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Published in:
Planning Theory and Practice

DOI:
10.1080/14649357.2022.2034921

Routledge
Taylor & Francis Group

Planning Theory & Practice

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rptp20

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To cite this article: Casper Oukes, Wim Leendertse & Jos Arts (2022) Enhancing the Use of Flood Resilient Spatial Planning in Dutch Water Management. *A Study of Barriers and Opportunities in Practice*, Planning Theory & Practice, 23:2, 212-232, DOI: 10.1080/14649357.2022.2034921

To link to this article: https://doi.org/10.1080/14649357.2022.2034921

Published online: 02 Mar 2022.

PLANNING THEORY & PRACTICE
2022, VOL. 23, NO. 2, 212–232
https://doi.org/10.1080/14649357.2022.2034921

Enhancing the Use of Flood Resilient Spatial Planning in Dutch Water Management. *A Study of Barriers and Opportunities in Practice*

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ABSTRACT
Around the world, deltaic and coastal regions like the Netherlands are facing challenges from climate, change such as sea-level rise as well as more frequent and extreme natural events. Since 2009, the Dutch government has tried to mitigate flood vulnerability by deploying a balanced mix of flood protection measures, resilient spatial planning and crisis management (Multi-Layer Safety). However, recent evaluations have concluded that resilient spatial planning is (too) limitedly applied in practice. This article aims to understand the barriers and opportunities for resilient spatial planning in flood risk management by comparing two cases where resilient spatial planning was opted for: Dordrecht and the IJssel-Vecht Delta. The study suggests a large gap between the wide array of possible measures, and those that are actually realized in practice. Three physical-spatial barriers were identified: maximum flood depths, lack of space, and rigidity of the existing built environment. Additionally, institutional-organizational barriers were found, including: a false, low or non-existent safety perception or risk awareness, and therefore a lack of urgency to act; a lack of political and societal support; a suboptimal collaboration between stakeholders; ambiguity regarding responsibilities; finances and a cost-benefit imbalance; and a lack of human capital. Subsequently, the article explores possibilities to overcome these barriers. Overcoming these barriers can pave pathways for flood resilient spatial planning. The institutional-organizational barriers appear surmountable, whereas the physical-spatial barriers prove to be more problematic and form the most important restrictive factor for resilient spatial planning in flood risk management.

ARTICLE HISTORY
Received 9 April 2020
Revised 25 August 2021
Accepted 19 October 2021

KEYWORDS
Flood resilience; water management; adaptation; spatial planning; Multi-Layer Safety

Introduction

Deltaic and coastal regions around the world are facing major challenges. On the one hand, these regions face the effects of global climate change such as sea-level rise and increasing extreme natural events like floods and droughts (Laeni et al., 2019; Van der Voorn et al., 2017). However, it is these regions that are predominantly urban, hosting both the largest and the

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fastest growing cities. Many of these regions are flood prone and vulnerable to extreme flood events (Scott et al., 2013). Both the impact and likelihood of severe flood events have considerably increased over the past decades. and changing conditions are expected to drastically exacerbate this trend in the coming years (Zevenbergen et al., 2013). The Dutch delta is no exception and, with more than 60% of its territory located in flood-prone areas (PBL, 2010), the Netherlands can be seen as a paragon of flood vulnerability relevant to other countries.

For decades, water management has been a core business of the Dutch government. Initially this was a sectoral approach using engineering-driven technical measures (Restemeyer et al., 2017). Because of flaws in this approach, the Dutch water management strategy shifted to a more integrated, holistic, systematic, resilience- and risk-based approach (Slobbe et al., 2013; Schoeman et al., 2014, Forrest et al., 2019): the Multi-Layer Safety concept (MLS). This concept was introduced in the Dutch National Water Plan in 2009 to improve the integration of direct flood protection, spatial planning and emergency response into flood risk management (Gersonius et al., 2016). MLS comprises a set of measures and instruments subdivided into three layers (Klostermann et al., 2014):

1. *Direct flood protection.* Focusses on reducing flood risk probability through flood defence structures such as dikes, dunes, levees, dams, and other infrastructural measures.
2. *Resilient spatial planning.* Focusses on minimising the consequences of a flood by pursuing proactive spatial planning and flood-proof spatial designs. Examples are compartmentalization of dike rings, prevention of building in flood-prone areas, and designing flood-proof designs for vulnerable functions such as schools and hospitals.
3. *Crisis management.* Focusses on minimising the consequences of a flood by enhancing preparedness. This can be done through adequate risk communication and adequate emergency response (e.g. early warning systems, disaster management, evacuation).

Various scholars discussed the large disparity between theory and practice in MLS and stressed the importance of bridging the gap (Gersonius et al., 2016; Kaufmann et al., 2016; Walker et al., 2013). For instance, the recent Dutch Delta Programme (2019) concluded that there is room for improvement in MLS, especially regarding the second layer: resilient spatial planning. Since 2010, there has been a focus on resilient spatial planning in response to increasing flood risk in the Dutch national Delta Programmes. After a hopeful start, however, the progression faltered. According to the Delta Programme of 2018 (Delta Programme, 2018), resilient spatial planning has been shown to be too non-committal, open-ended, and free of obligations. This has resulted in major differences between regions and municipalities in awareness and approach towards resilient spatial planning. The Delta Programme of 2019 underlined the poor application of the second layer of MLS in flood risk management. According to Thaler et al. (2019), one reason may be that drivers and barriers of societal transformation in hazard management require more research. According to Driessen et al. (2018), flood risk management literature is well-grounded in risk assessments and future scenarios and is based on profound insights into the effectiveness of technical measures. However, the question of which governance actions should be taken to improve flood resilience has received lesser attention, despite the strong barriers that social and institutional factors often present to successful flood risk management.

This study aims to enhance the understanding of why resilient spatial planning (the second layer of MLS) is limitedly applied in the practice of flood risk management. The study focusses on the questions of what barriers are encountered in practice and what opportunities are seen to enhance flood resilient spatial planning. The intent is to provide practical recommendations that support practices to overcome apparent barriers and to seize planning opportunities. This study analyses the (underlying reasons for the) presence and absence of flood resilient spatial planning in two cases in the Dutch delta: The Island of Dordrecht and the IJssel-Vecht Delta, and captures this in a practical concept for the assessment of flood resilient spatial planning.

Theoretical Background: Resilient Flood Risk Management

Until the 1990s, the guiding paradigm in water management in the Netherlands was mainly positivistic, knowledge-based and command-and-control (Schoeman et al., 2014), assuming "predictable uncertainty." However, in the 1990s, there was growing recognition that traditional flood control measures were an insufficient answer to the increasing risks and challenges (Restemeyer et al., 2015). A new paradigm in water management started to evolve based on prevention and anticipation rather than command-and-control. This paradigm is sometimes referred to as the "new water culture" (Woltjer & Al, 2007). Table 1 shows the differences between this new water culture and traditional water management.

