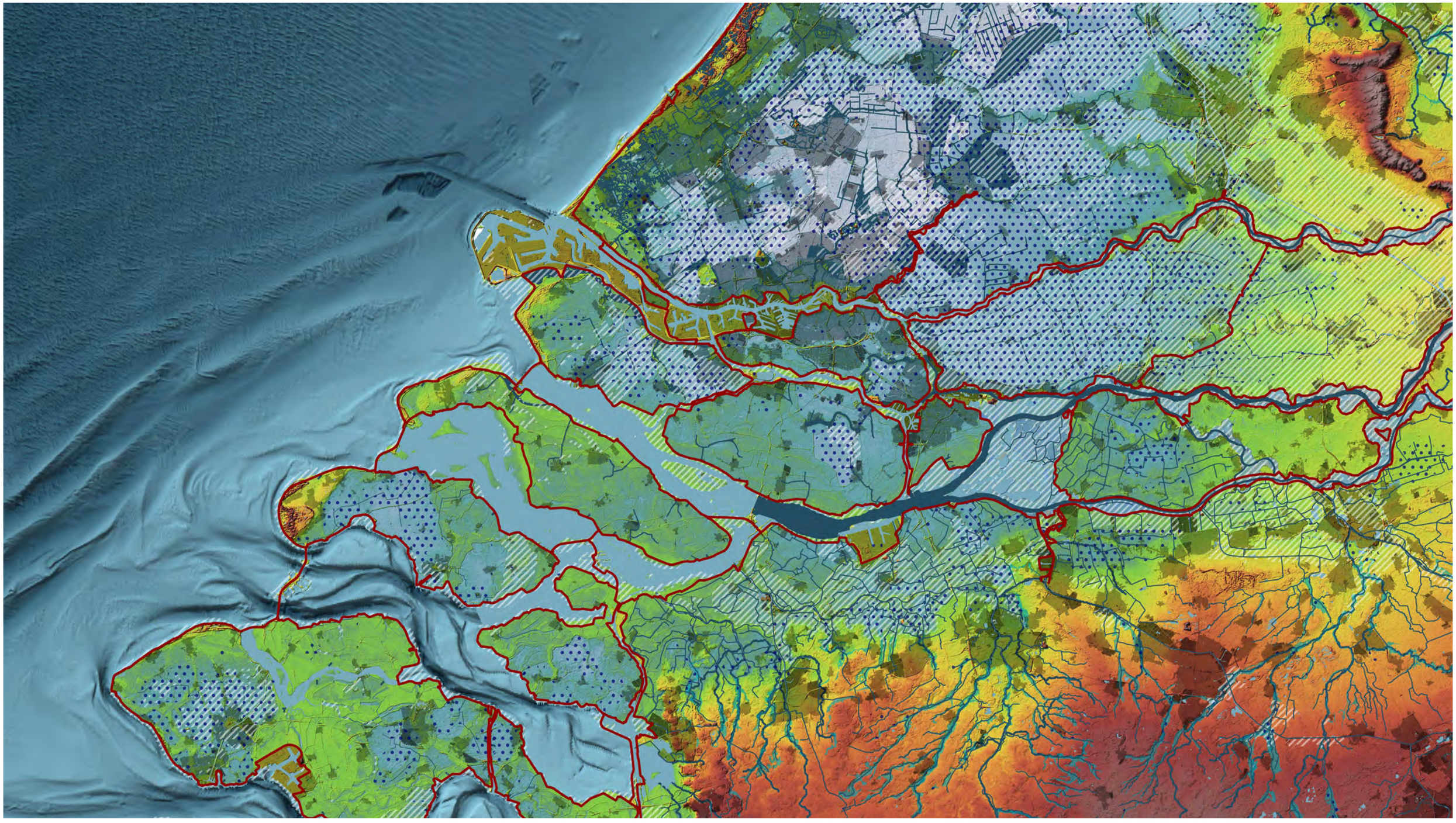

Final Report

IABR Atelier Delta Rijnmond-Drechtsteden 2100

Final Report
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The research by design conducted by the IABR-Atelier Delta Rijnmond-Drechtsteden 2100 is the intellectual property of the IABR. The research was carried out by lead designers Dirk Sijmons, Lodewijk van Nieuwenhuijze, and Jelmer Teunissen, together with De Urbanisten, H+N+S Landscape Architects, and PosadMaxwan.

