilitate a systematic exploration of the added value of cooperation.

5.2. Assumptions, conditions and limitations of Co-Add

However, this promising initial result makes a critical reflection on the assumptions, the conditions to be met for application of Co-Add, and some of the potential pitfalls, even more necessary. Critical assumptions underlying the instrument include first that no single stakeholder can determine the outcome. Instead the actions of multiple stakeholders determine whether there are potential cooperation opportunities. Stakeholders are dependent on each other to achieve particular results. Second, each actor assesses the value of a cooperation opportunity based on their 'subjective' perspectives and technical knowledge provided during the second workshop by researchers who studied the identified opportunities. One needs to realise that the added value of cooperation is a snapshot and may change with time when valuations alter, for example when actors get new information. The focus of Co-Add on dialogue with people representing groups of interests contrasts with methods such as social cost benefit analysis (SCBA). SCBA, that is commonly used in flood defence assessments in the Netherlands, aims to obtain a more representative measure of a larger population, for example obtained through surveys rather than through dialogue (cf. Ruijgrok and De Groot, 2006). A third assumption of Co-Add is the free will of the stakeholders to cooperate to gain benefit, i.e. it looks for win-win situations in which cooperation delivers more than not cooperating. Instruments such as strategic stakeholder management (SSM) similarly focus on supporting dialogue to 'find a solution that is supported by all involved parties and considered as beneficial' (Wesselink and Paul, 2010, p.13). However, the mutual gains in SSM are evaluated in a qualitative manner, whereas Co-Add focuses on identifying and subjectively quantifying cooperation opportunities, providing a rank ordering per stakeholder and per cooperation opportunity.

Conditions for the application of Co-Add are that stakeholders wish to cooperate more with each other or realise they could achieve more value by cooperating but do not yet know how to do so. In such a situation, application of the Co-Add instrument for area-specific participative planning processes could be undertaken. Furthermore, careful implementation of the instrument is critical for success. The steps to be taken should be very clear and participants should be selected with care. For instance, all relevant stakeholders should be invited, the dominance of particular sectoral interests should be avoided, and stakeholders need to be able to commit the time required. Otherwise there will be no commitment to the process or results might not be taken seriously. It also happens in real world cases that not everyone can be present during the entire process, which is a potential pitfall. That was the case with the municipality during the first workshop in NFB. If this happens, an assessment of whether to proceed with the process as planned needs to be made, or whether their input can be secured in another way, for example by interviewing them beforehand and checking results afterwards. Other potential pitfalls are the length of the workshops: are participants willing and able to spend two days? And, how much room is there for flexibility? In the case of NFB these concerns could be dealt with, for example by transitioning step 3 from a workshop activity to an online questionnaire. This shows both that the workshop design was too optimistic in terms of time, and that there is the flexibility to adapt the activity to fit the situation.

5.3. Further development and learning about Co-Add and similar instruments

To deepen the understanding of the value, the functioning and pitfalls of Co-Add it would be good to further evaluate the instrument in a structured manner. Useful methods include before-after measurements of participants' problem understanding or the use of an observer (McEvoy et al., 2018; McEvoy et al., 2019). Such evaluation can facilitate identifying the learning that occurs, how the instrument contributes to the decisions made, and which parts of the instrument are considered useful or would benefit from improvement. Moreover, applying Co-Add in multiple case studies will provide additional insights on the instrument and its application, and can facilitate developing and testing strategies to overcome the pitfalls. For example, would Co-Add work in bigger groups, or in more contested situations, and can it be less time-intensive? Or, how could the input and commitment of stakeholders that are absent during the workshops be secured in the follow up process? Or, could online workshops fully or partially replace the physical workshops? Would this facilitate wider involvement of stakeholders? These questions pose challenges to research on participatory methods in

general and to instruments like Co-Add in particular.

As the foundations of Co-Add lie in policy analysis and game theory, it is specifically suited to real-world (operational) problems concerned with multiple stakeholders who have not (yet) formed coalitions or at least have not explored ways of addressing the problem in a group setting. Case studies in the biophysical public domain or at the interface of the public-private domain are particularly suitable for Co-Add because of the multi-stakeholder context where coalition building may lead to added value. By applying the instrument, stakeholders will gain insight regarding the feasibility of an opportunity: does it lead to added value for them and others, and are all critical stakeholders willing to participate? Co-Add is less useful when stakeholders are not interested in cooperation, when the problems are relatively small compared to the required time investment, or some of the conditions such as mutual trust are not met.