Many of the changes listed above are caught in the concept of "resilience" (Davoudi, 2012; Shaw, 2012; Desouza & Flanery, 2013; Kuhlicke & Steinführer, 2013), a concept much discussed in climate adaptation and planning literature nowadays. Generally, a dichotomy can be identified between resilience and resistance. Whereas the prime focus of a resistance strategy is to reduce the chances of a hazard to occur, resilience focusses on reducing the effects on the system if a hazard does occur. The resistance strategy is strongly related to "keeping the water out" – with technical measures at its core. Resilience relates to "living with water" and is based on a strategy that relies on risk management instead of hazard control (Restemeyer et al., 2015). However, resistance and resilience are not simple opposites, but are also complementary. According to Restemeyer et al. resistance is the "power to withstand a hazard" and can be viewed as part of a resilience strategy.

Figure 1, adapted from Van Veelen (2016), defines flood risk as the probability of a hazard occurring multiplied by the potential consequences of that hazard. Instead of solely focussing on minimising the probability of a hazard (resistance strategy), a risk-based approach aims, not only to reduce flood probability, but also to minimize the consequences if a flood occurs (Van Veelen, 2016). In doing so, it adopts an integral approach pursuing "resilience."

Table 1. Key aspects and differences in water management in and between the twentieth and twenty-first centuries (after Van der Brugge et al., 2005).

Old water management style (twentieth century)	New water management style (twenty-first century)
Command and control	Prevention and anticipation
Focus on solutions	Focus on design
Monistic	Pluralistic
Planning-approach	*Process-approach*
Technocratic	*Societal*
Reactive	*Anticipative and adaptive*
Sectoral water policy	*Integral spatial policy*
Pumping, dikes, drainage	*Retention, natural storage*
Rapid outflow of water	*Retaining location-specific water*
Hierarchical and closed	*Participatory and interactive*

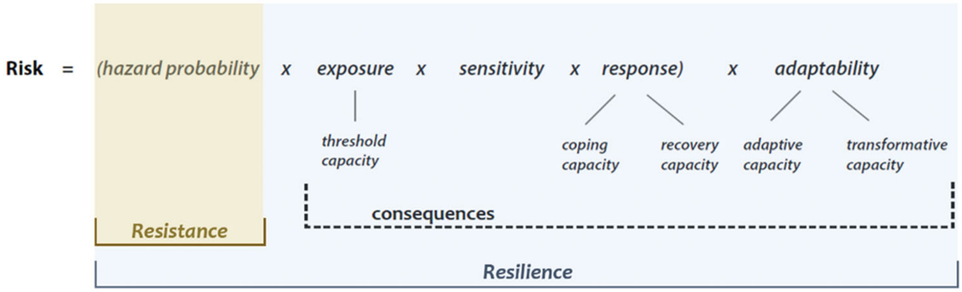

Figure 1. Risk-based definition of resilience (after Van Veelen, 2016).

The concept of resilience, however, proves to be ambiguous (see for example Davoudi et al., 2013; Meerow et al., 2016; Meerow & Newell, 2019; McClymont et al., 2020). For example, McClymont et al. distinguish various forms of resilience:

- Engineering resilience – the ability of a system to bounce back.
- Ecological resilience – the ability of a system to absorb changes and still persist.
- Evolutionary resilience – the ability to withstand, recover from, and reorganise in response to disturbances i.e. "a system's ability to radically transform to a new state and therefore focused on longer-term resilience" (McClymont et al., 2020, p. 1153).

Restemeyer et al. (2015) state that evolutionary resilience demands both robustness, adaptability, and transformability. It is characterized by the interplay of disturbance, reorganization, sustainment and development, with a focus on adaptive capacity, transformability, learning and innovation (Forrest et al., 2018). Because this is especially relevant to this study, the word resilience will refer to evolutionary resilience throughout this study.

In recent "urban resilience" literature the general deployment of the concept of resilience is critiqued since it mostly assumes spatial or urban designs as general systems ignoring the complex interactions within and functioning of these systems. Scholars highlight that those empirical studies should include questions like "resilience of what to what and for whom?" to give the concept meaning in the domain of spatial and urban planning (see for example Carpenter et al., 2001; Meerow & Newell, 2019). By studying barriers and opportunities both in the theory and the practice of two concrete cases, these questions are addressed in this study, thereby enriching the concept of resilience in the context of flood resilient spatial planning.

To make the concept of resilient flood risk management tangible and to structure this study, the contributors followed Restemeyer et al. (2015) and Davoudi et al. (2013) who dissected four important components of resilience:

1. *Persistence,* which refers to the power to withstand a hazard such as a flood. For example, by building concrete technical defensive measures such as sluices, dams and dikes.
2. *Preparedness*, which refers to the human capacity for foresight and intentionality as well as the search for ways to enhance their ability to anticipate and plan.
3. *Adaptability or adaptive capacity,* which refers to the flexibility of the system.
4. *Transformability*, which refers to the capacity to transform the stability landscape itself and to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable.

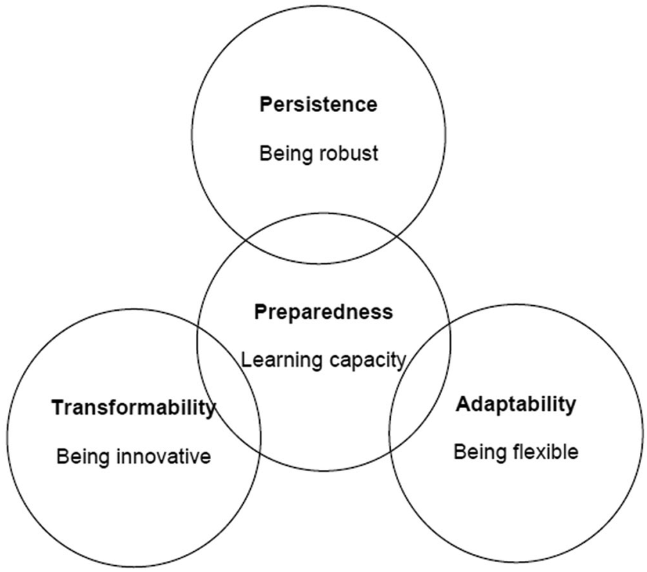

Figure 2. Four components of resilient planning (after Davoudi et al., 2013 and Restemeyer et al., 2015).

The four components are diagrammed in Figure 2.

