6 Improving the Allocation of Flood risk management interventions From a Spatial Quality Perspective

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In this publication, the developed integrated method for including spatial quality as an ex-ante criterion in flood risk management strategy development is presented in detail and tested. Based on the results of the earlier research-by-design exercise, as described in the third publication, it is concluded that the key to making spatial quality an ex-ante criterion is to make sure sufficient interchangeable flood risk management interventions, with varying locations, are available, since having multiple effective measures from a flood risk perspective makes selection based on other criteria, such as spatial quality, possible.

In this paper, the ways in which a range of interchangeable measures can be included by considering flood risk management interventions at different scale levels (varying from system scale to local scale interventions) and at different flood risk layers (including both flood risk reduction and consequence reduction measures) is described.

As a base reference situation, the impact on spatial quality of the 'business as usual' flood risk management strategy for this region is assessed. Subsequently, the ways that the flood risk management interventions can be shifted away from the locations in which they have a negative effect on spatial quality, by considering alternatives with a better (preferably neutral or positive) impact on spatial quality is tested. This is done by systematically deploying interventions at different scale levels and safety layers, while assessing their impact on spatial quality. Based on this assessment, the combinations of measures that result in an optimal impact on spatial quality, can be selected for the regional flood risk management strategy.

This case study research demonstrates that the developed method, compared to the business as usual reference strategy, allows for spatial quality to become an ex-ante criterion, resulting in the formulation of a flood risk management strategy with an improved impact on spatial quality. The approach includes the following steps:

- An inventory of the current and potential flood risk protection strategies
- An inventory of the spatial characteristics, ambition, and potentials of the region
- A qualitative assessment of the existing situation and (if available) of a reference flood risk management strategy
- Systematic research-by-design on how flood risk management interventions at different scales can shift the local flood risk management interventions (and a qualitative assessment of this shift)
- Systematic research-by-design on how interventions in different flood risk intervention layers can shift the flood risk intervention (and a qualitative assessment of this shift)

Key aspects: research-by-design, layer of the interventions, scale of the intervention, Rijnmond Drechtsteden and Alblasserwaard Vijfheerenlanden case study area, expert meetings, stakeholder meetings, spatial characteristics of the area.

Abstract

This paper describes an integrated Approach to flood risk management protection and spatial design that allows for the active involvement of landscape architects and urban designers in the allocation of flood risk management interventions within the Dutch delta. The Dutch Rijnmond–Drechtsteden area is used as a case study to demonstrate how choices regarding the scale and layer of a flood risk intervention can shift the location of that intervention. A spatial assessment framework is used to test the spatial impact of different flood risk management interventions at different locations and to determine where the intervention is most required from a spatial point of view.

§ 6.1 Introduction

Delta regions throughout the world are subject to increasing flood risks. These regions often have high population numbers and make a significant contribution to GDP; approximately 50 % of the world's urbanised areas are located in deltas (UN-Habitat 2006). Countries such as the Netherlands, Bangladesh, and Vietnam, and cities such as Jakarta and New York, are developing flood protection strategies to protect inhabitants and economic centres against flooding.

This paper concentrates on the Netherlands, where ongoing subsidence, climate change, the growing economic value of low-lying parts of the country, and the discovery of new failure mechanisms of dikes have created a significant long-term flood risk challenges. In response to this, the Dutch government established the Delta Programme. The aim of this programme is to develop long-term strategies to provide protection against flooding. Its main focus is on developing high-level choices with respect to the scale and type of interventions that are required. At the same time, the programme needs to ensure that the Dutch Delta remains an attractive place in which to live, work, recreate, and invest (Delta Committee 2008: 11). In order to develop sustainable urban deltas, there is a need for interdisciplinary approaches in which urban designers and civil engineers can collaborate (Meyer 2009: 385).

Several studies present typologies and design principles for integrated design at a local scale to integrate dikes in its surroundings (Stokman et al. 2008; Veelen et al. 2010), revitalise river fronts (Prominski et al. 2012), obtain extra space for water (Baca Architects et al. 2009), and design flood-proof houses (Nillesen & Singelenberg 2011). The Delta Urbanism book series aims to deliver methods for urban design at the scale of the delta. The publications stress the need for interdisciplinary approaches (Meyer 2009: 97) and show interesting examples of regional design and scenario studies addressing flood risk protection, but the contours of such approaches remain undefined. Both the Dutch Dialogues project and the Atelier for Coastal Quality have been successful in setting up workshop series in which designers and experts from other disciplines worked together (Atelier Kustkwaliteit et al. 2013; Meyer, Morris, & Waggonner 2009). The recent flood protection project, 'Room for the River', introduces Quality Teams, consisting of experts in the field, established to ensure the enhancement of spatial quality in relation to flood risk protection measures (Klijn et al. 2013).

The existing approaches to integrate flood risk protection and spatial design either study the effects on or potentials of alternative interventions for the surroundings to formulate a preference, embed necessary flood risk management interventions in a qualitative way, or exploit the potential for synergy at locations where flood risk and spatial assignments overlap. On a local scale, a flood risk assignment is often approached by interdisciplinary teams of spatial designers and civil engineers; the assignment itself, however, remains a given fact and is defined in an earlier research stage by civil engineers. Landscape architects and urban designers only get involved in such studies in the later stages (Prominski et al. 2012: 16), limiting their role to the task of optimally embedding a flood risk intervention at a given location, in order to achieve the best possible spatial quality.

This paper presents the first contours of a method that combines the perspectives of flood risk protection and spatial quality enhancement in an early analysis stage in which choices with respect to different scales and types of interventions within a delta are addressed. Flood risk management interventions can be implemented at different spatial scales and flood risk layers, resulting in different locations of those interventions. As this paper demonstrates, this mechanism offers the potential to allocate interventions to locations in a delta that are most suitable from a spatial point of view, and thus enables a more prominent role for the spatial assignment of an area in the development of flood risk strategies.