The Atelier was commissioned by the Delta Program Rijnmond-Drechtsteden (DPRD), the Province of South Holland, the Port of Rotterdam Authority, and the municipalities of Rotterdam, Dordrecht, and Smart Delta Drechtsteden, as part of the 2026 review of the Preferred Strategy for the Rijnmond-Drechtsteden Delta Program.

The results are publicly available and compiled in this publication. The insights and illustrations are inseparable from the specific research question and context in which they were developed. The use or publication of this material, in whole or in part, outside that context may lead to misinterpretation and is therefore discouraged.

Partners

Contents

0 Foreword 5

1 Introduction 8

2 The Polder Strategy 16

- 2. 1 Flood Safety 19
- 2. 2 Port and Shipping 25
- 2. 3 Freshwater 27
- 2. 4 Urban Design 30
- 2. 5 Landscape 32
- 2. 6 Area Studies 33
- 2. 7 Transition Pathway 41
- 2. 8 Conclusions 42

3 The Estuarine Strategy 45

- 3. 1 Flood Safety 50
- 3. 2 Port and Shipping 57
- 3. 3 Freshwater 60
- 3. 4 Urban Design and Rural Areas 62
- 3. 5 Landscape and Ecology 62
- 3. 6 Area Studies 65
- 3. 7 Transition Pathway 69
- 3. 8 Conclusions 70

4 Reflection on Spatio-Economic Implications 74

- 4. 1 Assessment Framework Based on Future Scenarios 80
- 4. 2 Opportunities and Risks of the Polder Strategy 82
- 4. 3 Opportunities and Risks of the Estuarine Strategy 88
- 4. 4 Summary of Reflections 94

5 Adaptation Pathways 98

- 5. 1 Adaptation Pathways 99
- 5. 2 Reflections on Governance Instruments 103

6 Conclusion and Start of a New Beginning 106

- 6. 1 General Conclusions 107
- 6. 2 Research Program 109
- 6. 3 Research Questions and Topics for Further Research by Design 110
- 6. 4 Organization 114

References 117
List of Figures 118
Credits 119

Appendix A: Process Report 120
Appendix B: Future Scenarios 126
Appendix C: Shipping - Passages and Locks 141



Photo: Jannes Linders, from the series Between City and Sea

Foreword

Saskia van Stein
(Director IABR)

Drawing Distant Horizons Closer

This is the final report of the IABR Atelier Delta Rijnmond-Drechtsteden 2100, the culmination of a knowledge-development and research-by-design process that brings the future closer. The central research question was how the Rijnmond-Drechtsteden region can prepare for a 2-meter sea-level rise in a world that is 2.5 degrees warmer. It is a question that calls for a recalibration of our interactions with, and relationship to, the waters of our delta and the broader spheres of everyday life and institutional systems. These are questions that have been asked repeatedly throughout our cultural history, yet today they seem more pressing than ever.

The International Architecture Biennale Rotterdam (IABR) is a cultural knowledge institution that actively stimulates public debate on the spatial challenges of our time through research by design, exhibitions, and public programs. For more than two decades, and particularly through its IABR Ateliers, the IABR has developed extensive experience with research by design, deploying the strengths and tools of spatial designers to explore how major societal challenges are connected to creating just, sustainable, and future-proof living environments. By identifying concrete room to maneuver amid complexity and, through careful analysis, contextualization, and reflection, enriching it with the power of imagination, design can provide direction. In this way, change becomes less abstract, difficult decisions are brought closer, and new perspectives and alternative ways of engaging come into view.

The future, however, is plural and more uncertain than ever. Successes from the past offer fewer and fewer guarantees for the future, although there are still lessons to be drawn from history. After decades of accelerating growth and a technocratic mastery of nature, the consequences of planetary changes, such as shifting weather patterns, are difficult to grasp. Control depends on continuity, and continuity is precisely what is lacking. The worldviews, scenarios, and financial models that emerge from the social ideologies and cultural values underpinning contemporary society have proven insufficiently adaptive, particularly in the face of uncertainty. As the world becomes more volatile, the call for more inclusive visions – and for a reassessment of our individual willingness to change – continues to grow louder.

