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Asset management of flood defences as a co-production—An analysis of cooperation in five situations in the Netherlands

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Abstract

Flood defences are in practice often multi-used, multi-managed and multi-financed. Flood defence asset management contains technical, organizational and spatial complex issues involving multiple organizations. In the literature, little attention has been given to the conditions for successful cooperation between organizations in flood defence asset management. This paper elaborates on this aspect of mature asset management from a practical point of view. Although the importance of a fit-for-purpose cooperation seems trivial, practice shows that the shape of cooperation is often the coincidental result of implicit or ad-hoc choices and is not deliberately designed. This paper reports on empirical data gathered in a case consisting of five different situations related to collaboration in flood defence management. The management context consists of three main tasks: performance assessment, reinforcement and daily management, and three decision levels: strategic, tactical and operational, resulting in nine different management environments and related interfaces. For effectively achieving desired outcomes, the shape of cooperation has to be explicitly chosen dependent on the complexity of content and organizational context, and relevant external circumstances: *situational cooperation*.

KEYWORDS

asset management, integrated flood risk management, risk governance, embankments and levees

1 | INTRODUCTION

Flood defence asset management is technically and organizationally complex because of the nature of flood defence infrastructure, the location in public space, the number of involved parties, the financial structure and the large risks of flooding. In flood defence asset management, roles and responsibilities are often fragmented within and between organizations (Bakker & Cook, 2011; Deltares, 2020; Mees et al., 2018). Cooperation within and between organizations is necessary (FAIR, 2020) as a part of mature asset management. It seems an open door that such shapes of cooperation ideally would be deliberately designed to be fit-for-purpose to a particular management context. However, practice suggests that the shape of cooperation is often the result of implicit or ad-hoc choices. In this paper, we elaborate on the cooperation in practice, based on a case with five different situations in flood defence asset management and we provide recommendations to move forward.

Asset management (AM) is defined as "the coordinated activities of an organization to realize value from assets. Realization of value will normally involve a balancing of costs, risks, opportunities and performance benefits" (ISO, 2014, par. 3.3.1.). This definition is applicable to all types of assets. Following this definition, flood defence asset management contains governance, risk management, reinforcement and maintenance. Cooperation between role holders on different decision levels is important for effective asset management of infrastructures (Swier, 2019; Van der Velde et al., 2013). In two recent flood defence asset management research projects, FAIR (FAIR, 2020; Vonk et al., 2020) and ROBAMCI (Deltares, 2020), three decision contexts or decision levels were distinguished: strategic, tactical and operational (Figure 1). The *strategic level* is about flood defence policy and focuses on the long term and flood defence context. The *tactical level* is about prioritization and planning at the system level and focuses on the mid-long term horizon. The *operational level* is about actual projects and interventions and focuses on the short term. Higher levels provide boundary conditions for tasks on a lower level, and lower levels provide feedback to higher levels. Following these decision levels, three roles are defined for asset management of systems: (1) the asset owner, who has the ultimate responsibility for the function to be delivered by the asset portfolio (strategic level), (2) the asset manager, who is responsible for the compliance of the total asset portfolio with standards, budgets, spatial planning and stakeholder requirements (strategic and tactical level), and (3) the service provider, who is responsible for the actual condition of assets given the available budgets and spatial and stakeholder constraints (operational level).

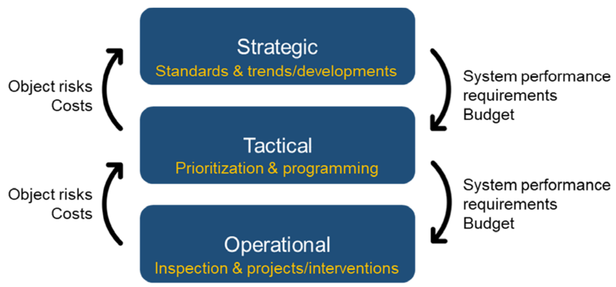

FIGURE 1 Decision levels for infrastructure asset management.

The primary function of flood defences is to prevent floods. In addition, often other types of infrastructure (e.g., communication networks, roads, wind turbines, and buildings are built on or adjacent to flood defences (Kothuis & Kok, 2017; Voorendt, 2017). Natural habitats of flora and fauna are on the flood defences as well (Marijnissen et al., 2021). Thus, flood defences are multi-functional, multi-financed and therefore multi-managed (FAIR, 2020; Hulscher et al., 2021). The complexity of flood defence asset management increases due to technical innovations, data requirements, and changes in policy, such as the change in safety standards in the Netherlands (Deltares, 2020; FAIR, 2020; Staatsblad, 2016).

Due to the increasing complexity, practical bottlenecks and dilemmas arise. This prompts flood defence asset management to mature (Volker et al., 2013). Goldratt and Cox (1986) point out the role of bottlenecks in a manufacturing process, defining a bottleneck as a constraint resource that creates limitations in the production process. In this paper, we use this definition in the context of cooperation for flood risk management: the constraints are the interests of involved stakeholders, creating limitations to the asset management process of dikes. In this paper, a dilemma is defined as a situation in which a nontrivial choice has to be made between options to solve the bottleneck. This choice is difficult because all options have downsides leading to ambiguous solutions.