First, the method and its underlying concepts are explained. Then the main characteristics of the Rijnmond–Drechtsteden case study area in the Netherlands are described from a spatial and flood risk point of view. Next, the results from the application of the method in that case study area are described. The paper ends with conclusions and recommendations.

§ 6.2 Methodology

In this section, the underlying principles of the scale and layer of the flood risk intervention are explained, as well as the research-by-design and spatial assessment method that are applied to shift the flood risk intervention to a more favourable location.

§ 6.3 Research-by-design

Research-by-design can be defined as a study in which knowledge and understanding are generated by studying the effects of actively varying design solutions as well as their context (De Jong & van der Voordt 2005: 21). As will be demonstrated in the next sections, systematically applying flood risk management interventions at different scales and flood risk layers will lead to different design solutions and interventions at different locations. In this study, research-by-design is used to visualise and study the spatial impact of those varying design solutions and shifting contexts. This creates understanding about the spatial impact of high-level choices regarding the scale and layer of the flood risk intervention. Once the impact is understood, the knowledge gathered can be used to select or create the most favourable flood risk intervention strategy from a spatial point of view.

§ 6.4 The Scale of a Flood Risk Intervention

Flood risk management interventions can be implemented at different scales, varying from large (such as an entire delta system) and medium scales (such as polders and river branches), to local (such as a stretch of land or section of dike within the delta) and small scales (such as a single building).

As shown in Fig. 6.1, interventions at the scale of a delta system and the medium scale of river branches and dike-rings can influence water levels throughout the entire delta. As a result, the local flood risk protection assignment can be changed and thus, so can the need for specific local interventions. In order to demonstrate how this mechanism can be actively used to allow the shifting of local-scale interventions to the most suitable locations the following steps have to be taken:

- Identify the relevant flood risk strategies on the medium and large scale that are effective from a hydraulic point of view;
- Visualise the impact on the local normative water levels;
- Let civil engineers describe appropriate flood risk management interventions at specific local sites, based on normative water levels; and
- Let an expert team assess the impact of the flood risk intervention on the spatial quality.

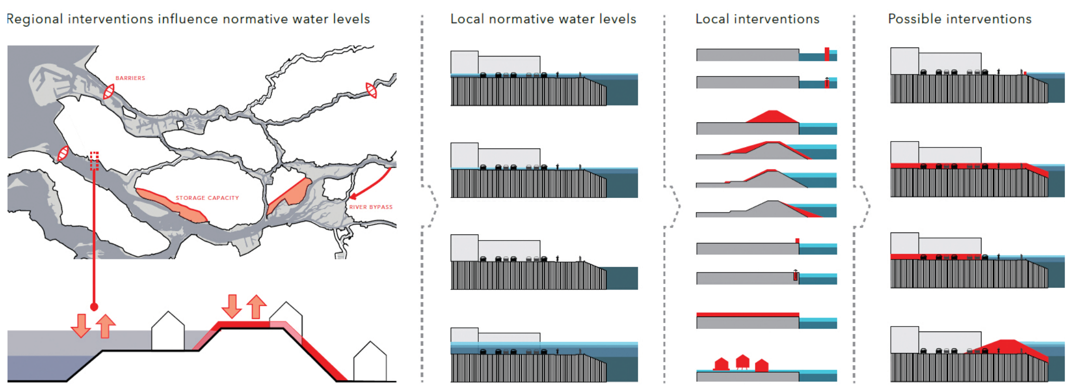

FIGURE 6.1 Schematic representation of the impact of regional flood risk management interventions on local flood risk management interventions. Regional interventions influence the local water levels and flood risk assignments and, with that, the probable local flood risk management interventions.

§ 6.5 The Layers of a Flood Risk Intervention

Flood risk is defined as the probability of a flood multiplied by the consequences of a flood. Therefore, interventions that reduce the probability of a flood are, at least to some degree, interchangeable with interventions that reduce detrimental consequences. Flood risk management interventions can be implemented on different ‘flood- risk layers’. A first layer, the layer of (1) probability, includes prevention measures such as dikes and barriers, and interventions that reduce the normative water level. Two others are related to consequences, namely (2) exposure, which includes interventions such as flood-proof buildings, the protection of vital infrastructures, compartmentalisation, and restrictive building policies, and (3) vulnerability, which includes interventions that allow people to evacuate an area safely and allow rapid recovery after a flood (Expertise Netwerk Waterveiligheid 2012).