These developments also affect the design disciplines themselves. The field faces the challenge of moving beyond its extractive material basis and negative externalities, such as CO_2 emissions, toward a regenerative and sustainable practice that embraces new technological, ecological, economic, and sociocultural possibilities. At the same time, the current era of multiple planetary crises and the spatial consequences of climate change are driving profound shifts in the geopolitical landscape. In short, both society and the design disciplines are searching for new directions. All of this affects who we are, how we relate to one another, the choices society makes, and the ways in which policy helps shape society.

Complex processes are shaped by factors that are often unknown and interact in ways that are difficult to understand. How can we avoid becoming paralyzed by uncertainty while still providing direction? The IABR Atelier Delta Rijnmond-Drechtsteden 2100 was designed to connect these different forces. By creating room for processes to unfold, different forms of knowledge, collaboration, exchange, transdisciplinary, and interdisciplinarity can inform one another. New forms of knowledge and (mutual) understanding emerge through the cross-fertilization of research, experimentation, and dialogue.

Between March 2025 and January 2026, the IABR organized a series of thematic workshops. Starting from what we do know – including inspiring lessons from the past – we moved forward. The Atelier built on insights generated through the Eo Wijers Competition 2023, as well as other relevant initiatives and research, including NOVEX and the accumulated experience of the consortium. Across five working sessions, participants explored key themes, invited experts, and exchanged knowledge. Together, they examined the historical layers and ongoing transitions of the port complex, the future of agriculture, and the translation of long-term scenarios into governance decisions, connecting

‘Complex processes are influenced by factors that are often unknown and interact in ways that are difficult to understand. How can we avoid becoming paralyzed by uncertainty while still providing direction?’

‘By creating room for processes to unfold, different forms of knowledge, collaboration, exchange, transdisciplinarity, and interdisciplinarity can inform one another. New forms of knowledge and (mutual) understanding emerge through the cross-fertilization of research, experimentation, and dialogue.’

these issues through design and discussion. More about the process can be found in Appendix A.

Navigating this research-by-design process together, placing societal challenges at the center, and broadening both the design disciplines and the lived experience brought to the table by all participants has produced outcomes rich in ideas and far greater than the sum of their parts. This raises various questions about identity, authorship, and the relationship between individual interests and the public interest, while fostering a sense of common purpose as the basis for knowledgeable decision-making. Decisions are also informed by recent policy developments, such as the principle of water and soil as guiding factors, with the aim of creating a more resilient and integrated spatial environment.

Delta Rijnmond-Drechtsteden 2100 was made possible by the Delta Program Rijnmond-Drechtsteden (DPRD), the Municipality of Dordrecht, the City of Rotterdam, the Port of Rotterdam Authority, the Province of South Holland, and Smart Delta Drechtsteden, all of which actively participated in the process. The IABR recognizes the individual talents of the design teams from De Urbanisten, H+N+S Landscape Architects, and PosadMaxwan. Yet the project’s true added value lies in its transdisciplinary and interdisciplinary approach and its connection to professional practice. The lead designers, the generational critical thinker, the core team, representatives of government and cultural institutions, the steering group, the external experts, the project manager – in short, everyone who contributed over the past year – demonstrate that it is possible to rise above uncertainty, institutional silos, and individual interests, and that a fundamental reconsideration of the spatial organization of our living environment can go hand in hand with a reorientation of the design disciplines. The result is a body of design proposals, a research agenda, guiding principles, preliminary conclusions, and questions that can support governments in making informed decisions about actions, resources, and priorities – decisions that serve the public interest today while helping shape the long term. Rather than presenting finished blueprints, this report offers directions for thinking and acting: a building block for an iterative process in which making choices and adjusting course become standard practice.

Trust and commitment are essential to this endeavor. I would therefore like to conclude my foreword by expressing my deep appreciation for everyone’s contributions and their measured yet decisive approach, and by extending my special thanks to our clients for creating the conditions that made this project possible.