Research Method

The study started with a scoping review of the relevant literature in the fields of resilience and resilient flood risk management. Relevant studies were identified by using academic databases (Elsevier Scopus, Science Direct, WorldCat Discovery) and internet search engines (Google Scholar, Microsoft Academic) to combine search terms such as resilience, water management, socio-ecological systems, climate adaptation, resilient spatial planning and Multi-Layer Safety.

To get a better understanding of barriers and opportunities for the application of resilient spatial planning in practice, it was decided to study two cases in-depth in a qualitative way (Bryman, 2015). This enabled the development of a practical and tangible concept of flood resilient spatial planning which is grounded in the cases (Bryant & Charmaz, 2017). The Island of Dordrecht and the IJssel-Vecht Delta in the Netherlands were chosen as cases, because both explicitly opted for resilient spatial planning following the MLS-concept. As indicated in the introduction, the urbanized Dutch delta can be viewed as an exemplar of flood vulnerability also relevant to other countries (see also PBL, 2010; Zevenbergen et al., 2013).

The first case focusing on the Island of Dordrecht, is located in the Rijnmond-Drechtsteden region. This region comprises 1.6 million inhabitants and, combined with the city and port of Rotterdam, it is a key economic zone in the Netherlands (Restemeyer et al., 2017). Surrounded by a multitude of rivers and canals, the 120,000 inhabitants of Dordrecht are essentially living on an island (see Figure 3). The city of Dordrecht has operationalised Multi-Layer Safety in its flood risk strategy plan "Zelfredzaam Eiland" (Self-Reliant Island), aiming to upgrade existing flood prevention measures, facilitate self-reliance, and prevent societal disruption (MIRT, 2018).

The second case focussing on the IJssel-Vecht Delta, is a vulnerable region influenced by various water systems such as Lake IJsselmeer to the west. The region has approximately 200,000 inhabitants. Due to its dynamic and complex nature, the IJssel-Vecht Delta has been assigned as

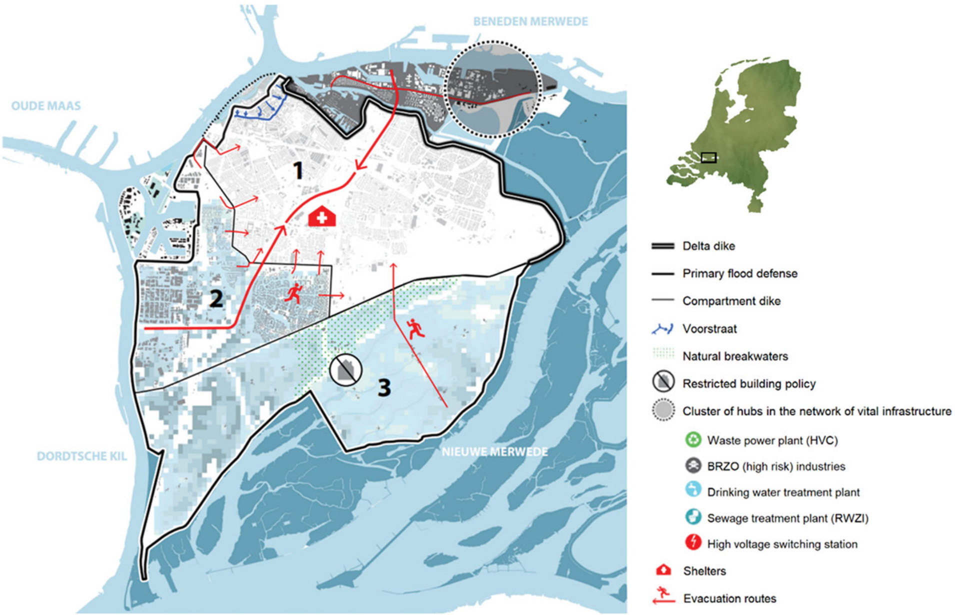

Figure 3. Elaboration of the strategy of the "Zelfredzaam Eiland" (source: Rijkswaterstaat, 2013).

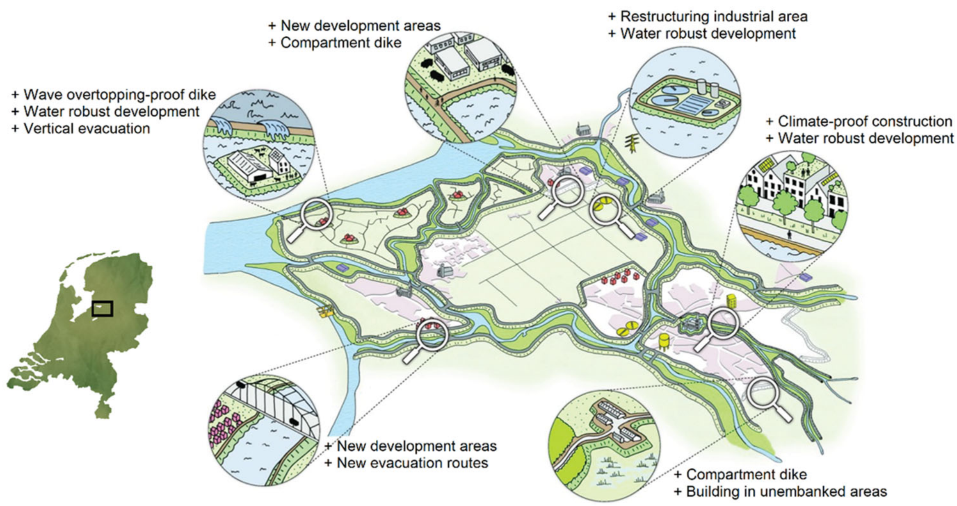

Figure 4. Overview of the Programme IJssel-Vecht Delta and its major projects (source: modified from URHAHN, 2015).

a focus point in the national Delta Programme (Blom, 2019). Because of its vulnerability, the core stakeholders of this region jointly developed the Programme IJssel-Vecht Delta between 2011 and 2018 (see Figure 4), which aimed to improve water safety of the region (Blom, 2019). In this Programme the MLS concept was adopted.

After the cases were chosen, relevant policy documents were analysed, such as the overarching water management policy plans, spatial plans and project-related documents. Both the current plans and policy documents as respective predecessors were incorporated to recognise potential policy shifts over time.