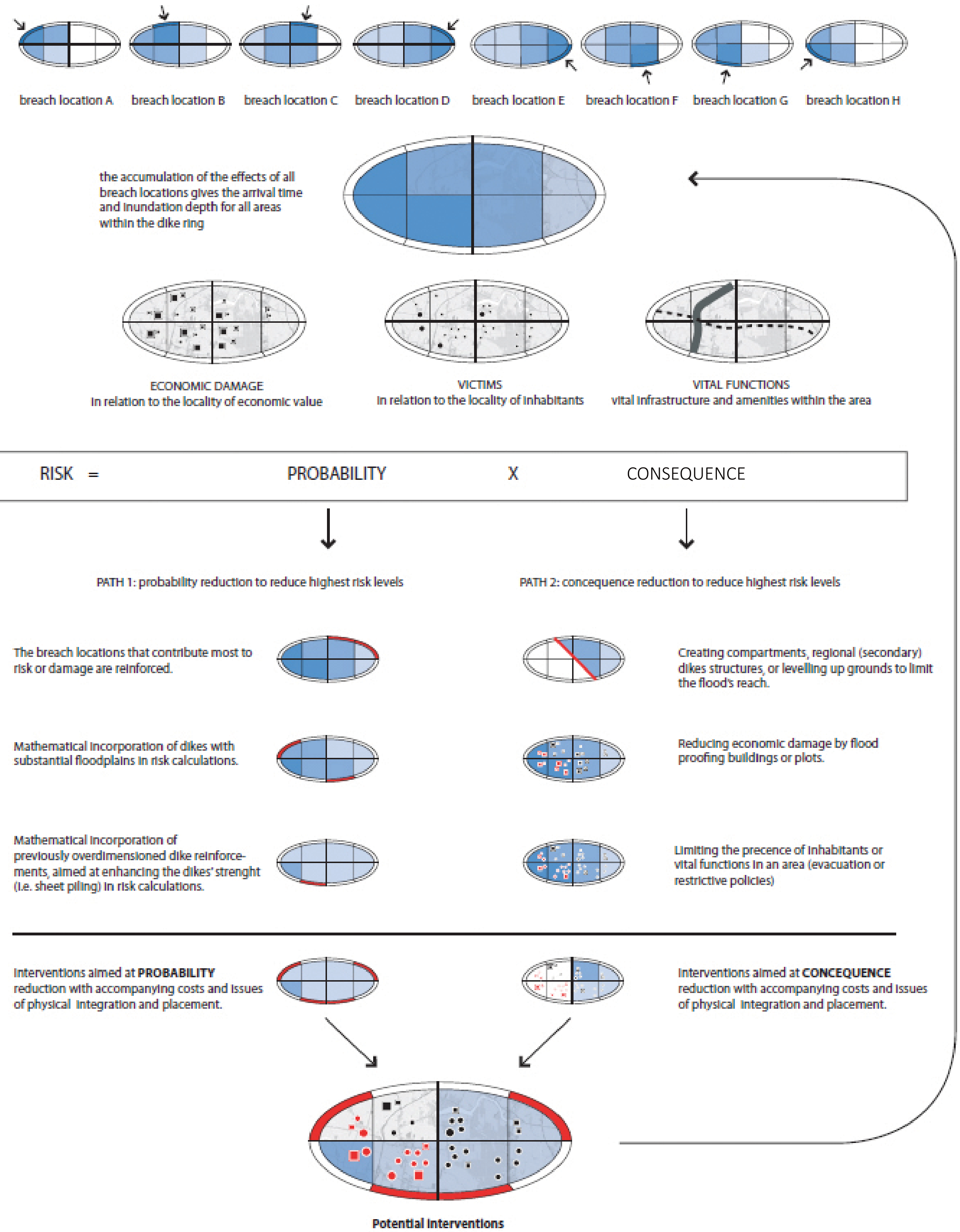

FIGURE 6.2 Schematic representation of the multi-layer safety approach showing the data as they were developed by the engineering company, as well as the proposed research-by-design method

The proposed method is closely linked to the concept of flood risk maps, such as those used in the Dutch Delta Programme. A flood risk map shows how deeply and within what time period areas will flood, and what the estimated number of fatalities and the economic damage suffered will be. As Fig. 6.2 visualises, the map is an overlay of the consequences for several dike breaks at different locations. This means that the flood risk in a random area within a dike-ring can either be targeted by local interventions that reduce potential damage or by reducing the probability of a dike break at a certain place that contributes to the flood risk at that location.

A differentiated design approach is proposed here in which flood risk management interventions at different layers work together. Specific locations that are preferred from a spatial point of view are used as a starting point for the flood risk management strategy. The design approach is cyclical: two parallel tracks for interventions that can reduce the probability, or the consequences, are investigated.

The following steps are taken to shift the flood risk assignments to the most suitable locations:

1. Selection of flood risk management interventions that either have:
   a. A positive effect on spatial quality and a considerable contribution to flood risk reduction, or
   b. A neutral impact on spatial quality and a major contribution to flood risk reduction flood risk management interventions
2. Update the risk map so that the new or remaining focus points of the risk assignment are defined.
3. Address the remaining problematic risk areas with a second round of flood risk management interventions while using design optimisation to embed the necessary interventions.
4. Update the risk map and, if necessary, repeat steps 3 and 4.

§ 6.6 Spatial Assessment Framework

The spatial assessment framework used in this study builds on the 'Ruimtelijke Kwaliteits Toets' (Spatial Assessment Framework) that was used by the Dutch 'Room for the River' project (Bos, Lagendijk & Beusekom 2004). The assessment criteria are based on the definition of spatial quality as a combination of utility, attractiveness, and robustness. They are derived from previous studies on qualitative criteria (Hooimeijer, Kroon & Luttik 2001; Gehl et al. 2006), and contain factors such as ecological functioning, maintainability, identity of the surroundings, recognition of structures, cultural recognition, alteration, logic of spatial arrangement, relation to the water, reversibility, development opportunities, and uniqueness.

In order to assess the impact of a flood risk management strategy, the following steps have to be taken:

- Adapt the spatial assessment framework to specific conditions for a case study area;
- Visualise the various (local-scale) locations that need to be evaluated in a consistent and neutral fashion;
- Assess the current situation as a reference, using an expert team and relevant criteria from the framework;
- Assess the new situation related to the flood risk protection strategy, using an expert team and relevant criteria from the framework.

Fig. 6.3 shows an example of the assessment list used in the Rijnmond– Drechtsteden area. Assessments can be judged as positive, negative, or neutral. A positive assessment indicates that the flood risk intervention may improve the spatial quality, or that synergy with the spatial assignment or ambition of the area is expected. A negative assessment indicates a negative impact on the existing spatial quality; it would be preferable to shift the necessary flood risk intervention away from this specific location.