Saskia van Stein
– Director International Architecture Biennale Rotterdam (IABR), January 2026



The Delta Rijnmond-Drechtsteden 2100 team, from bottom left to top right: Han Meyer, Elena Chevtchenko, Ellen Kelder, Marijne Kreulen, Shuangyun Chen, Yeeun Boo, Marlies van der Maarel, Jaap van der Salm, Lodewijk van Nieuwenhuijze, Dirk van Peijpe, Dirk Sijmons, Marcel van der Meijs, Melany van Twuijver, Berry Gersonius, Vera Konings, Esma Hoogen dijk, Saskia van Stein, Lena de Rouw, Pieter Jacobs, Jelmer Teunissen, Marc Eisma, Hans Heupink. Photo: Sabine van der Vooren

1 Introduction

Introduction

Dirk Sijmons,
Lodewijk van Nieuwenhuijze,
and Jelmer Teunissen
(Lead Designers)

‘If there is one region in the Netherlands where the full administrative complexity of the collision between our globalized economy and the planet’s boundaries will play out, it is the Rijnmond-Drechtsteden region.’

The current crisis caused by climate disruption has at times been succinctly characterized as a head-on collision between our globalized economy and the planet’s boundaries. In several respects, those boundaries have already been exceeded, making it clear that we are dealing with a polycrisis and that the challenges extend far beyond global warming, sea-level rise, and flood safety. These challenges may well force us to slow the pace of the global economy. It is a slow-moving disaster with physical, social, and economic consequences that will be felt throughout every layer of society. Slow-moving, because this is a crisis better described in terms of centuries than decades.

If there is one region in the Netherlands where the full administrative complexity of the collision between our globalized economy and the planet’s boundaries will play out, it is the Rijnmond-Drechtsteden region. This region is dominated by its port complex, which stretches from Dordrecht to Maasvlakte 2. The port network extends from Moerdijk to Antwerp, Venlo, and the Ruhr region. Its indirect influence reaches even farther. It serves as the gateway to the capital-intensive agricultural and horticultural complexes extending from the Westland region to Brabant.

This is also where the country’s major rivers converge before flowing through the estuary into the North Sea. Changing river discharge patterns – with rivers increasingly fed by rainfall rather than meltwater – add a new dimension to flood safety issues while also affecting the economy. Inland shipping, for example, will increasingly be unable to operate, or will be severely restricted, for days at a time because of extremely high or low water levels. Rising sea levels – especially when combined with periods of high river levels that may last for weeks – will ultimately require far-reaching water management measures. Measures to keep Rotterdam, Dordrecht, and the municipalities outside the flood safety system safe – such as new storm surge barriers, locks, strengthened and new flood defenses, high-water storage, and large-scale pumping stations – may in time also require a reconfiguration of the port complex and the urbanized area.

Such measures are needed not only to ensure flood safety but also to safeguard freshwater availability – not only for urban areas, but also for the port industries, the Westland region, and the rural hinterland. This becomes even more pressing because climate change will also bring prolonged periods of drought and low river discharge. In addition, it is prudent to prepare the region for erratic weather events, such as clusters of intense rainfall occurring in the ‘wrong’ season. In other words, the adaptation measures needed to protect ourselves against the consequences of unavoidable warming will require spatial interventions.

This adaptation must go hand in hand with planning the mitigation measures needed to slow the pace of climate change. In this region, such measures will be closely tied to uncertainties surrounding the pace at which the fossil fuel industry – concentrated in the port complex – is phased out and the speed at which the rest of the economy is electrified. In the foreseeable future, mitigation and adaptation measures in the Rijnmond-Drechtsteden region will strongly influence one another.

This report is about addressing these challenges – which may still seem far away – and about how the region should prepare for them from a governance perspective. It starts from the observation that environmental challenges and the resulting issues of flood safety are so deeply intertwined with the region’s social, spatial, and economic functioning – and thus with the future of the Dutch economy – that, although they can be distinguished for the sake of clarity, they cannot be separated.

In other words, our assignment was to identify the long-term prospects for flood safety in relation to spatial and economic developments in the Rijnmond-Drechtsteden region. We interpreted ‘the long term’ as the point at which we are confronted with 2 m of sea-level rise (or more), whether that occurs by 2100 under an extreme scenario or at a later date. All of this serves as a building block for the advice that the region’s Administrative Area Consultation (Gebiedsoverleg, GO) will submit to the Delta Commissioner as part of the revision of the Rijnmond-Drechtsteden Delta Program.