The last decades have witnessed a tendency towards integrated management of resources (e.g., Correljé & Broekhans, 2015; Bubeck et al., 2017; Dinh & McIntosh, 2019). At the same time, aversion to change leads to a preference for traditional approaches within the flood risk management sector (Deltares, 2019; Dent & Goldberg, 1999; Gillessen et al., 2016). This conservative balance between stability and change is intrinsically given by the capital importance of the end goal: to protect people and properties against flooding (Wiering et al., 2017). However, this hampers innovation and fully integrated management (Avoyan & Meijerink, 2021; Cumiskey et al., 2019). Woodhouse (2014) highlighted the importance of finding the best mix of activities to provide the best life cycle performance and to optimize work delivery programs of the managed assets. Key elements in such an integrated approach would be participation and cooperation (Almoradie et al., 2015; Cumiskey et al., 2019). However, establishing cooperation among the main actors involved in flood risk management is a challenge (Ishiwatari, 2019).

The aim of this paper is to explore the practice of cooperation in flood defence asset management. This paper contributes to the limited literature found on this subject and explores insights for shaping successful cooperation within and between involved organizations.

This research takes an organizational perspective on flood defence asset management and focuses on the shape of cooperation in different situations of flood defence asset management. We presume that in practice the shape of cooperation depends on ad hoc responses to bottlenecks and dilemmas. The research question, therefore, is: how do dilemmas and bottlenecks influence the shape of cooperation in the practice of flood defence management?

The next sections present the methodology, case study results, and discussion and conclusion.

2 | METHODOLOGY

This research has an exploratory character in the sense that its main contribution is in the empirical data gathered in the case of the Netherlands. This case is selected because it has a rich history in flood defence asset management with institutional settings that have developed over many centuries. Case studies are a preferred strategy to answer "why" and "how" questions (Yin, 2003).

We consulted nine regional Water Authorities and the Foundation for Applied Water Research (STOWA) to inventory situations reflecting experienced organizational problems and practices on the interfaces of different decision levels and different main flood defence management tasks.

Within this context, five "common" asset management situations were selected based on the following criteria:

1. Situations should be geographically distributed in the Netherlands and related to primary dikes.
2. Situations should be coping with asset management questions that require cooperation on different decision levels.
3. The set of situations should include a variety of flood defence tasks, such as daily management, performance assessment and reinforcement.
4. The situations should span across the entire field of strategic, tactical and operational asset management.
5. Situations should be representative, in the sense that they are likely to occur in multiple Water Authorities.

The five situations cover several interfaces between decision levels and main flood defence tasks. Full coverage of the field of asset management was not possible within this exploratory study.

For each situation, data were gathered through semi-structured interviews and document analysis. To create a broad view of actual practice, in total 67 interviews were held with respondents holding different roles and responsibilities, see Table 1, providing the names of the situations in the first column.

We performed a qualitative analysis of the situations. The response of institutions to changes is reflected in dilemmas and bottlenecks at these interfaces. For each situation, we extracted dilemmas and bottlenecks, shapes of cooperation to overcome them, and crucial aspects to improve the cooperation. Each situation resulted in a

TABLE 1 Overview of interviews per role and per situation in the case.

Situation	Board and management	Project management team	Daily maintenance	Specialists and intern consultants	Other Water Authorities and HWBP	Knowledge institutes and private parties	Totals
1. Trajectory approach – Strategy development of trajectory reinforcement	2	5		6			13
2. Management agreement liquefaction prevention	1			2	3	1	7
3. Innovative dike reinforcement		5	3	5	3	4	20
4. Dealing with damage to dikes by beavers	4		4	6	1	1	16
5. Vision on long term monitoring	1	2	1	7			11
total	8	12	8	26	7	6	

separate report and in this paper, a meta-analysis is reported on the bottlenecks and dilemmas related to the challenges of cooperation. This meta-analysis was verified by experts from all organizations involved.

To show the current and desired shape of cooperation, we plotted the observed development of the organization on two dimensions of cooperation. For the first dimension, the intensity levels of cooperation defined by Sadoff and Grey (2005) have been used (unilateral, coordination, collaboration, and joint action). For the second dimension, a distinction has been made between internal and external cooperation, corresponding with the Infrastructure Asset Management Maturity Model (IM^3, Volker et al., 2013). Herein, internal cooperation is defined as cooperation within an independent government institution and external cooperation is defined as cooperation between an independent government institution and another actor (public or private).

Based on the analysis of situations and literature insights, directions to shape the organization of flood defence asset management for effective collaboration are proposed.

3 | CASE STUDY: COOPERATION IN THE NETHERLANDS

3.1 | Context of flood defence asset management

Asset management of the primary flood defences is a joint legal task of the Ministry of Infrastructure and Water Management (from now on "The Ministry") and 21 regional Water Authorities. Water Authorities are responsible for the management of the majority of the primary flood defences in their respective regions, consisting of dikes and hydraulic structures. The Ministry is responsible for the dunes, storm surge barriers and large dams protecting low-lying western parts of the country against storm surges. These organizations cooperate with other public authorities and have three main tasks in flood defence asset management.

The first task is the daily management of flood defences, mainly performed by the Water Authorities. It includes inspection, maintenance, licensing and management of the revetments. Daily management during high water events includes high water inspection, implementing emergency measures if needed, and collecting and communicating information between organizational levels within the Water Authorities and regional crisis management teams headed by the safety region (ENW, 2017). During high water events, the Ministry is responsible for flood forecasting and warning, and the Ministry, provinces, and safety regions are responsible for evacuation.