UTILITY / EXPERT	Ecologist	Urban designer	Urban designer	Landscape archi	Landscape archi
Functioning as residential, commercial, recreational, or public space				+ −	o
Accessibility and routing				+	o
Ecologic functioning	−				
Maintainability		+	+		+
ATTRACTIVENESS					
Identity of the location /surroundings		−		−	−
Recognition of structures		−			−
Cultural recognition					
Spatial recognition		−		−	−
Diversity/alteration					
Uniqueness			−	−	
Logic of spatial arrangement		−			
Image			−	−	
Water-safety experience				+	+
Attractiveness	−		+	−	o
Scale of intervention vs. local scale			−	−	+
Relation to the water	−		−	−	
ROBUSTNESS					
Reversibility			−	+	−
Development potential		+	−	+	o
Multi-functional use of space				+ −	
Robustness		+		+	+
Flexibility				+	
Durability					

ASSESSMENT

- − −
- −
- o
- +
- ++
- Dominant argument

GROUP ASSESSMENT

- −
- o −
- +
- −
- o
- o −

FIGURE 6.3 The spatial criteria list used in the expert session on spatial assessment

§ 6.7 The Rijnmond–Drechtsteden and Alblasserwaard Areas

The Rijnmond–Drechtsteden area is shown in Fig 6.4 and contains the greater Rotterdam area including the Port of Rotterdam, which is an important economic driver in this region. The area faces a twofold danger of flood: it is threatened by storm surges at sea and, potentially simultaneous, peak river discharges. A system of dike-rings combined with a network of storm surge barriers protect the Netherlands against floods (Jonkman, Kok, & Vrijling 2008).

The Netherlands will have to extend its flood risk protection system in order to maintain the current flood risk standards with regard to the expected long-term flood risk challenge. Currently the location of flood risk management interventions, as well as the timescale for their implementation, are determined by the Dutch water boards, which are government bodies charged with a wide range of water management responsibilities. They test the strength of dikes every six years and act to heighten or strengthen them if current flood risk standards are no longer met (Waterschap Hollandse Delta). Fig 6.5 shows, in red, the dike raises that will be required for the year 2100, also referred to as the 'business-as-usual' flood risk protection strategy. We see an attention point around the subsiding peat polders of dike-rings 15 and 16. The Alblasserwaard (dike-ring 16) was selected as a case study area at the medium-scale level; the area and its dike raising task are shown in more detail in Fig. 6.6.

In the Alblasserwaard, two main types of landscape can be distinguished: riverfronts and polders (Steenbergen et al. 2009: 251). The riverfronts are relatively densely built, while the open peatland polder mainly consists of grasslands, with the exception of some built-up ribbons along drainage canals. The polder has an extensive drainage system that includes the windmills of Kinderdijk, a world heritage site.

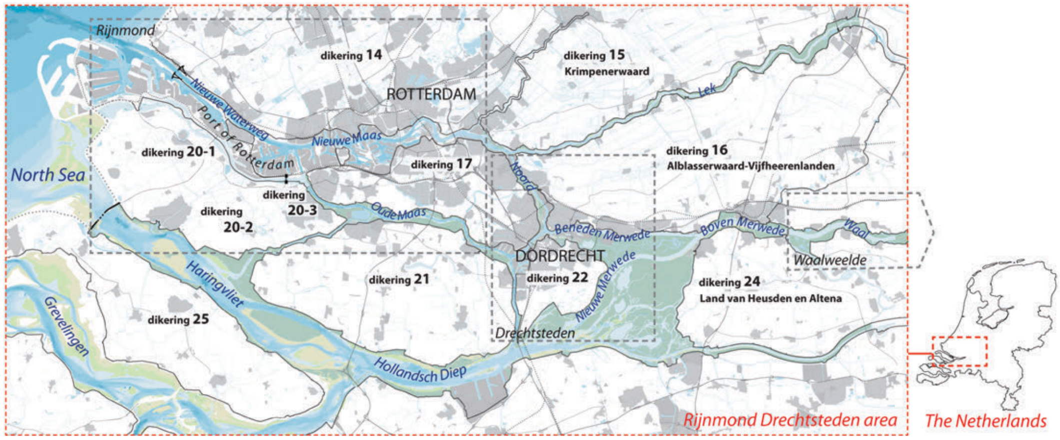

FIGURE 6.4 Map of the Rijnmond–Drechtsteden area

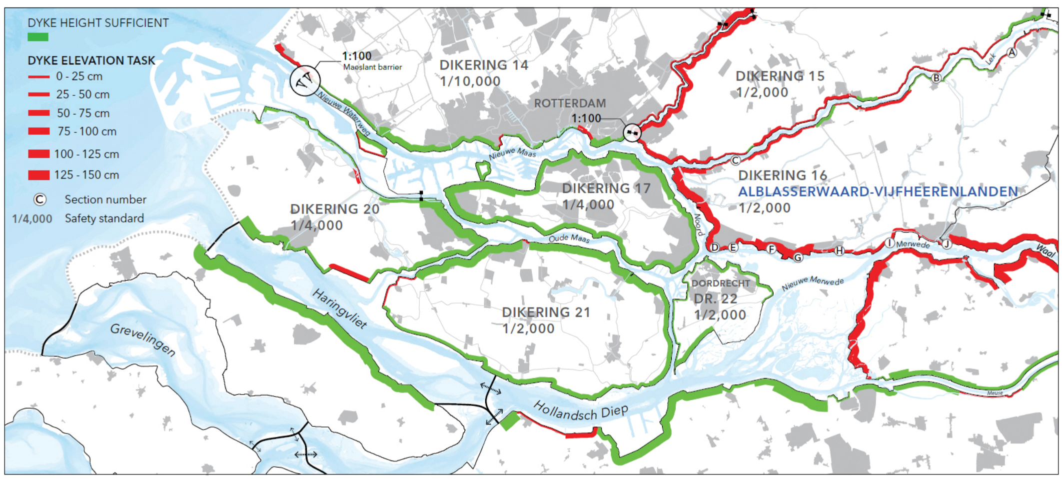

FIGURE 6.5 Indication of the regular dike raisings planned according to the 'business-as-usual' flood risk management strategy for 2100, including land subsidence and climate change (Data: vd Kraan 2012)