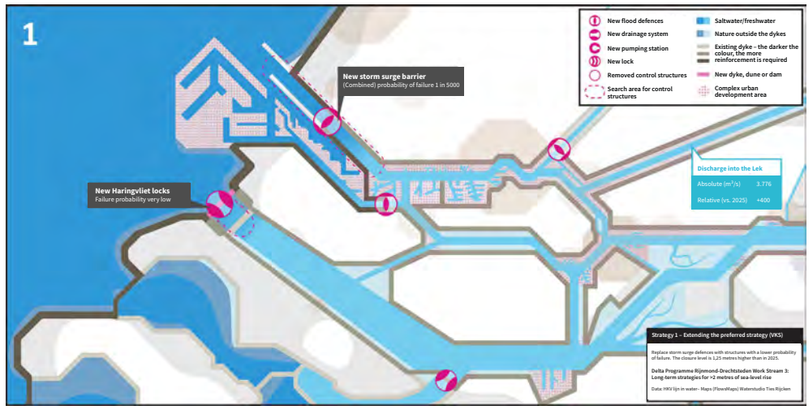
Working session 4, 'City and Hinterland,' at the WaterSchool, Studio Makkink & Bey, Rotterdam. Photo: Sabine van der Vooren

The Role of Research by Design

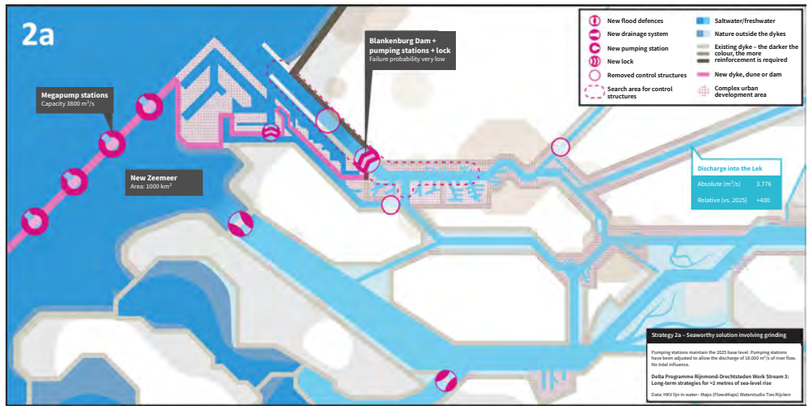
If all the implications of every alternative and variant for flood safety identified in earlier studies, such as the HKV report Long-Term Flood Safety Strategies for DPRD (2025), are systematically cross-referenced with the possible spatial development pathways for this region, the number of combinations quickly becomes unmanageable. We sought to make this multitude of possible futures manageable by using research by design as the working method for this atelier. Research by design can be characterized as a mode of knowledge production based on an iterative process in which hypotheses – in this case, spatial and/or environmental engineering hypotheses – are continually alternated with reflection on and discussion of the results. The comments and improvements that emerge are then used to formulate the next hypothesis. This process is repeated until a workable outcome is reached. Compared with other modes of knowledge production – induction and deduction – research by design is often described as 'abduction.' The problem is 'abducted' in order to explore whether, once we let go of the illusion that there is a single correct answer, we can develop pathways for action that are 'good enough' to move the policy process forward. This type of research requires a safe space in which the 'abducted' problem can be examined and discussed from every angle by stakeholders. As an architecture biennale, the IABR has played a pioneering role in providing such an open space for the cultural domain.

In 2025, three design firms – PosadMaxwan, De Urbanisten, and H+N+S Landscape Architects – carried out this research by design on behalf of the IABR for the participating authorities. PosadMaxwan developed spatial-economic scenarios for the DPRD region. De Urbanisten and H+N+S each investigated the spatial implications of one family of flood safety strategies. They mapped the extremes of the range of possibilities without losing sight of their interconnections.