6. Conclusion

The instrument Co-Add was developed to enable stakeholders to systematically identify cooperation opportunities in complex natural resource management and decision-making situations involving multiple organisations with diverse interests and individual constraints such as budgeting limits. In particular, the instrument seeks to facilitate the exploration of cooperation opportunities to overcome social dilemmas. Nature-based flood defence solutions are characterized by social dilemmas (Janssen et al., 2020) and a case study in Noard-Fryslân Bûtendyks formed the locus for application of the Co-Add instrument. In this application, the stakeholders were found (i) to understand the added value of cooperation opportunities as well as which stakeholders are needed to realise the cooperation opportunity, (ii) to embrace a broader view than just that of their own organization, (iii) to identify which solutions are more achievable than others, and (iv) to select a known social dilemma for follow-up action.

Cooperation is not always an obvious or easy option. It brings challenges with respect to planning, control and budget. At the same time, it can bring added value. The Co-Add instrument facilitates the participatory identification of this potential added value and how it can be realized. The instrument represents an intervention that takes into account the interests of all stakeholders involved. Although the application of the method in the case Noard-Fryslân Bûtendyks revealed that the instrument works in practice, it is necessary to undertake other area-specific participative planning processes to test and evaluate it further. Research into the more general applicability of the Co-Add instrument could address its potential use as a monitoring instrument on the changing added value of cooperation within a given network or its potential use within serious games to enable stakeholders to understand the value of cooperating.

Credit author statement

Heleen Vreugdenhil has had the lead in writing the original draft using the workshop reports and instrument description. She developed the storyline (introduction, theory and discussion/ conclusions) and has done the project organization.

Stephanie Janssen has developed the structure of the Co-Add instrument and has tested this in the case study. She has organised the process and wrote the results in a report. She critically reflected on the paper and has made significant contributions to the case study description.

Jill Slinger has given the paper theoretical depth and did extensive editing.

Leon Janssen has acquired the funding. He has supervised Stephanie and Heleen, was involved in the empirical study and actively contributed to the writing and editing, in particular on game theory.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work is part of the research project BE SAFE (Bio-Engineering for Safety using vegetated forshores, Projectnumber 850.30.014), financed primarily by the Netherlands Research Council (NWO). The involvement of HV and JS was also supported by the Multi-actor Systems Research Programme of the Delft University of Technology. Moreover, the authors are particularly grateful to the participants of the workshops and the reviewers who really helped to improve the paper.

References

Bark, R.H., Martin-Ortega, J., Waylen, K.A., 2021. Stakeholders' views on natural flood management: implications for the nature-based solutions paradigm shift? Environ Sci Policy 115, 91–98. https://doi.org/10.1016/j.envsci.2020.10.018.

Basco-Carrera, L., Warren, A., van Beek, E., Jonoski, A., Giardino, A., 2017. Collaborative modelling or participatory modelling? A framework for water resources management. Environ. Model. Softw. 91, 95–110.

Baum, F., MacDougall, C., Smith, D., 2006. Participatory action research. J. Epidemiol. Community Health 60 (10), 854.

Begg, C., 2018. Power, responsibility and justice: a review of local stakeholder participation in European flood risk management. Local Environ. 23 (4), 383–397.

Bradford, R.A., O'Sullivan, J.J., van der Craats, I.M., Krywkow, J., Rotko, P., Aaltonen, J., Bonaiuto, M., De Dominicis, S., Waylen, K., Schelfaut, K., 2012. Risk perception – issues for flood management in Europe. Nat. Hazards Earth Syst. Sci. 12, 2299–2309. https://doi.org/10.5194/nhess-12-2299-2012.

Bridges, T.S., Banks, C.J., Chasten, M.A., 2016. Engineering with nature. Advancing system resilience and sustainable development. Mil. Eng. 108, 52–54. Available online: https://ewn.el.erdc.dren.mil/pub/Pub_1_EWN_TME-JanFeb2016.pdf.