The pictures and sketches of the area in Fig. 6.7 show that the three rivers along Alblasserwaard have their own distinctive characteristics. The steep Lek dikes form a clear separation between the polder and the river. Along the Lek we find ribbons of individual houses and some villages inside the dike-ring. Dikes that were reinforced over time now almost absorb some of the dike houses. The unembanked areas are used for extensive water-related industries, for recreation, or as floodplains. Along the Noord, we find ribbons of small terraced houses, opposite a changing sequence of large industrial sheds, flood plains, and picturesque river views. The southern edge of the polder is most densely urbanised. The south-western edge of the Alblasserwaard polder is part of the Drechtsteden: an urban cluster positioned along the intersections of the rivers Merwede, Noord, and Oude Maas. The unembanked areas of this economic sub-centre have been raised and are mainly used for harbour-related activities, which obstruct the view of the river. Along both sides of the dike are ribbons of terraced or detached houses positioned close to each other. The shrinkage of the population that is expected from 2030 onwards makes the liveability and identity of the area an important focus point in the regional vision of the Alblasserwaard area (Provincie Zuid-Holland 2012).

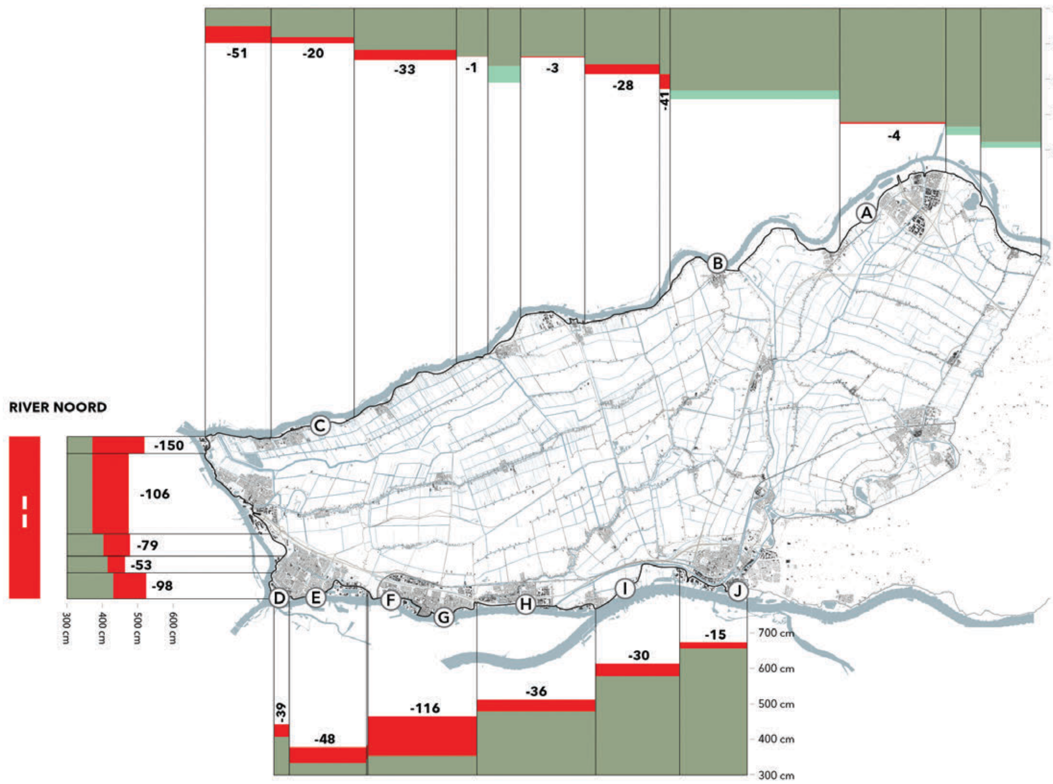

FIGURE 6.6 Map of the Alblasserwaard, including the dike raising tasks for 2100 (Data: vd Kraan 2012)

FIGURE 6.7 Sketch and pictures of the three rivers surrounding the Alblasserwaard

§ 6.8 Applying the Spatial Assessment Framework

The first step in the research was to apply the spatial assessment framework to the 'business-as-usual' flood risk protection strategy in order to describe the effects of the strategy shown in Fig. 6.5. The spatial assessment framework, as described previously, was adapted to the specific situation of the Rijnmond–Drechtsteden area; criteria like future value, feasibility of gradual development, logic of the spatial arrangement, and seasonal attractiveness were added by the expert team, which consisted of two urban designers, two landscape architects, and an ecologist.

The spatial assessment method is described in detail in an article by Anne Loes Nillesen in Municipal Engineer (2013). Here, some exemplary assessments are briefly described. A selection of the sections assessed is shown in the left column of Fig. 6.8. We see that, according to the water levels predicted, the dike in section E would have to be heightened by 48 centimetres. According to the civil engineering expert, this requires either a quay wall or an elevation of the dike along the waterside. Both options are shown in more detail in Fig. 6.9. As the expert panel concluded, the first option would be an inappropriate element in this area and would interrupt the continuous flow of space from the square to the river; the second option would cause the same interruption and change the historical character of the dike as a result of the more gradual slope. Both options scored negatively. However, the expert panel indicated that a dike raising of 30 centimetres would be neutral if the raise is designed as a continuous but sloping public space.