For the cases, around 21 policy documents were analysed (see reference list), 9 semi-structured interviews conducted, and a focus group formed to discuss the intermediate results. The interviewees varied from (policy) advisors in water management and water safety to spatial planners. Interviewees were either privately-employed or employed by municipalities, provinces or water boards (see Appendix 1). All interviews were recorded and transcribed, and data was then inductively analysed through coding using the four components given in Figure 2 as initial codes. In the coding, groups of words (synonyms) were used that refer to the same code. Coding was done by hand by the lead author and subsequently discussed with the other authors. During the analysis, indicators (including barriers and/or opportunities) related to resilient spatial planning emerged and were used as secondary codes – see Appendix 2 for the final coding scheme. The coding scheme just provides the codes without the interpretation as possible barrier or opportunity, since whether it refers to a barrier or opportunity is dependent upon the specific context. Subsequently, the two cases were compared to reveal relevant barriers and opportunities for resilient spatial planning in flood risk management. The preliminary results of this study were discussed in a focus group during the Coordination Group Meeting of the EU Interreg C5a project. The participants of this focus group had multidisciplinary backgrounds in the field of water management and urban planning as well as representing various organizations – including the Danish Coastal Authority, University of Twente, Rijkswaterstaat, Flanders Environment Agency, Province of Drenthe, and the Kent County Council. The results of this focus group are incorporated into the discussion and recommendations sections.

Flood Resilient Spatial Planning in Practice

This section describes the results of the interviews, following the four components per case and ends with a summary of emerging indicators of flood resilient spatial planning (across the cases).

The Island of Dordrecht

Persistence

A majority of interviewees mentioned "robustness" as being an important part of resilience (Interviewees 1, 3, 6, 7 & 8) and an indicator of persistence. As Interviewee 1 stated: "Prevention is the best way to avoid damages […]. Therefore, robust primary flood protection will remain the core of Dutch water management for the upcoming decades." Flood resilient spatial planning could enhance the robustness of a system by subjecting new developments in Dordrecht to a set of preconditions for flooding, heat stress, droughts and water safety. "Because after all, resilience is all about dealing with uncertainties" (Interviewee 1). Interviewees indicated that such preconditions can be operationalized by performance requirements for (new to build) objects. For example, a legal obligation for each (private) property is to have the capacity to accommodate a minimum of twenty millimetres of precipitation on the area of the property (Interviewee 8). Furthermore, Interviewee 2 mentioned water blocking baseboards in front of doors, and an obligation to have skylight windows to prevent people from being trapped in attics during a flood event. Interviewees 2 and 4 stressed the importance of making the current system more persistent by enhancing the robustness of vital infrastructure, such as available drinking water, electricity and data connections. Due to the restricting spatial configurations of the city, the compartmentalization of the island of Dordrecht was not regarded as an efficient measure (e.g. Interviewee 5). To actively pursue and stimulate such strategies and measures, the presence of well-functioning governmental organizations, institutions and monetary funds was regarded as another persistence-enhancing indicator (Interviewee 8).

Preparedness

Awareness and preparedness were considered key by all interviewees. For instance, Interviewee 1 stated that "Everything begins with generating awareness. This is the first step and requires a continuous dialogue about climate change, and linking this to current events." Awareness can be raised by facilitating a dialogue between the local government and inhabitants, where the municipality tries to provide perspectives on what citizens themselves can do to mitigate the consequences of floods and flooding – by, for example "de-paving" gardens or prepping emergency kits. As Interviewee 8 stated: "This awareness is definitely growing." In its strategy, Dordrecht pays much attention to preparedness by strongly focussing on crisis management and generating sufficient and accessible evacuation routes, shelters and safe zones (Interviewee 5; MARE, 2011; MIRT, 2018). According to Interviewee 4, raising awareness in this case is supported by being an island: "In Dordrecht there is a broad awareness of its spatial characteristics of being an island: in times of flood, evacuation options are limited and there needs to be sufficient self-reliance." Interviewees stated that the stress test and the risk dialogue – as promoted in the national Delta Plan on Spatial Adaptation (2018) – are measures that can and should be used more to operationalize the process of generating awareness and preparedness (Interviewees 1, 5).

Adaptability and Transformability

According to Interviewee 8, the components of adaptability and transformability are mainly about the extent, speed and degree to which the administrative system is able to change and adapt to new developments. "It is, however, very difficult to value and judge this" (Interviewee 8). The difference between adaptability and transformability was clearly expressed by Interviewee 2: "Adaptation is an incremental modification of a system to foster resilience. Transformation, however, is a considerable change towards a different system." A crucial issue for the interviewees regarding "transformability" was whether or not it will remain possible to live in the western part of the Netherlands in the future. This question goes beyond consequence reduction and according to Interviewee 1, is currently not taken into consideration enough. The key to enhancing adaptability and transformability is no-regret decisions, synergies and open options for the long term (Interviewees 1 and 4). This could mean enhancing the system's water retention capacity by reducing paved surfaces and enhancing "green-blue infrastructure" (Interviewee 8).

The IJssel-Vecht Delta

Persistence

Persistence and robustness were considered important components of resilience in the IJssel-Vecht Delta (Interviewees 4, 6, 7, 9). A new neighbourhood (Stadshagen) northwest of Zwolle, where various districts were built on elevated grounds, was mentioned as a good example for this. Throughout Zwolle, more neighbourhoods can be found that were developed at "delta sea level." The same goes for several farms on Kampereiland, that were built on dwelling mounds (Interviewee 9). Between the Stadshagen neighbourhood and the N331 motorway, a water and noise barrier one meter high was constructed on top of a clay layer (IJssel-Vechtdelta, 2018).

This barrier was designed as a compartment dike that can absorb the first wave of water after a dike breach (Interviewees 6, 7, 9). "This is an example of combining the first and second layer of the concept of Multi-Layer Safety […] and also an example of a synergistic solution" (Interviewee 6). According to Interviewee 7, the persistence of the region was strongly supported by multi-level and cross-sectoral collaborations between governments, entrepreneurs, educational institutions and citizens.

Preparedness

Improving awareness and preparedness formed a crucial part of the Programme IJssel-Vecht Delta. The Province of Overijssel informed, campaigned and educated to improve awareness of citizens (Interviewee 9). Furthermore, in Zwolle the project "SensHagen" was started (Gemeente Zwolle, 2019), in which inhabitants install instruments in their houses and gardens which provide actual information about groundwater and precipitation levels. "Projects like this are examples of communicational- or educational means to enhance the water-awareness of the inhabitants" (Interviewee 9). Another example is the lower Kampereiland region where inhabitants are warned via a text message of a potential water threat (Interviewee 6). In the city of Kampen, a substantial part of the primary water defence system of the inner-city centre relies on a mobile dike (Interviewee 5) that is to be raised by a team of volunteers in case of flood. Each year this team practices so that within a few hours the centre of Kampen can be protected from high water levels (Interviewee 9). Furthermore, the Safety Region of the IJssel-Vecht Delta actively manages the realization of sufficient and accessible high safe zones where people can evacuate in case of flood. This, in combination with a flexible evacuation strategy (IJssel-Vechtdelta, 2015) ensures multiple action perspectives for every region of the IJssel-Vecht Delta and fosters the effectiveness and efficiency of crisis management (Interviewees 6, 7).