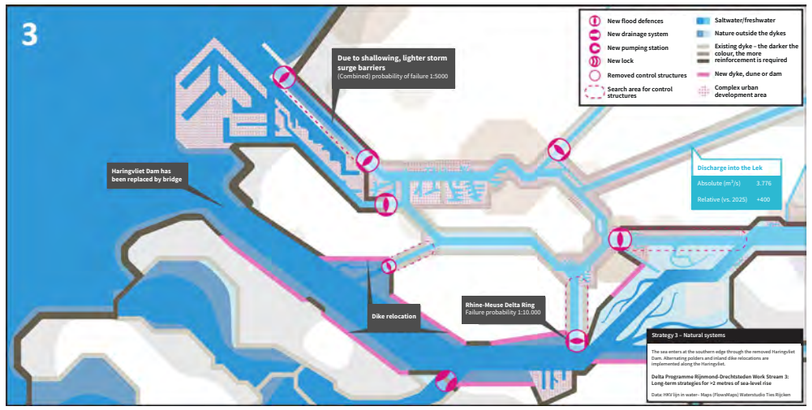
The results of the research not only serve as a building block for preparing the advice that the administrative parties in the Rijnmond-Drechtsteden region will submit to the Delta Commissioner, but will also be presented at the 2026 International Architecture Biennale Rotterdam as examples of research by design.



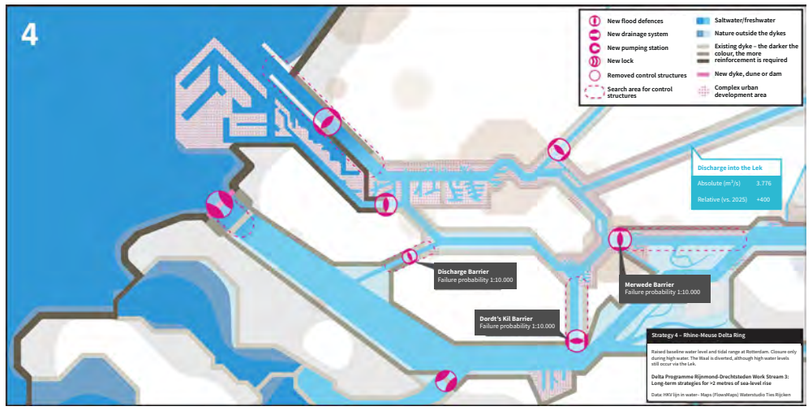
Elaboration of the 'Extension of the Preferred Strategy' (HKV, 2025; image: Waterstudio Ties Rijcken)



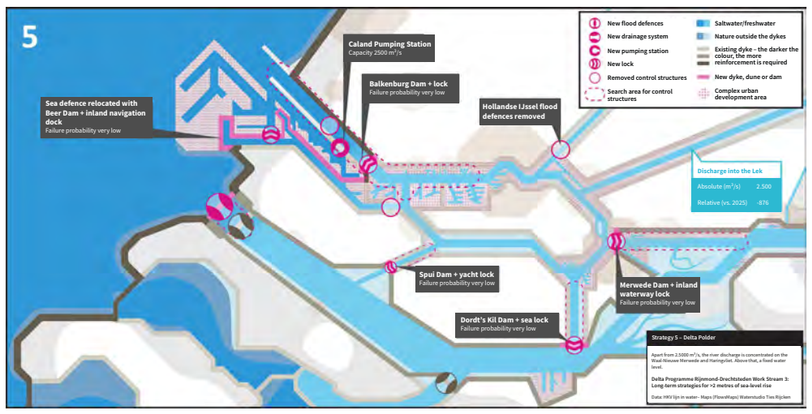
Elaboration of 'Seaward' (HKV, 2025; image: Waterstudio Ties Rijcken)



Elaboration of 'Nature-Based' (HKV, 2025; image: Waterstudio Ties Rijcken)



Elaboration of 'Rijnmond Ring' (HKV, 2025; image: Waterstudio Ties Rijcken)



Elaboration of 'Delta Polder' (HKV, 2025; image: Waterstudio Ties Rijcken)