The local impact on the scale of the section is already related to a larger scale perspective. This is demonstrated by the assessment of section B, shown in detail in Fig. 6.9. The dike reinforcement blocks the view of the river from the main road, a situation that in other sections has been assessed as negative. In this case, however, on the larger scale, the reinforcement creates an interesting sequence of blocking and allowing views. The same applies to the historical buildings in sections F and G.

The demolition of incidental buildings does not harm the overall character, whereas completely restructuring the dike would eliminate its existing, distinct character. For section H, raising the dike could create the opportunity for a landscaped park and is assessed positively.

§ 6.9 Shifting the Scale of Flood risk management interventions

In order to demonstrate the impact of a large-scale flood risk intervention and its ability to shift the local flood prevention measures, the flood- risk strategies from the Delta Programme are considered, including the improvement of the Maeslant storm surge barrier, additional water storage capacity in the Grevelingenmeer, and a bypass along the River Merwede. Fig 6.10 shows the effects on the normative water levels and thus on the local assignment to raise dikes for the combined flood risk management interventions. We see that some local assignments for the Alblasserwaard have shifted. The middle column of Fig. 6.8 shows the impact of the regional flood risk management interventions on the local-scale interventions in more detail. Compared to the 'business-as-usual' strategy in the left column, some of the negatively assessed flood risk management interventions (sections D, E, and J) disappeared or reduced (sections F and G) from 116 centimetres to approximately 65 to 91 centimetres. This reduction changed the assessment to a less negative score, since the more modest dike raising task extends the timeline of the necessary intervention. In this case, a more gradual transformation of the existing characteristics of a ribbon consisting of different houses from different time periods could be achieved.

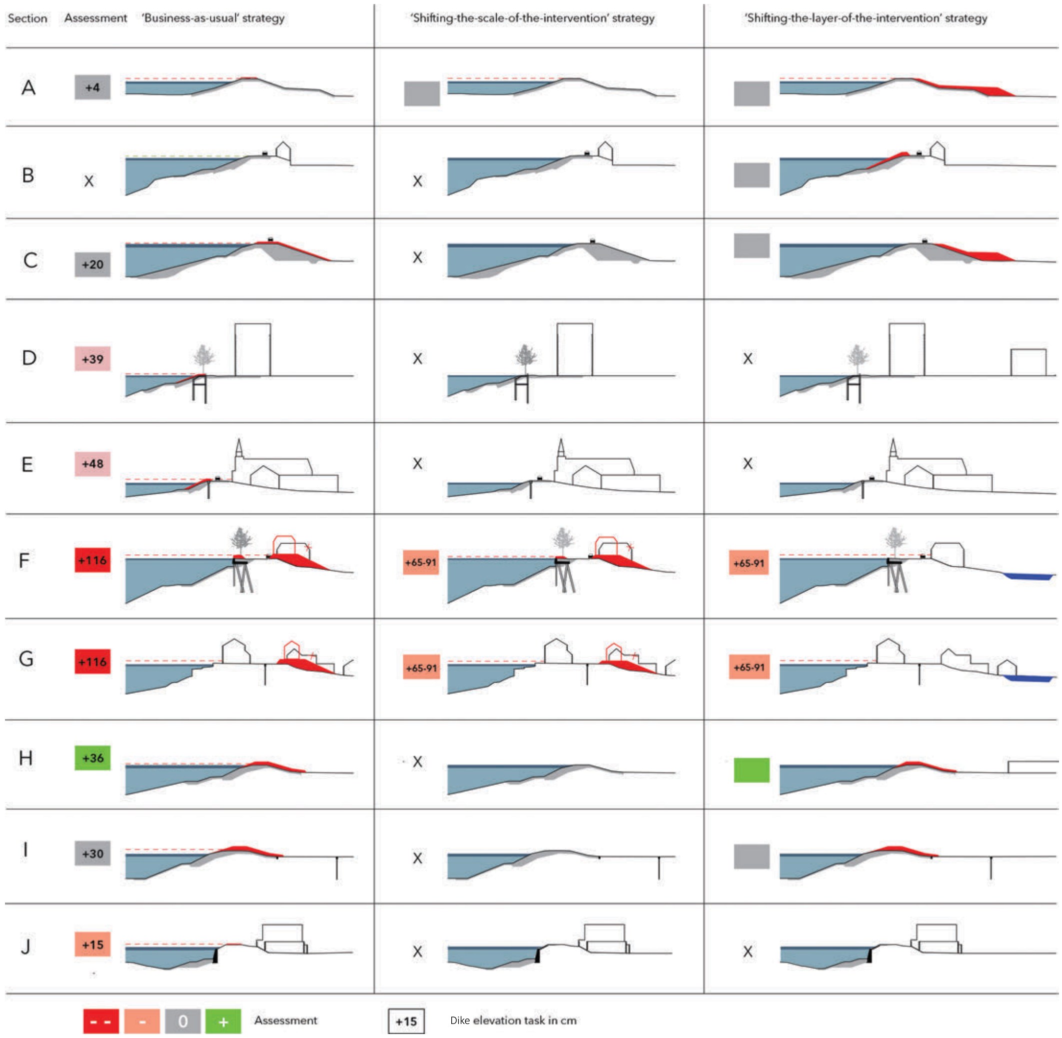

FIGURE 6.8 Example of sections used in the assessment of the impact of the different flood risk strategies on the local-scale spatial quality. (Data on section: Water Board; data on normative water levels: vd Kraan 2012)