The second main task is the periodic safety assessment (every 12 years). The Ministry is responsible for the development of design and assessment rules and the tools to perform the calculations (en Milieu, 2017). The Water Authorities are responsible to perform the assessments. Most Water Authorities outsource the preparatory work, such as data collection and calculations. The Ministry checks the assessments, summarizes outcomes on the national level and reports the national overview to the Dutch parliament.

The third main task is the reinforcement of flood defences based on the outcomes of the periodic safety assessments. The Water Authorities are responsible for reinforcement and often outsource large parts of the design to the consultancy market. The implementation is procured by contractors, under the supervision of the Water Authorities.

A reinforcement commonly requires additional space and changes the appearance and functionality of a land-water transition. Thus, in addition to the responsibilities and interests of public authorities, a reinforcement affects the interests of stakeholders such as citizens, farmers, businesses, nature organizations and recreation. These stakeholders participate via law-based procedures such as the Environmental Impact Assessment. According to Kothuis & Kok (2017), flood defence systems "can make or break the relation between city and water. So municipalities and provinces have to be involved as well" (p. 97). Hence, there is a range of actors with different roles and interests involved in flood defence asset management (Table 2). This setting of multiple actors and sectors with multiple roles and interests makes flood defence asset management a complex task.

To maintain the flood defences on the politically decided service level, cooperation between institutions and stakeholders is required because:

1. The assets are in public space and although flood prevention is their primary function they are also used for other functions (Kothuis & Kok, 2017; Marijnissen et al., 2021; Voorendt, 2017).
2. Multiple authorities are involved in the management of flood defences and even for a single function multiple actors are involved in the decision process (Deltares, 2020; Dieperink et al., 2014; FAIR, 2020).
3. The realization of "value" is in principle achieved through minimization of investment costs (Vonk et al., 2020), leaving little room in the budget for realizing co-benefits,

TABLE 2 Overview of involved actors and their role in the Dutch flood defence system (adapted from Dieperink et al., 2014).

Actor	Role
Regional Water Authority (RWA)	Manage flood defences, (reinforcement, monitoring, maintenance and operation).
Ministry of Infrastructure and Water Management (Min. I&W, including public works)	Setting standards, finance and policy making, for some parts of the flood defence system the same role as the RWA as well).
National Flood Protection Programme (HWBP)	Alliance of RWA and Min. I&W to coordinate and subsidize the reinforcement on a national scale.
Foundation for Applied Water Research (STOWA)	Centre of expertise of the regional water managers, the Dutch Water Authorities.
Province	Coordinating water management and spatial planning.
Municipality	Coordinating, responsible for local spatial planning, informing citizens and taking part in disaster management.
Safety region	Coordination of disaster management. Partnership between authorities and public services related to disaster management, chaired by a selected mayor of communities involved.
Emergency services	Dealing with calamities.
Citizens	Behind the flood defences the "users" of the service, involved in participation processes. Outside the dikes (the not-by-dikes protected areas) responsible for themselves.
Research institutes	Participating in most of the roles of the Ministry and Water Authority, by research, operationalization of knowledge and tools to support flood defence tasks.
Nature organizations	Participate in reinforcement projects to strive for nature-based solutions
Private companies/market	Participate in most of the roles of the Ministry and Water Authority, by application of knowledge and tools in the main flood defence tasks.

4. Reinforced flood defence infrastructures commonly require more space to cope with soil subsidence and increasing hydraulic loads due to climate change.
5. The context of flood defence asset management is continuously changing over time due to the enforcement of new acts, knowledge, rules or policies (Deltares, 2020; FAIR, 2020).

3.2 | Overview of situations studied

The geographical locations of the five studied situations are presented in Figure 2. To present the nature of the situations, the situations are also plotted in Figure 3 (which is slightly adapted from (Den Heijer et al., 2020)) based on the decision levels involved in the situation (strategic, tactical and operational) and the specific task (daily management, assessment and reinforcement). The vertical contains the task "Assessment" twice to clarify the interfaces to both of the other tasks, which makes the "vertical" actually a "cylinder." Therefore, Figure 3 consists of nine unique fields, in this paper referred to as management environments. The boxes in orange (top left) mark the different actors involved. Figure 2 and Figure 3 illustrate a wide spread of the total set of five situations to explore the case of the Netherlands.

3.3 | Description, results and analysis

Next, the five situations are briefly described. For more details, we refer to the supplementary material (linked to this paper) and De Leeuw et al. (2021).

3.3.1 | HHNK (Hoogheemraadschap Hollands Noorderkwartier)

Trajectory approach—Strategy development of trajectory reinforcements. Urged by new legislation the Water Authority has to take up the challenge to adapt to new roles and responsibilities in participative processes in spatial planning for dike reinforcement. In the existing unilateral action, the narrowly defined project would not hold, because of the required integrated approach. However, the Water Authority lacks a clear vision of the shape and implementation of such an approach: corresponding responsibilities and grants are not clear, and the staff is not familiar with adaptive working processes. The management of the Water Authority approached these practical bottlenecks as a dilemma: choosing between a mandatory step to an integrated approach,