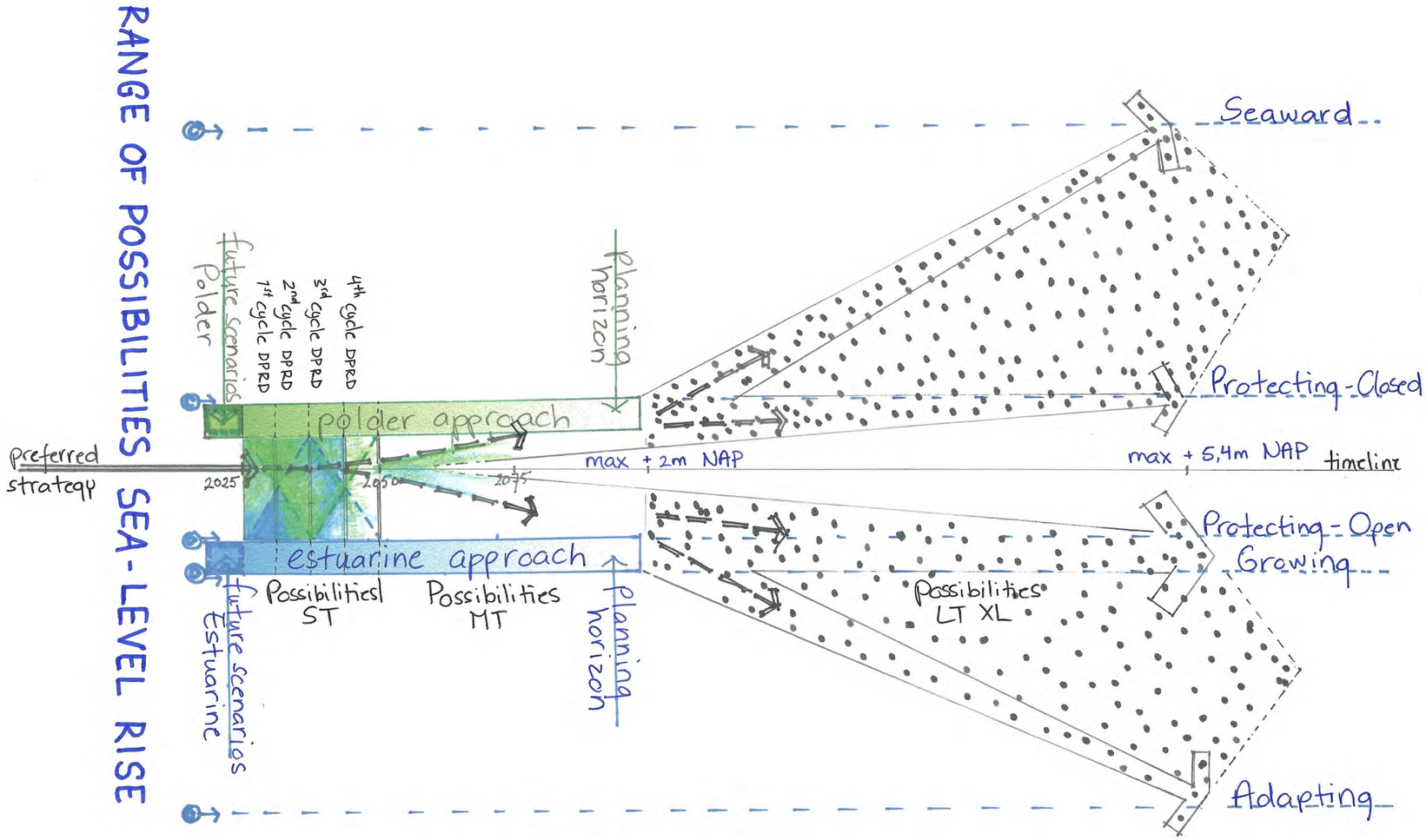
Steps in the Research by Design

This research by design process took as its starting point the five long-term flood safety strategies developed by HKV and Ties Rijcken as part of the DPRD program (see left):

1. Extension of the Preferred Strategy
2. Seaward (new flood defense system in the sea)
3. Nature-Based (open Haringvliet with storm surge barriers around Rijnmond-Drechtsteden)
4. Rijnmond Ring (system of storm surge barriers around Rijnmond-Drechtsteden)
5. Delta Polder (locks around Rijnmond-Drechtsteden)

These five strategies can be regarded as regional interpretations of the approaches developed by the various consortia as part of the long-term exploratory study Room for Sea-Level Rise (Protecting, Seaward, Adapting, and Growing; 2025). Each strategy consists of a different combination of 'building blocks' – such as the type of connection to the sea, storage capacity, pumping and discharge capacity, storm surge barriers, and the distribution of discharge – which together form a plausible long-term flood safety strategy.