Adaptability and Transformability

Since 2014, local governments have been working on a Spatial Development Plan for the Kampereilanden, that combines current water challenges with the qualities of the landscape. In this region there are many measures in place, under construction or planned. For example, a dike was adjusted to allow overflow in times of extreme high-water levels to rule out a potential dike breach (Interviewee 7). This flexible measure can be described as a hybrid combination of a first and second-layer measure (Interviewee 9). Furthermore, the project "Frankhuis" took future stricter water safety standards into account in the spatial planning process as the project was built on a robust, double level quay (Interviewee 9). Additionally, the project tried to compensate the obstruction of natural rainwater infiltration (IJssel-Vechtdelta, 2018) through water infiltration, retention and storage enhancing measures. Likewise, measures can be found throughout the IJssel-Vecht Delta, such as wadis (Interviewee 9) and "green-blue infrastructure" networks (Interviewee 6). In the interviews, signs of transformability have not been mentioned apart from the development of long-term visions (Interviewee 5) and choosing for no-regret strategies (Interviewee 4).

Practical Indicators of Flood Resilient Spatial Planning

After analysing the data retrieved from the cases, two general dimensions of measures and indicators of resilience emerge: a physical-spatial dimension and an institutional-organizational dimension. Each dimension contains the four components of resilience. In Figure 5 the two

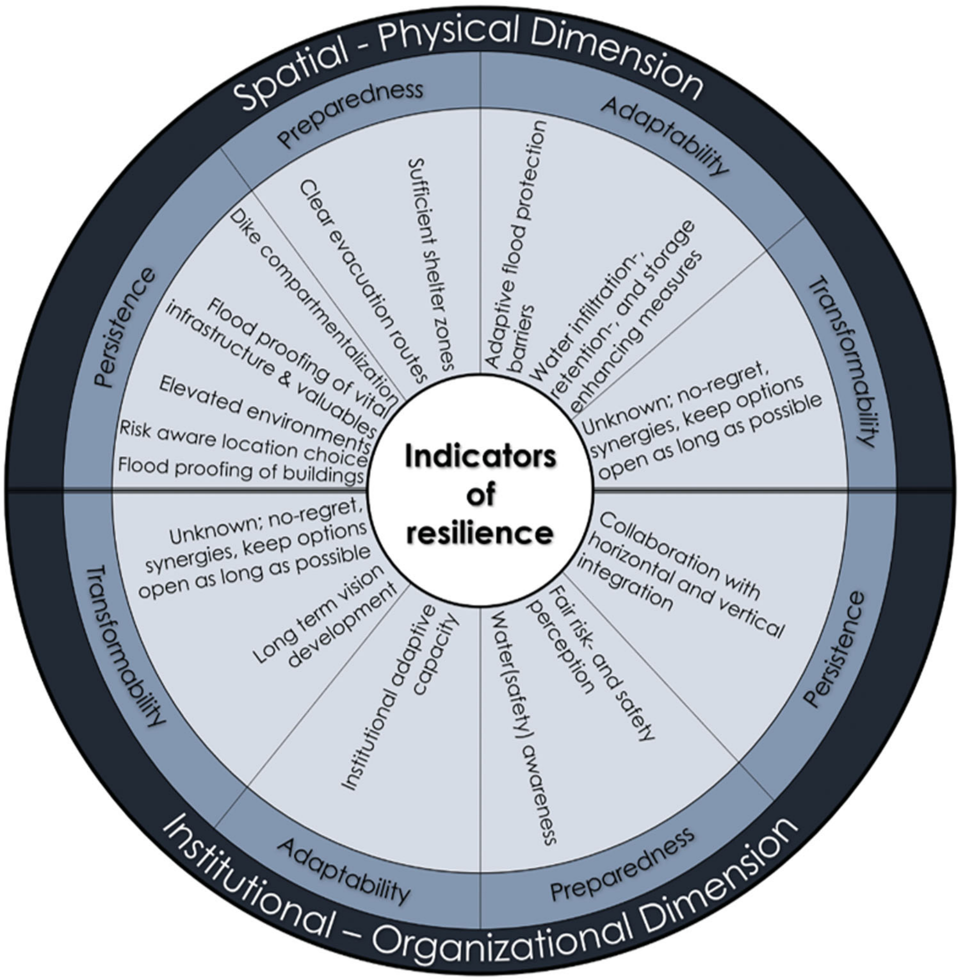

Figure 5. A practical concept for the assessment of flood resilient spatial planning.

dimensions and the four components of resilience are shown along with all emerging indicators from the interviews and the focus group.

When comparing the two cases, it can be noted that there is much similarity in the strategies and measures regarding the second layer of MLS. Both cases showed clear indicators of persistence in the spatial-physical dimension through, for example, the deployment of compartmentalizing dikes, the flood proofing of critical infrastructure and buildings, elevated environments and a location choice based on risk awareness. Also, indicators of persistence, such as early collaboration between important stakeholders regarding both horizontal and vertical integration, were found on the institutional-organizational dimension. Furthermore, the availability of funds and financing structures proved to be an important indicator in this dimension. Flood depth was a crucial factor in determining whether persistence-measures would be successful or not. When floods are deep, they can simply exceed the mitigating capacity of second-layer measures. Therefore, the action perspectives for shallow floods were considerably different from the action perspectives for deep floods. The Klimaateffectatlas (2019) distinguished different categories of flood depths to which different action perspectives are linked. As the flood depths increase, the possibilities and opportunities for second-layer measures decrease.

The existence of clear evacuation routes and shelter zones are important spatial-physical indicators to be prepared for flooding. Strongly related to this is water (safety) awareness. To foster awareness the provision of adequate information, stakeholder involvement and participation is important. This is in line with Forrest et al. (2018), who stressed the increasing relevance and role of local non-state actors in flood risk management, such as citizens and communities. Stakeholder participation should therefore be regarded as an important indicator of resilience.

In the IJssel-Vecht Delta case several spatial-physical measures emerged such as water infiltration, retention, and storage capacity and adaptive flood protection barriers. Regularly mentioned was the adaptive capacity of institutions. This is in line with Van den Brink et al. (2014), who stated that the adaptive capacity of institutions "encompasses the characteristics of institutions (formal and informal; rules, norms and beliefs) that enable actors (individuals, organisations and networks) to cope with climate change, and the degree to which such institutions allow and encourage actors to change these institutions to cope with climate change" (p. 982). In the article, Van den Brink et al. (2014) developed a comprehensive diagnostic tool – the adaptive capacity wheel – to assess the adaptive capacity of institutions.