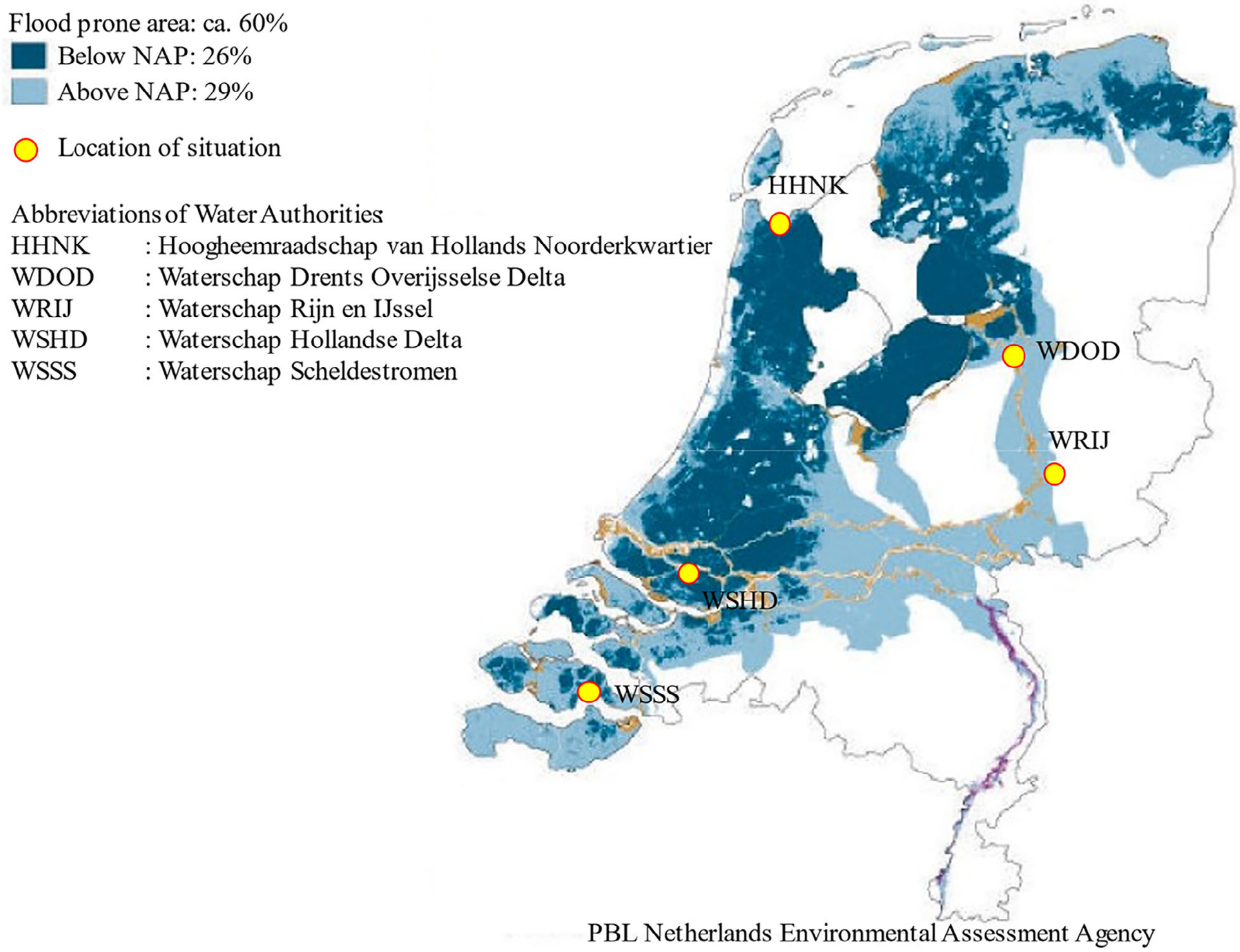

FIGURE 2 Locations of the situations. HDSR, HHNK, WDOD, V&V, WSHD, WRIJ, and WSSS are the abbreviations of the Dutch Water Authorities responsible for the flood defences in the selected situations.

keeping a rather disciplinary and project-like approach on the one hand, and embracing a complex fully integrated approach on the other hand. The Water Authority responded to this situation by intensifying its cooperation with regional partners and widening its scope, as a preparation for the fully integrated approach. It is therefore moving from unilateral action to collaborative action or even joint action.

3.3.2 | WSSS (Waterschap Scheldestromen)

Management agreement liquefaction prevention. The occurrence of macro-instability caused by liquefaction of the foreshore might increase the probability of dike failure. In the Scheldt River basin, Rijkswaterstaat (part of the Ministry) is responsible for the maintenance of the estuary adjacent to the dikes, and dikes the Water Authority for the dikes along the Scheldt. In practice, the cooperation became unilateral because of the 2016 flood risk legislation and a connected change of responsibilities within Rijkswaterstaat. The old agreements (establishing responsibilities for actions and costs of the two involved institutions, in this paper, referred to as external cooperation) between the public authorities need to be renewed, fitting to the renewed Water Act (Staatsblad, 2016) and the protection scheme (HWBP, 2020). Activities to prevent liquefaction are eligible for a subsidy from the HWBP, provided there is "good management." However, neither has this practice been defined yet, nor has a framework agreement for funding been concluded. Furthermore, there is not yet a specification of the extent of an acceptable level of erosion beyond which action is required. The Water Authority has to trade-off between performing and financing foreshore repairs in expectation of reimbursement, at risk of not getting funded, or only starting repairs when funds are granted, at risk of delaying critical repairs. Agreements about the specification of responsibilities regarding the financing of maintenance of the foreshore are necessary to enable the Water