Browder, G., Ozment, S., Bescos, I.R., Gartner, T., Lange, G.-M., 2019. Integrating Green and Gray: Creating Next Generation Infrastructure. World Bank and World Resources Institute, Washington, DC, USA, p. 134. ISBN 978-1-56973-955-6.

Capgemini Consulting, 2013. Accelerated Solutions Environment. The innovative way to resolve complex issues. https://www.capgemini.com/consulting-de/wp-content/uploads/sites/32/2017/08/ase-broschure-en-web.pdf.

Clifford-Holmes, J.K., Slinger, J.H., de Wet, C., Palmer, C.G., 2018. Modelling in the 'muddled middle': a case study of water service delivery in post-Apartheid South Africa. In: Social Systems Engineering: The Design of Complexity, Vol. ch11. John Wiley & Sons, Hoboken, New Jersey, USA, pp. 215–234. https://doi.org/10.1002/9781118974414.

Colman, A.M., Bacharach, M., 1997. Payoff dominance and the Stackelberg heuristic. Theor. Decis. 43 (1), 1–19.

Cunningham, S.W., Hermans, L.M., Slinger, J.H., 2014. A review and participatory extension of game structuring methods. EURO J Decis Process 2, 173–193.

Cunningham, S.C., Kothuis, B., Slinger, J.H., 2015. Contested issues game structuring approach. In: Kothuis, et al. (Eds.), Delft Delta Design. Houston Galveston Bay Region Texas, USA. Delft University Publishers, Delft, NL.

d'Hont, F.M., 2020. Co-design in the coastal context. PhD Thesis. Delft University of Technology. https://doi.org/10.4233/uuid:0fdce774-854d-4b2e-a391-758479dd5abc.

Enserink, B., Kwakkel, J., Bots, P., Hermans, L., Thissen, W., Koppenjan, J., 2010. Policy Analysis of Multi-Actor Systems. Eleven International Publ.

Evers, M., Jonoski, A., Maksimovič, Č., Lange, L., Ochoa Rodriguez, S., Teklesadik, A., Cortes Arevalo, J., Almoradie, A., Eduardo Simões, N., Wang, L., Makropoulos, C., 2012. Collaborative modelling for active involvement of stakeholders in urban flood risk management. Nat. Hazards Earth Syst. Sci. 12, 2821–2842. https://doi.org/10.5194/nhess-12-2821-2012.

Fisher, R., Ury, W., Patton, B., 1991. Getting to Yes: Negotiating Agreement Without Giving In. Randhom House Business Books, London.

Fleischhauer, M., Greiving, S., Flex, F., Scheibel, M., Stickler, T., Sereinig, N., Koboltschnig, G., Malvati, P., Vitale, V., Grifoni, P., Firus, K., 2012. Improving the active involvement of stakeholders and the public in flood risk management – tools of an involvement strategy and case study results from Austria, Germany and Italy. Nat. Hazards Earth Syst. Sci. 12, 2785–2798. https://doi.org/10.5194/nhess-12-2785-2012, 2012.

Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., Nanu, F., 2020. Enhancing nature-based solutions acceptance through stakeholders' engagement in co-benefits identification and trade-offs analysis. Sci. Total Environ. 713, 136552.

Hermans, L., Cunningham, S., Slinger, J., 2014. The usefulness of game theory as a method for policy evaluation. Evaluation 20, 10–25.

Hermans, L., Cunningham, S., de Reuver, M., Timmermans, J., 2018. Actor and Strategy Models : Practical Applications and Step-Wise Approaches. Wiley, Hoboken, NJ.

Janssen, S.K.H., Hermans, L.M., 2017. Voorlanden voor Veiligheid. Analyse van implementatiedilemma's in de casestudy Koehool-Lauwersmeer. Werkdocument (in Dutch).