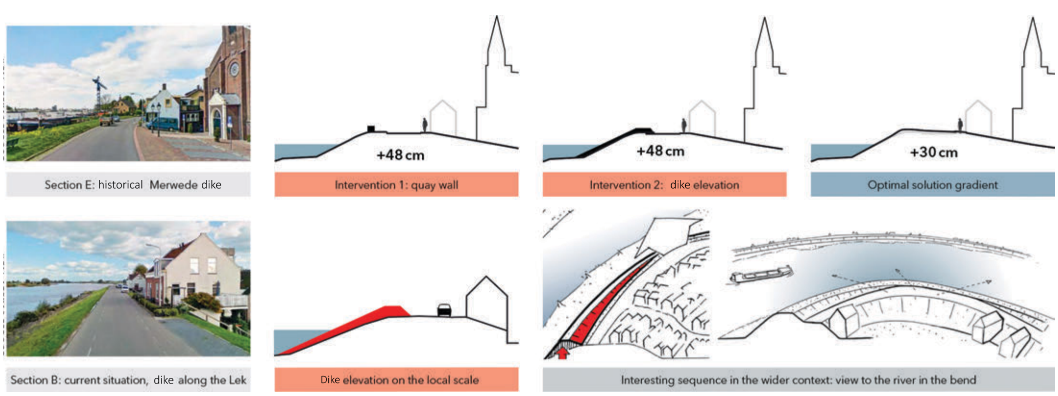

FIGURE 6.9 Detailed example of sections E (above) and B (below) used in the assessment of the impact of flood risk strategies on the spatial quality at a local-scale

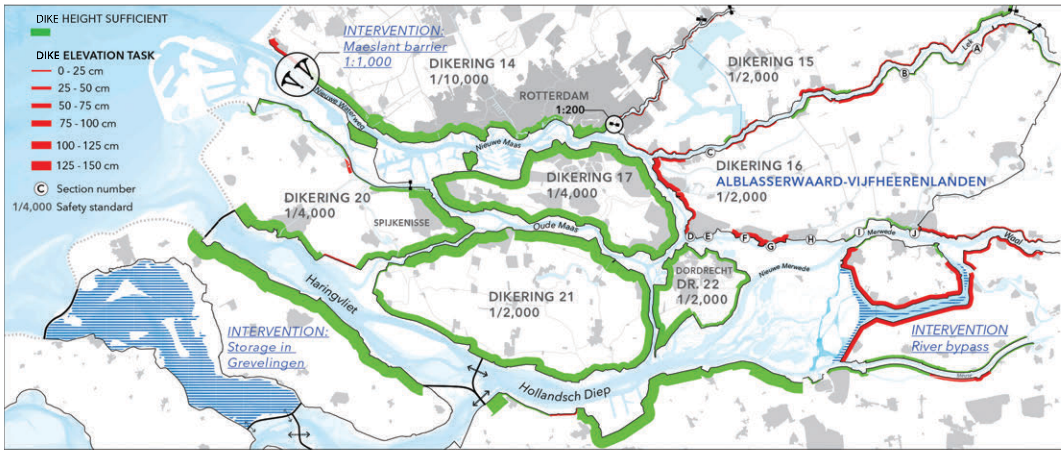

FIGURE 6.10 Indication of the regular dike raises planned up until 2100, with the flood risk protection strategy including land subsidence and climate change, an improved Maeslantkering, and a new green river and water storage at the Grevelingen Lake (Data: Deltares 2013)

§ 6.10 Shifting the Flood Risk Layer of Interventions

The western part of the Alblasserwaard is positioned 3.5 metres lower than the eastern part. In Fig. 6.11, it is shown that the eastern dikes would take a relatively large share in the potential damage caused, since a dike breach at the eastern part of the dike-ring would flood this ring in its entirety. In the first round of interventions, it is proposed to strengthen the eastern dike sections. Expert judgements performed as part of the Delta Programme inidcate that the reinforcement of those sections alone to a 1:100,000 standard would reduce the number of fatalities by 60 %. Possible consequences are further reduced by interventions from the second layer that focuses on local areas that suffer a large share of the economic damage or the number of fatalities. In Figs. 6.11 and 6.12, it is shown how the damage in some areas that inundate quickly and deeply can be reduced by setting up life-saving flood shelters.

In Fig. 6.12, another example of the interchangeability between interventions in the layer of the probability and consequence reduction is shown. The calculated water levels consist, to some extent, of wave heights: according to a rule of thumb, expressed during the expert session, the wave height makes up approximately 50 centimetres of the normative water level. The damage caused by the overtopping of waves, therefore, is considerably less than the damage caused by a dike break. In order to postpone problematic dike reinforcements in sections F and G, it could be decided to maintain the current dike heights and collect the water that tops over in a water retention area behind the dike. Such a retention area may coincide with current requests for extra rainwater storage.