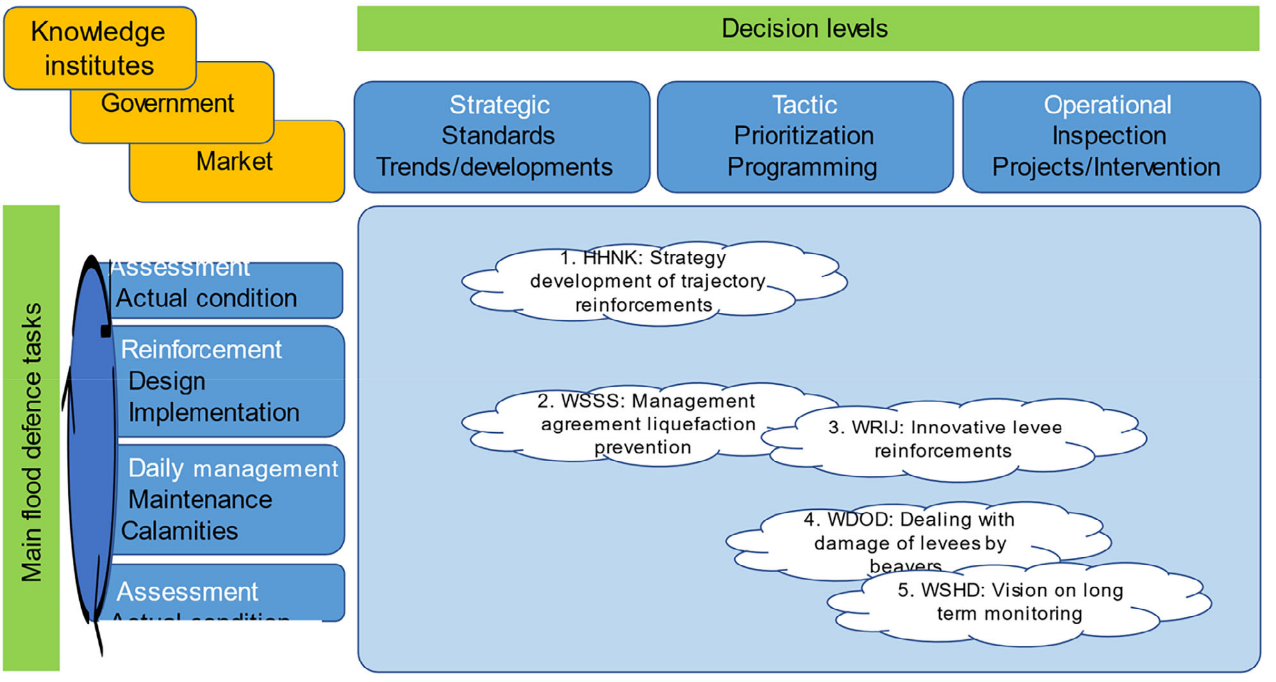

FIGURE 3 Overview of situations with respect to decision level and main flood defence task. Note the "vertical" axis is a "cylinder" since the three main tasks each interface with the two others. "Assessment" is twice on the vertical axis to visualize this.

Authority to weigh the risks. Therefore, the Water Authority intends to change cooperation from unilateral to external coordination.

3.3.3 | WRIJ (Waterschap Rijn en IJssel)

Innovative dike reinforcements. The Water Authority is responsible for dike reinforcement projects. Different departments have a unilateral task to assess dike performance, implement reinforcements and maintain the dike. A project team of the Water Authority selected an innovative measure for the cost-friendly reduction of piping probability over the life cycle of their dikes. The maintenance department of the Authority was not involved in this decision. It is not familiar with the monitoring and maintenance of this measure. Due to this bottleneck, the department hesitates to take over the responsibility after the reinforcement is finalized. The Water Authority has to the trade-off between acceptance of performance uncertainties of innovative solutions or acceptance of the use of extra cost and space for dike reinforcement using standard methods. The observed response of the Water Authority points out they accept the performance uncertainties and take organizational measures to manage the corresponding risks. The design department has to develop knowledge as a preparation for design and implementation. This knowledge is also required to develop a fit-for-purpose life cycle monitoring and maintenance scheme. Therefore, coordination of the knowledge transfer between departments is key for the willingness to take over the responsibility. The Water Authority strives to improve the yet unilateral cooperation between the departments towards coordinated cooperation, by giving appropriate mandate and power to an innovation manager to fulfill this task.

3.3.4 | WDOD (Waterschap Drents Overijsselse Delta)

Dealing with damage of dikes by beavers. Since the reintegration of the beaver in the Netherlands, beaver populations along the rivers are increasing. During high water, beavers retract to dikes where they dig holes underneath the water surface, affecting flood risk. According to Natural Law, beavers are a protected species, and their preservation extends from provincial to European policy. The province is responsible for nature conservation policy. Nature management organizations are responsible for the actual management of Natura2000 areas. The Water Authority, however, must guarantee flood safety and therefore take action. These organizations cooperate unilaterally on their own task. The water authority has to trade off whether to take into account the risk of digging beavers in their maintenance and reinforcements, or to strive for a coordinated protocol to seek a joint policy on the management of the population with an eye on flood risk management.