Janssen, S.K.H., Hermans, L.M., Vreugdenhil, H.S.I., 2019. Handreiking Meerwaarde van Samenwerken: Een participatief instrument voor het vormen van coalities (in Dutch).
Janssen, S., Vreugdenhil, H., Hermans, L., Slinger, J., 2020. On the nature-based flood defence dilemma and its resolution: a game theory based analysis. Sci. Total Environ. 705, 135359.
Karl, H.A., Susskind, L.E., Wallace, K.H., 2007. A dialogue, not a diatribe: effective integration of science and policy through joint fact finding. Environ. Sci. Policy Sustain. Dev. 49 (1), 20–34.
Kelly, A., 2003. Decision Making Using Game Theory: An Introduction for Managers. Cambridge University Press.
Ker Rault, P.A., Jeffrey, P.J., 2008. Deconstructing public participation in the Water Framework Directive: implementation and compliance with the letter or with the spirit of the law? Water Environ. J. 22 (4), 241–249.
Ker Rault, P.A., Vreugdenhil, H., Jeffrey, P., Slinger, J.H., 2013. Readiness and willingness of the public to participate in integrated water management: some insights from the Levant. Water Policy 15 (S2), 101–120.
Kerr, N.L., 1983. Motivation losses in small groups: a social dilemma analysis. J. Pers. Soc. Psychol. 45 (4), 819–828. https://doi.org/10.1037/0022-3514.45.4.819.
Klaassen, R., Kothuis, B., Slinger, J., 2021. Engineering roles in Building with Nature interdisciplinary design - Educational experiences. In: van Bergen, J., Nijhuis, S., Brand, N., Hertogh, M. (Eds.), Building with Nature Perspectives. Cross-Disciplinary BwN Approaches in Coastal Regions. Research in Urbanism Series (RiUS) Vol 7. TU Delft Open, Delft, Netherlands, pp. 73–98. ISBN: 978-94-6366-379-3.
Kothuis, B., Slinger, J., Cunningham, S., 2014. Contested Issues Game Structuring approach - CIGAS workshop Houston report, results and refection: Exploring stakeholder-based joint commitment to action for flood protection decision-making in the Houston Galveston Bay Area. http://repository.tudelft.nl/view/ir/uuid%3A20692794-0d27-41c9-881f-60c89071ed13/.
Lane, S., 2017. Natural flood management. *WIREs* Water 2017 (4), e1211. https://doi.org/10.1002/wat2.1211.
Lynch, A.L., Murthy, U.S., Engle, T.J., 2009. Fraud brainstorming using computer-mediated communication: the effects of brainstorming technique and facilitation. Account. Rev. 84 (4), 1209–1232.
Mayer, I.S., Van Daalen, C.E., Bots, P.W., 2004. Perspectives on policy analyses: a framework for understanding and design. Int. J. Technol. Policy Manag. 4 (2), 169–191.
McEvoy, S., van de Ven, F.H.M., Blind, M.W., Slinger, J.H., 2018. Planning support tools and their effects in participatory urban adaptation workshops. J. Environ. Manag. 207, 319–333.
McEvoy, S., van de Ven, F.H., Santander, A.G., Slinger, J.H., 2019. The influence of context on the use and added value of planning support systems in workshops: an exploratory case study of climate adaptation planning in Guayaquil, Ecuador. Comput. Environ. Urban. Syst. 77, 101353.
McEvoy, S., van de Ven, F.H., Brolsma, R., Slinger, J.H., 2020. Evaluating a planning support system's use and effects in urban adaptation: an exploratory case study from Berlin, Germany. Sustainability 12 (1), 173.
Meyer, V., Kuhlicke, C., Luther, J., Fuchs, S., Priest, S., Dorner, W., Serrhini, K., Pardoe, J., McCarthy, S., Seidel, J., Palka, G., Unnerstall, H., Viavattene, C., Scheuer, S., 2012. Recommendations for the user-specific enhancement of flood maps. Nat. Hazards Earth Syst. Sci. 12, 1701–1716. https://doi.org/10.5194/nhess-12-1701-2012.