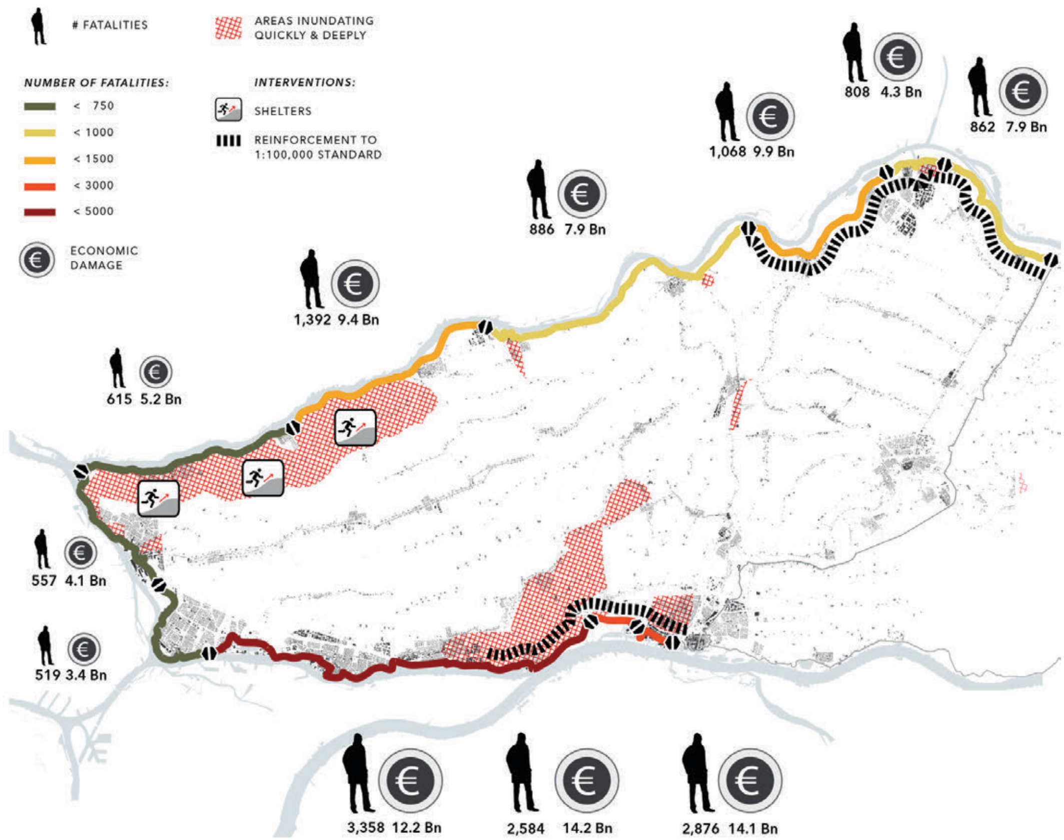

FIGURE 6.11 Schematic representation of the potential share of different dike trajectories in the amount of economic damage and number of fatalities (Data: Deltares) and the proposed flood risk management interventions on different flood risk layers.

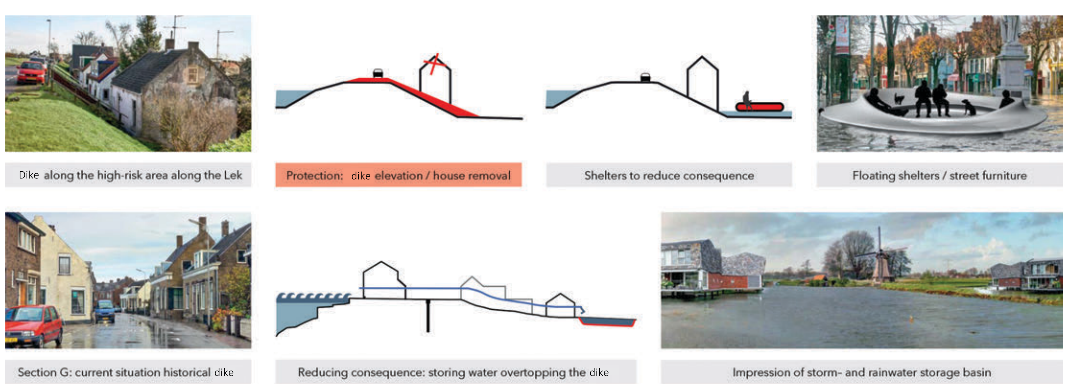

FIGURE 6.12 Raising the dike and constructing extra shelters as alternatives for risk reduction

§ 6.11 Conclusions and Recommendations

The research-by-design methodology defined and evaluated in this study demonstrates how the aspects of scale and flood risk intervention layer can be systematically employed to shift the location of a flood risk intervention to a, from a spatial point of view, more suitable location. The concept of the scale of the intervention, when applied in the dike-ring-dominated Rijnmond–Drechtsteden area, primarily facilitates shifting a flood risk assignment along a dike. The concept of the flood risk intervention layer extends the possible locations for flood risk management interventions towards the inner dike area.

The method includes:

- An inventory of the current and potential flood risk protection strategies
- An inventory of the spatial characteristics, assignments, ambition, and potentials of the region
- A qualitative assessment of the existing situation and, if available, a reference flood risk management strategy
- Systematic research-by-design on how different flood risk management interventions on different scales can shift the local flood risk assignment (and a qualitative evaluation of this shift)
- Systematic research-by-design on how interventions in different flood risk intervention layers can shift the local flood risk assignment (and a qualitative evaluation of this shift)

In order to apply the method in the manner of a spatial assessment framework for weighing up different flood risk strategies at the scale of the delta, the method should include an assessment of:

- The effects on local-scale spatial quality for the entire area that is influenced by the flood risk intervention
- The effects of interventions on a regional scale on spatial quality

The proposed methodology gives the designer the opportunity to actively participate in the debate concerning the location and scale of flood risk management interventions, resulting in a more integrated design approach. The systematic approach and the strong connection to variables and data sets makes it easier to communicate the propositions, from a spatial point of view, to engineers working on the Delta Programme.

The method can be relevant for other urbanised delta areas. Obviously, the criteria for spatial quality will have to be adjusted to the local situation, in collaboration with an expert panel. The types of data used in this research are commonly used by engineering companies throughout the world. Although different companies use different models, the type of data used to support delta decisions are often similar.

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