Both cases struggled with transformability enhancing measures. As Interviewee 5 stated: "Transformability is a difficult component. Actually, it is not that much a measure; it is mainly a mindset to incorporate uncertainty in long-term spatial visions […] and in future spatial development." In neither the interviews nor the focus group were detailed examples of transformability mentioned, other than that this would take into account no-regret measures aiming for synergies. Options are being kept open as long as possible based on a long-term vision.

Discussion About Barriers and Opportunities in Flood Resilient Spatial Planning

Our research corroborates the gap between the wide array of potential measures and strategies of flood resilient spatial planning (the second layer of MLS) in theory, and the limited realization in practice. This gap seems to be the result of persistent barriers attached to many of the second-layer measures.

Physical-Spatial Barriers

The most important physical barrier mentioned by interviewees was the deep maximum flood depths in the two cases. The flood depth of an area can exceed the mitigating capacity of second-layer measures. "If this happens, then looking at the second layer is pointless. Then you just need to make sure that there are good evacuation plans" (Interviewee 2). As flood depths in the Netherlands are generally relatively deep, opportunities for the second layer of the MLS approach are limited. According to several interviewees, flood depth and the associated primary risks should be the lead consideration of MLS measures. The interviews indicated – in line with the Klimaateffectatlas. (2019) – that structural second-layer measures to alleviate damages are already limited and expensive when flood depths exceed 20 cm. In the case of higher flood depths, regions should focus on guaranteeing sufficient and accessible evacuation routes and elevated safe zones.

A second physical-spatial barrier is the rigidity of the existing built environment. The rigidity of the existing built environment reduces the possibility to radically change urban environments into something new (Interviewees 2, 9) as is also discussed by various authors such as Leichenko et al. (2015) and Restemeyer et al. (2017).

A third physical-spatial barrier is a simple lack of space in a relatively small and densely populated country like the Netherlands since measures of flood resilient spatial planning generally require more space than is available. "To build climate robust, we simply need space, and space is scarce" (Interviewee 8).

Institutional-Organizational Barriers

The most important institutional-organizational barriers seem to relate to safety perception, risk awareness and urgency (Interviewees 2, 3, 4, 5, 9). The Netherlands has a long history of fighting and accommodating water. The Dutch water management sector has been so successful in this mission that water experts, policy makers and citizens have a very high perception of safety based on the first layer of protection which includes dikes, dams, and storm surge barriers (Deltacommissaris, 2018). This high safety perception results in a low awareness (OECD, 2014) of the flood risks among stakeholders and citizens. Involving stakeholders, such as real estate developers, private property owners and businesses, together with citizens, however, is crucial for enhancing the water resiliency of a system (Interviewees 2, 3, 7). Awareness about urgency is a first – but very difficult – step towards preparedness to act.

In the interviews and focus group, finance came up as an important barrier – as Interviewee 2 stated: "The second and third layer of the MLS approach structurally struggle with a lack of money. For primary flood defence there is the national Delta Fund, but it remains fuzzy who is responsible to pay for second- and third-layer measures." In practice, flood resilient spatial planning measures are considered additional to (not as a replacement of) first layer measures, and therefore require additional investments. In this, interviewees mentioned the discussion about the most effective and efficient investments. "When the chances of a flood are small, you are not going to flood-proof each and every single building […]. These benefits do not outweigh the costs" (Interviewee 2). Furthermore, investments have to be made in the short-term, while the return is only visible in the long-term (Interviewee 8). In the interviews and the focus group the financial aspect was considered the key institutional-organizational barrier to the second layer of the MLS concept.

Another institutional-organizational barrier mentioned in the interviews is the (lack of) cooperation between important stakeholders in flood risk management. The water sector and the spatial planning sector seem to be separate worlds. The aim of water management is to guarantee water safety and largely relies on primary flood defence mechanisms. In the spatial planning sector this is often perceived as a "given,' a necessary starting point from which to begin. Also, both sectors have their own policies, legislation and authorities which hampers integration (Deltacommissaris, 2018). "How can you align the interests […] in such a way that everybody pursues climate change adaptation? It requires an extensive reorganization of the entire decision-making process in which sectoral walls need to be breached" (Interviewee 1). In the IJssel-Vecht Delta programme close- and cross-sectoral collaboration has been a strong asset. For example, a steering group representative of the region regularly met to discuss the most urgent dilemmas. Nevertheless, integration is not the panacea to all perceived problems.

Table 2. Barriers to transformation in natural hazard management as discussed by Thaler et al. (2019).

Barriers to transformative governance according to Thaler et al. (2019)
• *Lack of political leadership* • *Legal restrictions* • *Infeasible conditions to implement new technologies* • *Lack of (financial) resources* • *Lack of social capital and/or policy entrepreneurs* • *Informational barriers related to knowledge gaps* • *Cultural barriers such as a lack of risk awareness and interests*

In fact, a full cross-sectoral integration is often undesirable as it may result in endless negotiation, planning, and decision-making processes (Interviewee 8).

Responsibility ambiguity is another barrier, directly related to the previous. The various stakeholders in flood resilient spatial planning (e.g. provinces, municipalities, water boards, safety regions, citizens, market companies) are numerous and all act from their own responsibilities and interests. It is difficult to align these stakeholders in one resilience-enhancing strategy with a clear division of responsibilities.

Another institutional-organizational barrier for flood resilient spatial planning is (the lack of) human capital – i.e. expertise, skills, or the availability of personnel. The fruition of the MLS concept and its second layer are often left to a handful of enthusiastic people inside a governmental or private organization.

Evolutionary resilience is widely discussed in literature about transformative governance (see for example Chaffin et al., 2016; Fedele et al., 2019; Thaler et al., 2019). Interestingly, the interviewees in this study scarcely mention transformability, apart from stating that transformability is less a measure, but mainly a mindset for incorporating uncertainty in long term spatial visions. However, many of the barriers identified appear to be relevant to transformability nonetheless. The paradigm shift to a "new water culture" – i.e. an integrated MLS approach – by taking away barriers and using opportunities to better include flood resilient spatial planning in the MLS approach can be viewed as transformative governance or a system transformation. This is also supported by Restemeyer et al. (2015) who argue that only when adjustments are made to both the physical and social environment can transformability occur. Table 2 shows the barriers for transformative governance as identified by Thaler et al. (2019) – based on multiple case studies. The barriers discussed are also identified in this study as shown above. Different from Thaler et al., this study showed the important role of flood depth and cooperation between stakeholders, including clarity about responsibilities. This may be due to their focus on transformational governance and this study's focus on resilience itself and adaptability of the system at hand.