The observed response was to move towards an increase of awareness about the risk of burrowing species and an increase of mutual understanding of unilateral responsibilities between all the stakeholders involved (Province, Water Authorities and nature conservation managers and stakeholders). Knowledge sharing and an increase in mutual understanding led to a joint policy established in a beaver-protocol. The Water Authority moves from the internal and unilateral decision-making towards external and more coordinated actions. This is a shift from internal to external, though still unilateral cooperation (every authority kept its own responsibility and tasks).

3.3.5 | WSHD (Waterschap Hollandse Delta)

Vision on long term monitoring. The existing monitoring scheme is performed on a project basis and focuses on specific actions. The Water Authority expects the assessment and reinforcement of flood defences based on long-lasting monitoring to pay off. However, a decision for long-lasting monitoring would lead to changes in the organization and budgets: although HWBP takes benefits from monitoring as well, the cost of data collection is not eligible for grants by HWBP, thus, the Water Authority should organize the budgets itself. The Water Authority has to trade-off the dilemma between acceptance of life cycle monitoring efforts on its own account, combined with an organizational effort for sound internal cooperation, or acceptance of too costly and space-consuming dike designs, mainly paid by HWBP.

The Water Authority is investigating how a broad, accepted vision and sustainable support can be acquired in its own organization, to implement monitoring as a continuous source of information for long-term life cycle dike management. This leads to innovation of the workflow because the monitoring is organized in different departments. To break through without financial consequences the Water Authority strives to improve the yet unilateral cooperation between the departments towards coordinated cooperation between the maintenance, assessment and design departments.

3.4 | Reflections on situations

The five situations highlight several bottlenecks and dilemmas faced in the practice of integrated asset management. Bottlenecks can be categorized at three levels (De Leeuw et al., 2021): the lack of clear and supported vision of tasks and long-term developments (strategic level); the lack of a clear and supported view of responsibilities (tactical level), and the lack of clear rules and practices for financial, organizational and technical performance (operational level). The situations show the waterboards respond ad-hoc to the bottlenecks, aspiring for a shape of cooperation in which the bottleneck can be solved, summarized in the trade-offs in Table 3.

Although the situations as such are different, there are commonalities. All situations face changing circumstances: legal changes (new Water Act and new Environment and Planning Act), change of rules and protocols (organizational, financial) or change of opportunities (technical, innovations). Such changes could be the catalyst to seek other shapes of cooperation. Seeking a fitting shape for cooperation is in accordance with the principles of adaptive asset management (FAIR, 2020).

The aspiration of the Water Authorities to improve cooperation originates from technical or spatial challenges (situation 3), organizational challenges (i.e., responsibilities, tasks and roles; situations 1, 2, 3, 4, and 5) and changing external circumstances (situations 1, 2, and 4). Figure 4 plots the aspired change in the shape of cooperation for each situation in a grid of the intensity of cooperation (Sadoff & Grey, 2005) and the asset management dimensions (IM^3, Volker et al., 2013). In Figure 4:

TABLE 3 Overview of the trade-offs in the five situations.

	Character to approach the trade-off	
Situation	**The one option**	**The other option**
1. Trajectory approach—strategy development of trajectory reinforcement	Mandatory contribution to integrative approach	Embrace integrative approach
2. Management agreement liquefaction prevention	Pre-invest in your own account	Spacious dike dimensions
3. Innovative dike reinforcement	Innovation, no maintenance track record	Spacious dike dimensions
4. Dealing with damage to dikes by beavers	Spacious dike dimensions	Protected status of beavers
5. Vision on long term monitoring	Budget risk	Safety risk