MG Taylor Corporation, 1997. Modeling Language Spotlight. Scan, Focus, Act. http://legacy.mgtaylor.com/mgtaylor/glasbead/SFA.htm.
Mingers, J., Rosenhead, J., 2004. Problem structuring methods in action. Eur. J. Oper. Res. 152 (3), 530–554.
MinIenM, 2015. Kader Zorgplicht Primaire Waterkeringen. Den Haag [in Dutch].
Mitsch, W.J., 1996. Ecological Engineering: a new paradigm for engineers and ecologists. In: Schulze, P.C. (Ed.), Engineering within Ecological Constraints. National Academy Press, Washington, DC, USA, pp. 114–132.
Morris, R.L., Konlechner, T.M., Ghisalberti, M., Swearer, S.E., 2018. From grey to green: Efficacy of eco-engineering solutions for nature-based coastal defence. Glob. Chang. Biol. 24 (5), 1827–1842. https://doi.org/10.1111/gcb.14063.
Nesshöver, C., Assmuth, T., Irvine, K.N., Rusch, G.M., Waylen, K.A., Delbaere, B., Wittmer, H., 2017. The science, policy and practice of nature-based solutions: an interdisciplinary perspective. Sci. Total Environ. 579, 1215–1227.
Ostrom, E., 2001. Social Dilemmas and Human Behaviour. *Economics in Nature: Social Dilemmas, Mate Choice and Biological Markets*, pp. 21–41.
O'Sullivan, J.J., Bradford, R.A., Bonaiuto, M., De Dominicis, S., Rotko, P., Aaltonen, J., Waylen, K., Langan, S.J., 2012. Enhancing flood resilience through improved risk communications. Nat. Hazards Earth Syst. Sci. 12, 2271–2282. https://doi.org/10.5194/nhess-12-2271-2012.
Paavola, J., Hubacek, K., 2013. Ecosystem services, governance, and stakeholder participation: an introduction. Ecol. Soc. 18 (4).
Pleijte, M., Kuidersma, W., Hettinga, N., Tepic, J., 2014. Samenwerken in gebiedsontwikkeling. Een verkenning naar rollen en ambities van Rijkswaterstaat. Dienst Landelijk Gebied en waterschappen in gebiedsontwikkeling, Alterra Wageningen UR, Wageningen [in Dutch].
POV Waddenzeedijken, 2018. Dijk met Voorland. Plan van aanpak Fase B (inclusief rapportage Fase A) [in Dutch].
Raiffa, H., Richardson, J., Metcalfe, D., 2002. Negotiation Analysis: The Science and Art of Collaborative Decision Making, 1st edition. Harvard University Press.
Roode, N., Maaskant, B., Boon, M., 2019. Handreiking Voorland. Projectoverstijgende Verkenning Voorlanden. [in Dutch].
Ruijgrok, E.C.M., De Groot, R.S., 2006. Kentallen Waardering Natuur, Water, Bodem en Landschap: hulpmiddel bij MKBA's [in Dutch].
Scharpf, F.W., 1997. Games Real Actors Play: Actor-Centered Institutionalism in Policy Research. Westview Press, Boulder, CO.
Slinger, J.H., 2015. Data from: Building with Nature @ TU Delft 2015 [Data/Video Material] 4TU Centre for Research Data. Retrieved from. https://doi.org/10.4121/uuid:cf9101c3-7eac-4e36-b500-df96c02dc034.
Slinger, J.H., 2016. Data from Engineering: Building with Nature 101x: Series of 11 Videos. [Data/Video material]. 4TU Centre for Research Data. Retrieved from. https://doi.org/10.4121/uuid:721edfdb-a984-470d-be4e-d66161c6c811.
Slinger, J.H., Vreugdenhil, H.S.I., 2020. Coastal engineers embrace nature: characterizing the metamorphosis in hydraulic engineering in terms of four Continua. Water 12 (9), 2504.
Slinger, J.H., Cunningham, S.W., Hermans, L.M., Linnane, S.M., Palmer, C., 2014. A Game-Structuring Approach Applied to Estuary Management in South Africa, 2, pp. 341–363.
Slinger, J., Stive, M., Luijendijk, A., 2021. Nature-based solutions for coastal engineering and management. Water. 13 (7), 976. https://doi.org/10.3390/w13070976.