Overcoming Physical-Spatial Barriers

The physical-spatial barriers are intrinsic characteristics of a system, and opportunities to alter them are limited. As discussed above, second-layer measures are most – if not only – effective for relatively shallow maximum flood depths (Interviewees 2, 4, 5). There is a limit to the effectiveness of measures, such as water retaining green-blue infrastructure, dwelling mounds, water blocking baseboards and other building modifications. When the maximum flood depth exceeds 20 cm, most of the second-layer measures simply do not work or are in sheer cost-benefit imbalance. The interviewees and the focus group suggested the opportunity for flood resilient spatial planning can mainly be found for water floods below 20 cm. Because coastal and fluvial areas concern mostly greater flood depths, opportunities can primarily be found in pluvial areas.

To make existing built environments flood proof is costly and strongly dependent upon the context. Interviewees indicated that it is often more efficient to invest in integral first-layer measures that protect an entire region rather than individual buildings. However, when adopted early in the decision and planning process, the costs of second-layer measures such as water blocking baseboards or the obligation to have skylight windows, can be limited.

The main opportunity for flood resilient spatial planning seems to be synergistic integration with other developments in the area i.e. combining second-layer measures and other challenges, such as the energy transition, neighbourhood revitalization or the sustainability ambition. The combined water and noise barrier mentioned (IJssel-Vechtdelta, 2018) is an example of this synergistic combination. Good examples can also be found in the Dutch Room for the River programme, where in several places flood protection is combined with urban development, agriculture, nature development and recreation (see Verweij et al., 2021). Also, Thaler et al. (2019) pointed out the opportunity of multi-functional use of the same space.

The use of flood plains appeared to be a subject of interest in the interviews (interviewees 2, 6). Flood plains are areas outside the limit of primary flood protection measures. Such areas can be found throughout the Netherlands and their full potential is not always recognized. Flood plains (often) have no (rigid) built environment and offer development locations in the direct vicinity of water bodies. Not every flood plain location is suitable for development; for example, these areas may fulfil a function as retention area for peak water discharges, or maximum flood depths may well exceed the afore mentioned 20 cm. As suggested by the interviewees, since deltaic areas such as the Netherlands have many flood plains, this is an opportunity worthy of further investigation.

Overcoming Institutional-Organizational Barriers

The first step in overcoming most of the institutional-organizational barriers seems to be to generating awareness for climate change adaptation (focus group; Interviewees 1, 3, 5, 6, 7, 9). Achieving risk awareness will result in a greater feeling of urgency and consequently more preparedness to act. The general public, individual households, businesses and companies should be aware of the potential consequences if spatial adaptation measures are not taken and acknowledge opportunities to actively pursue climate change adaptation themselves. Active and early involvement of the various stakeholders in the decision-making and planning process fosters an awareness and the preparedness to make (long-term) investments (Interviewees 2, 3, 7). This is also stated by Herath and Wijesekera (2020) and Zandvoort et al. (2019), who considered stakeholder awareness as a key factor in resilient flood management. These studies mentioned the lack of adequate governance tools to facilitate multiple stakeholders to reach shared solutions and to guide spatial transformation. Herath and Wijesekera (2020) saw this as a major cause for the insignificant role of spatial planning towards sustainable management of flood risk.

Multiple interviewees indicated it is important not to only focus on the necessity of flood resilience measures alone but also on the added value these measures can bring to the people's neighbourhoods. For example, replacing paved surfaces with "green-blue infrastructure" not only fosters rainfall infiltration, but improves the quality of the neighbourhood. Also, bottom-up

Table 3. Opportunities for transformation in natural hazard management as discussed by Fedele et al. (2019).

Opportunities for transformative governance according to Fedele et al. (2019)
• *Leaders and key agents to promote change*
• *Development of new institutional and regulatory frameworks*
• *Investments in research and experimentation*
• *Monitoring and evaluation*
• *Political and funding support to long0term action*
• *Creation of cross-scale partnerships, multi-level governance and multi-stakeholder and cross-sectoral collaboration*
• *Application of landscape and participatory approaches*
• *Bridging organisations to facilitate knowledge sharing*
• *Bridging organisations to increase awareness*

approaches and local initiatives (such as "SensHagen" in Zwolle) will help make communities more aware of what individual actions that can be taken as a (co)problem-owner(s).

To operationalize awareness and preparedness the stress test and risk dialogue, as developed in 2018's Delta Plan on Spatial Adaptation, are existing instruments that can be used. The stress test is able to expose vulnerable areas regarding precipitation, heat, droughts and floods, therefore generating awareness, while the risk dialogue between stakeholders stimulates involvement and consequently preparedness (Deltaplan Ruimtelijke Adaptatie, 2018). Additionally, cooperation between private and public stakeholders over multiple levels is important to facilitate the further spread of awareness and preparedness. This cooperation should be based on a balance between sectoral and integral spatial planning. In this, flood resilience should be incorporated in the planning of water boards, provinces, municipalities (Interviewees 1, 2, 7).

As mentioned above, the cost-benefit balance of second-layer measures is often negative and lacks a clear policy framework or juridical instrument (Deltacommissaris, 2018). Whereas the national financing structure of first-layer measures is well organised in the Netherlands through the national Delta Fund, such arrangements are lacking second-layer measures. Due to the weak profile and the long-term nature of flood resilient spatial planning, it is not "stimulating" to policy makers and the general public. Developing attractive long-term visions that emphasise integral synergistic opportunities supported by realistic examples of measures is therefore important. However, Fedele et al. (2019) argued: "Managers and policy makers should identify opportunities to consider transformative adaptation early in the selection of an adaptation strategy, e.g. as part of vulnerability or risk assessments" (p. 121).

Based on an extensive literature review, Fedele et al. (2019) defined opportunities to stimulate transformation adaptation and to overcome these barriers. The barriers and opportunities as mentioned in these articles are summarized in Table 3. The opportunities mentioned are partly in line with the opportunities identified by Fedele et al. (2019). The opportunities they mention are generally a mirror of the barriers mentioned by Thaler et al. (2019), as can be seen in Table 2. Taking away a barrier offers an opportunity. This study's findings provide some (additional) practical measures to enhance opportunities, such as synergistic integration of multiple challenges, the use of flood plains, and the use of stress tests and risk dialogue approaches.

Conclusions

In this study barriers and opportunities were examined both in theory and in practice which provided a better insight into why resilient spatial planning is limitedly applied in the practice of flood risk management. Another important result of the study is the identification of indicators of flood resilient spatial planning (Figure 5). These indicators emerged from planning practice and make the concept of resilient spatial planning more tangible and assessable, and are thus seen as a contribution to a wider use of resilient spatial planning in practice.