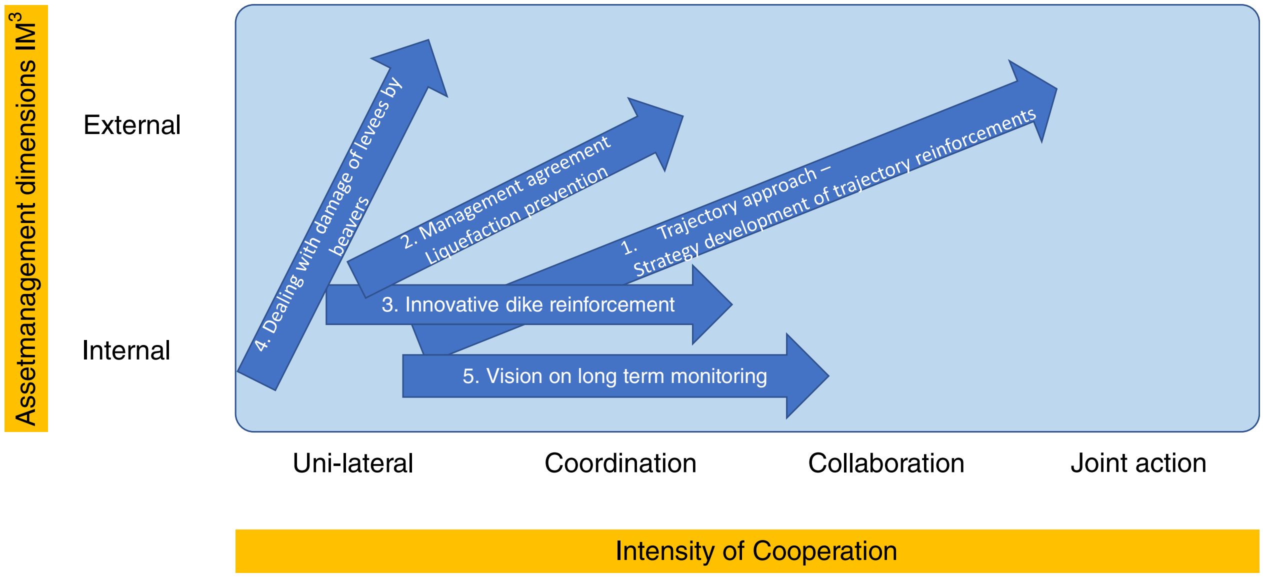

FIGURE 4 Overview of the Water Authority's observed change in the shape of cooperation for the situations in the case, in terms of cooperation intensity (Sadoff & Grey, 2005) and two relevant dimensions of the asset management maturity model IM^3 (Volker et al., 2013).

1. All arrows originate in the left part of the figure, and most of them are in the segment of internal unilateral action or coordination. This is interpreted as the institution's basic attitude, acting based on its own responsibilities and influence. All arrows are directed to the right or upward to external coordination. This is interpreted as the Water Authorities' aspired cooperation.
2. Most arrows are short, bridging only one segment, and one is longer, the Trajectory approach (situation 1).

When cooperation has led to agreements, rules, protocols, clear new responsibilities, decreased content complexity, or when the circumstances become stable, the required intensity of cooperation may decrease, but this temporal influence was outside the current scope of the research.

4 | DISCUSSION

The situations show the need to carefully shape cooperation. Situations in the case were raised by Water Authorities as problems they experience, related to cooperation. The Water Authorities selected the situations after they experienced the practical problems, with the aim to enable research cooperation. In this paper, we investigated the situations and the observed (intuitive) responses of these institutions. The trade-offs made in the situations described in this paper show how this works out in practice: the arrows in Figure 4 are mostly short, pointing to a careful search for intensification of the cooperation: not too ambitious, but steadily. This may be an artifact of the origin of the situations, brought in by the Water Authorities, who have a practical attitude and maybe intuitively look for situations for which the solution is nearby. The most noticeable observed change of cooperation is in the situation of the Trajectory approach, suggesting the need to both intensify cooperation and involve more organizations, in this situation on the level of a whole region.

Obviously, there is no universal "good" shape of cooperation. As cooperation is common in the daily work attitude of the Water Authorities, this opens the discussion of how to gain maximal benefits. The analysis of the situations shows how gaining benefits work in practice. Bottlenecks and dilemmas in cooperation have different characteristics. The bottlenecks are mostly caused by changes in technical or organizational starting points. Bottlenecks do not have a solution at first sight. Typical dilemmas have two sides, both leading to some negative impact. The dilemmas are mostly caused by different interests. Involved parties have different objectives and success indicators, weighing the dilemmas differently. The shape of cooperation between the involved parties depends on the benefits they get in accomplishing their own success indicators. The situations show the necessity to change the shape of cooperation, to overcome the bottlenecks due to change in circumstances as summarized in Figure 4, where the arrows vary in length and direction depending on the situation. The aspired change of cooperation changes the decision context and involvement of stakeholders, rearranging the bottlenecks in dilemmas, for which a trade-off can be made.

This finding shows that the success in asset management of flood defence systems is dependent on the practical implementation of cooperation and the ability and agility to choose and change the shape of cooperation depending on the situation: *situational cooperation*. Figure 5 shows the position of situational cooperation we found in the situations: a change (e.g., in law) may introduce a bottleneck (e.g., the change requires a new approach); when the involved stakeholders are able to relate this bottleneck to a dilemma with respect to cooperation, they can search for a shape of cooperation which enables to rearrange the bottleneck in such a way that the dilemma can be traded-off. In Figure 5, we illustrate a simple solution for a bottleneck between departments in the own organization, which could be solved by escalation to a management level exceeding the departments which were outside the scope of the current study.

Although the scientific developments on flood defence asset management maturity are mainly technical (ROBAMCI, Deltares, 2020; FAIR, 2020), this study shows that organizational maturity should be developed as well. This confirms the observation of others that mature asset management is not only technical but organizational and inter-organizational as well (Volker et al., 2013) and that integrated approaches have the potential to enable better outcomes (Cumiskey et al., 2019). This is a step further than suggested by Woodhouse (2014), who already pointed out the importance of evaluation and optimization of combining technical options and actions. Even technical and organizational changes interfere, as illustrated in situation 3 where a technical innovation requires a shift in the shape of cooperation.

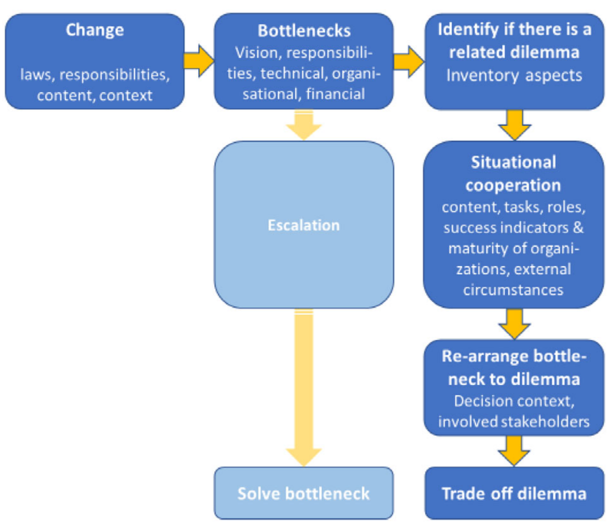

FIGURE 5 Schematic overview of observed coherence between change, bottlenecks, and dilemmas, pointing out the role of situational cooperation.