Straffin, P.D., 1993. Game Theory and Strategy. The Mathematical Association of America, Washinton, DC.
Susskind, L.E., Landry, E.M., 1991. Implementing a mutual gains approach to collective bargaining. Negot. J. 7 (1), 5–10.
Temmerman, S., Meire, P., Bouma, T.J., Herman, P.M., Ysebaert, T., De Vriend, H.J., 2013. Ecosystem-based coastal defence in the face of global change. Nature 504 (7478), 79–83.
Thieken, A.H., Mariani, S., Longfield, S., Vanneuville, W., 2014. Preface: flood resilient communities – managing the consequences of flooding. Nat. Hazards Earth Syst. Sci. 14, 33–39.
Thissen, W.A., Twaalfhoven, P.G., 2001. Towards a conceptual structure for evaluating policy analytic activities. Eur. J. Oper. Res. 129 (3), 627–649. https://doi.org/10.1016/S0377-2217(99)00470-1.
Thissen, W.A., Walker, W.E., 2013. Public Policy Analysis. Springer.
Van Loon-Steensma, J.M., 2015. Salt marshes to adapt the flood defences along the Dutch Wadden Sea coast. Mitig. Adapt. Strateg. Glob. Chang. 20, 929–948. https://doi.org/10.1007/s11027-015-9640-5.
Van Popering-Verkerk, J., Van Buuren, A., 2017. Developing collaborative capacity in pilot projects: Lessons from three Dutch flood risk management experiments. J. Clean. Prod. 169, 225–233.
Van Wesenbeeck, B.K., Mulder, J.P.M., Marchand, M., Reed, D.J., de Vries, M.B., de Vriend, H.J., Herman, P.M.J., 2014. Damming deltas: a practice of the past? Towards nature-based flood defences. Estuar. Coast. Shelf Sci. 140, 1–6.
Vinke-de Kruijf, J., Kuks, S.M., Augustijn, D.C., 2015. Governance in support of integrated flood risk management? The case of Romania. Environ. Develop. 16, 104–118.
Voorendt, M., 2017. Design principles of multifunctional flood defences. PhD thesis. Delft University of Technology, The Netherlands.
Vreugdenhil, H.S.I., Slinger, J.H., Kater, E., 2007. Adapting scale use for successful implementation of Cyclic Floodplain Rejuvenation in the Netherlands. In: Pahl-Wostl, C., Kabat, P., Möltgen, J. (Eds.), Adaptive and Integrated Water Management. Springer, pp. 301–321.
Vuik, V., Jonkman, S.N., Borsje, B.W., Suzuki, T., 2016. Nature-based flood protection: the efficiency of vegetated foreshores for reducing wave loads on coastal dikes. Coast. Eng. 116, 42–56.
Vuik, V., Jonkman, S.N., Willemsen, P.W.J.M., Borsje, B.W., Janssen, S.K.H., Hermans, L.M., Bouma, T.J., 2019. Voorlanden voor hoogwaterbescherming. H2O Water Matters Kennismagazine voor waterprofessionals (in Dutch).
Walker, W.E., 2000. Policy analysis: a systematic approach to supporting policymaking in the public sector. J. Multi-Criteria Decis. Anal. 9 (1–3), 11–27.
Water Act (Waterwet), 2009. visited 25-11-2020. update 2020. https://wetten.overheid.nl/BWBR0025458/2020-07-01/.
Waterman, R.E., 2010. Integrated Coastal Policy via Building with Nature. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands. Available online: http://resolver.tudelft.nl/uuid:fa9a36f9-7cf8-4893-b0fd-5e5f15492640.
Wesselink, M., Paul, R., 2010. Handboek Strategisch Omgevings Management. Met de casus: SOM toegepast op de besluitvorming Maasvlakte 2. Kluwer, Deventer.
Wetterskip Fryslân, 2016. Plan van aanpak verkenning Koehool-Lauwersmeer, Hoogwaterbeschermingsprogramma.
Wingfield, T., Macdonald, N., Peters, K., Spees, J., Potter, K., 2019. Natural Flood Management: beyond the evidence debate. Area. 2019 (51), 743–751. https://doi.org/10.1111/area.12535.
Witte, E.H., 2007. Toward a group facilitation technique for project teams. Group Processes & Intergroup Relations 10 (3), 299–309.