This study confirms that the realization and effectuation of second MLS layer measures is still limited in practice. It suggests that this is the result of persistent barriers attached to many of the second-layer measures. The following important institutional-organizational barriers were identified: a false, low or non-existent safety perception and risk awareness resulting in a low urgency to act; a lack of political and societal support; suboptimal collaboration between important stakeholders; ambiguity and uncertainty regarding responsibilities; finance and the (temporal) cost-benefit imbalance of second-layer measures; and a lack of human capital. Additionally, physical-spatial barriers were found, including: deep maximum flood depths; a lack of space; and rigidity of the existing built environment. Overcoming these barriers can pave the pathways for flood resilient spatial planning. Although difficult, some institutional-organizational barriers appear surmountable. Awareness and preparedness can be enhanced by honest and clear communication of the risks to stakeholders and the general public. This can be stimulated by an active and early involvement of important stakeholders in the decision-making and planning processes. The stress test and risk dialogue as developed in the 2018 Delta Plan on Spatial Adaptation can be used to operationalize this. A promising opportunity is combining second-layer measures with other developments and ambitions of the region to split costs while adding value in order to help overcome financial barriers.

In (most) literature, attention is focused on institutional barriers. However, this study reveals also the importance of physical-spatial barriers that can be more problematic to overcome as they are intrinsic characteristics of the system. Maximum flood depths in deltaic and coastal areas are generally very deep and therefore opportunities for flood resilient spatial planning are limited. Like the Netherlands, deltaic and coastal areas are mostly densely-populated and urbanized and a sheer lack of space can form an obstacle for deploying second-layer MLS measures. Moreover, the existing built-environment is rigid and constrains opportunities for flood resilient spatial planning.

In addition to other literature, this study suggests the following opportunities for flood resilient spatial planning:

- Flood resilient spatial planning is most effective for relatively shallow maximum flood depths.
- Flood plains at higher elevations and relatively low maximum flood depths may offer an opportunity to investigate further because they have no (rigid) built environment and are often underdeveloped.

The threefold MLS approach provides the Netherlands with a broad comprehensive strategy to safeguard it from floods. This approach can also be useful for flood vulnerable deltaic and coastal regions outside the Netherlands. However, the study shows that in practice the aspirations and expectations of what flood resilient spatial planning may achieve needs to be tempered. It shows that some barriers can be overcome and that there are ample opportunities to enhance the use of flood resilient spatial planning as an integrated part of the MLS approach. This study only comprises two Dutch cases, but the results and examples are potentially applicable for every flood-vulnerable deltaic or coastal region. The major challenge of these regions is that they have an intrinsic spatial dimension, which needs not only flood protection measures and crisis management but also a spatial planning approach. The indicators identified in this study can be used as a practical instrument for planners and managers to assess the potential for flood resilient spatial planning in a given situation.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Funding

The research presented here was supported by Rijkswaterstaat, the executive agency of the Ministry of Transport and Water Management in the Netherlands and the University of Groningen, Faculty of Spatial Sciences.

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Appendix 1. List of interviewees

1	*Interviewee 1:* Senior advisor on urbanization, sustainability and area-based approaches at Rijkswaterstaat, at the department "Water, Verkeer & Leefomgeving." Interviewee 1 is involved in the programme NKWK KBS which aims to help cities become more resilient to floods.
2	*Interviewee 2:* Privately employed expert on storm water- and flood safety for the city of Dordrecht, working on the development of an integrated flood risk management strategy.
3	*Interviewee 3:* Senior policy advisor on water, and programme manager of the EU Interreg FRAMES ("Flood Resilient Areas by Multilayer Safety Approach") project on climate change and floods. In this project, partners join forces to make regions more robust against the effects of floods and flooding.
4	*Interviewee 4:* Senior advisor of flood risk and consequence reduction at Rijkswaterstaat, at the department "Water, Verkeer & Leefomgeving." Additionally, Interviewee 4 is the secretary of the Workgroup "Safety" at the ENW ('Expertise Netwerk Waterveiligheid'), which assists the designation of a new water safety philosophy on the basis of flood risk.
5	*Interviewee 5:* Advisor on water safety at Rijkswaterstaat, at the department "Water, Verkeer & Leefomgeving" working on various projects focussing on the interface of spatial development and water safety. Currently involved in the "Programma Ruimtelijke Adaptatie," the "Deltaplan Ruimtelijke Adaptatie," and member of the guidance group on pilots of the Multi-Layer Safety concept.
6	*Interviewee 6:* Policy advisor on water safety at the water board "Waterschap Drents Overijsselse Delta" involved in multiple projects of the "Hoogwaterbeschermingsprogramma" in the IJssel-Vecht Delta, around the city of Zwolle.
7	*Interviewee 7:* Policy advisor on urban regions at the water board "Waterschap Drents Overijsselse Delta." Currently involved in climate change adaptation projects on heat, droughts, flooding, and consequence reduction of floods.
8	*Interviewee 8:* Policy advisor on water management, at the municipality of Dordrecht and the Drechtsteden region. Interviewee 8 is active in projects on water safety and spatial adaptation to climate change.
9	*Interviewee 9:* Advisor on communication and spatial development of the IJssel-Vecht Delta at the Province of Overijssel. Interviewee 9 was involved in the "Programma IJssel-Vechtdelta" and author of "IJssel-Vechtdelta: Werken aan waterveiligheid en klimaatadaptatie."

Appendix 2. Final code scheme

	Physical-Spatial dimension	*Institutional organisational dimension*
Persistence	Climate adaptive building Preconditions to new development Strong reliance on layer 1 measures Dike compartmentalization Increasing robustness of vital infrastructure Flood proofing of buildings Elevated development of buildings Modification to sewerage system Protection and elevated positioning of valuables	Well functioning governmental organizations and institutions Governmental monetary funds International stakeholder collaboration Cross sectoral stakeholder collaboration Early involvement of safety region
Preparedness	Sufficient and accessible elevated safety zones for evacuation Development of a super shelter (Wantij XL zone) Clear evacuation routes	Flood warning via text messages Education of school children Campaigning and provision of information High water brigade Kampen Stresstest and risk dialogue to raise urgency and awareness Broad awareness of limited evacuation possibilities
Adaptability	Enhance water retention capacity by reducing paved surface Enhancing green-blue infrastructure Willow tree forest as breakwaters Wave overtopping-proof dike Water proof road noise barrier Precipitation permeable street Water robust double level quay	Adaptive capacity and flexibility of governmental institutions Flexible evacuation strategy
Transformability	Choose for no-regret measures Keep options open for long term Look for synergies	Development of long term visions 'Can we remain living in the West of the Netherlands?'