In the situations studied, apparently, there was a tendency to change the bottlenecks in dilemmas. However, achieving integration in practice is a recurring challenge, especially in flood risk management where multiple actors need to work together across fragmented policy domains (Cumiskey et al., 2019). When a dilemma occurs within an organization, an escalation ladder can be used to solve the problem. When a dilemma is in between organizations, however, escalation possibilities are more complicated and the problem is harder to solve. This applies to flood defence projects: at each of the decision levels, an explicit nonjuridical possibility to escalate to a central point is missing. Given their multi-managed nature, a central, single authority hardly exists for the management of complex systems. Effective cooperation between actors is therefore vital to flood defence asset management. In this regard, cooperation intensities (Sadoff & Grey, 2005) are instruments to shape cooperation.

Based on the situations studied, two aspects seem important for the implementation of situational cooperation. Firstly, we observed that sharing of knowledge on different decision levels involved in the rearranged dilemma is important. This supports the findings of Ishiwatari (2019) who identified local bodies on site, trust with stakeholders, and usage of local knowledge as key factors to strengthen cooperation. Secondly, the adoption capacity of an organization to new procedures and methods seems important. The adoption of new working methods requires change on all levels of the organization. This is a difficult process that can take a long time, especially if certain rules, procedures and working methods have long been institutionalized in the organization (Dent & Goldberg, 1999; van Buuren et al., 2018).

The relevance of cooperation in flood defence management is not limited to the Netherlands (Sayers et al., 2021). In deltaic areas, worldwide cooperation will be important when risk reduction measures interfere with other interests such as space and finance. The effectiveness of management is dependent on the quality of fulfilling roles by the actors involved (Jonas, 2010), as well as the enabling context (Shao & Müller, 2011). Successful fulfillment of roles and tasks in multi-actor settings is one of the key aspects in the field of project and programme management (e.g., Hu, Y., Chan, A. & Le, Y., 2012; Shao et al., 2012; Shao & Müller, 2011; Shehu & Akintoye, 2009). This paper shows that awareness of tasks and roles in the organizations involved is also important for the management of flood defences because bottlenecks that cannot be solved by escalation have to be shifted to a decision context where it appears to be a dilemma. Situational cooperation in flood defence asset management will bring in an intuitively known yet underexposed pillar in the body of literature on Water Governance. Organizational maturity may be supported

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by tools such as training, serious games and sharing of best practices. The role of these tools should include clarification of the starting points of the own organization, decision contexts, creating awareness of the role of effective interface management, and adoption capacity.

Four limitations of this study are mentioned. First, the case study only contains five situations. Although the areas of interest in the management environments are covered in this exploratory study, future studies could focus on replication. Second, it is a Dutch case study. The main flood defence tasks and the decision levels are the same in all countries, but the institutional organization and responsibilities differ between countries, which could be the focus of a subsequent study. Third, the incentives for cooperation are time-dependent (arrows in Figure 4), but this was not included in the current study. For this study, situations were brought in with an actual problem or dilemma, for which intensified cooperation supported a way out. Other situations may benefit from less cooperation, for example, when a change has led to new accepted working methods it could be efficient to reshape the cooperation to a less intensive level. Thus, the right-directed arrows in Figure 4 do not point out that joint action would be better than unilateral action. As a fourth and final limitation, only two of the maturity indicators from Volker et al. (2013) are used in this study: those which mostly refer to cooperation.

5 | CONCLUSION

The explored five situations clearly show that different projects may ask for a different shape of cooperation, depending on the content, the typology and difference in tasks, roles, success indicators and maturity of the asset management in the involved organizations, and on relevant external circumstances. In other words, the success of asset management of flood defence systems depends on the practical implementation of cooperation and the ability and agility to choose and change the shape of cooperation depending on the situation.

The main conclusion from this paper is that the multi-managed practice of flood defence management requires *situational cooperation* to support rearranging bottlenecks in dilemmas for which a trade-off can be made. In the situations in our study, the Water Authorities chose the shape of cooperation dependent on the complexity of content, the complexity of organizational context, and relevant external circumstances. To deliberately design a fit-for-purpose shape of cooperation it is recommended to develop and use proper tools to identify and implement *situational cooperation* in flood defence asset management.

The bottlenecks that are faced in the five situations were categorized at 3 levels: the availability of a clear and supported vision on tasks and long-term developments (strategic level); the availability of a clear and supported view on responsibilities (tactical level), and the availability of clear rules and practices for financial, organizational and technical performance (operational level). It appeared that bottlenecks and dilemmas are weighed differently by different organizations or departments in organizations, due to different objectives and success indicators. The desired shape of cooperation between the involved parties depends on the benefits they get in accomplishing their own success indicators. Because a central authority as an escalation step does not exist for the management of complex multi-managed systems in public space in the Netherlands, sound cooperation is required for success.

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DATA AVAILIBILTY STATEMENT

The data that support the findings of this study is publicly available in De Leeuw et al. (2021).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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