When these strategies are placed in a temporal perspective, we see that, in broad terms, they can be understood over the medium to long term as belonging to two families of approaches, which we have called Polder and Estuarine (discussed in more detail on the following page). These approaches can, in turn, be regarded as regional interpretations of the approaches developed through Room for Sea-Level Rise. For each approach, the firms developed an integrated future strategy, applying its underlying principles as consistently as possible. In this way, they mapped two extremes that, taken together, make the range of possibilities for long-term flood safety policy visible.



Diagrammatic representation of the range of possibilities for adapting to sea-level rise in the Rijnmond-Drechtsteden region: the vertical axis shows a spectrum of approaches and the horizontal axis shows time in meters of sea-level rise; the Preferred Strategy and decision points in the short, medium, and long term are shown, with the Polder and Estuarine approaches positioned within this framework. (Lead designer; image: Lodewijk van Nieuwenhuijze)

The Medium-Term Range of Possibilities Defined by Two Approaches

The diagram on the left places the explored range of possibilities in a temporal perspective, distinguishing between the short-, medium-, and long-term ranges. The four consortia referred to earlier (Protecting, Seaward, Adapting, and Growing) assume a sea-level rise of 2 meters by 2100 and 5.40 meters by 2200. These are highly extreme values that the Delta Program considers unrealistic. In this exploration, however, we do assume a sea-level rise of 2 meters, because long-term planning must always take the most extreme scenario into account, but this level is no longer tied to the year 2100. The extremely long term begins once 2 meters of sea-level rise has been reached.

Short-term developments always start from the Preferred Strategy as currently established in flood safety policy. The Protecting-Closed and Protecting-Open strategies effectively explore the first crucial decision point: the prospect of an open or closed estuary. The Seaward and Adapting strategies explore a much more radical change of course. In the diagram, these strategies are therefore positioned at a considerable distance from the Preferred Strategy. Growing can be understood as a specific development of Protecting-Open and is therefore positioned close to that strategy.
For the medium term (up to 2 meters of sea-level rise), we have grouped the five regional flood safety strategies into two approaches: Polder and Estuarine. The assumption is that these two approaches capture the principal decision points up to 2 meters of sea-level rise, while the more radical system choices – which require a long period of preparation – will only come into play afterward. In other words, the range of possibilities between these two approaches can be regarded as a logical intermediate stage that keeps open the option of developing the more extreme strategies for the extremely long term.

The Polder approach comprises a family of solution directions in which we respond to the inevitable rise in sea level by adding a carefully designed combination of civil engineering measures to the water system, seeking safety through

‘If we take a step back and look at the combined outcomes of the three research by design projects, each of which explored these distant futures from its own perspective, it becomes clear that strategic decisions about flood safety, spatial planning, and port organization are closely interconnected.’

a closed system of defenses. The Estuarine approach comprises a family of solution directions in which the future is approached from an open estuarine perspective, relying much more heavily on natural processes of adaptation and growth to keep the region safe. Our research shows that both perspectives are feasible and can provide long-term safety, but that they differ fundamentally in both their value and their cost. Because water and soil – in the form of sediment – are indeed guiding factors in our region, the two approaches are also associated with fundamentally different spatial planning perspectives. To sum up:

Polder:
A perspective with a straightforward flood safety strategy that builds on our tradition of hydraulic engineering and – over time – implies the end of the open port.

- Port: Substantial reorganization of the port. Port interests will have to give way. The position of the maritime manufacturing industry around the Drechtsteden will weaken.maakindustrie rond de Drechtsteden.
- Urban: Urban design opportunities for direct access to freshwater, while keeping the areas of Rotterdam and Dordrecht outside the flood safety system safe.
- Nature: Ultimately, with the tidal system cut off, a familiar type of aquatic environment will emerge, although only after a long transition from brackish to freshwater.

Estuarine:
A perspective with an ultra-long-term strategy that calls for a new hydraulic engineering repertoire and – spread over a long period – implies a strategic retreat, primarily at the expense of agricultural land. This creates the time and space needed to achieve safety at lower cost.

- Port: The open port connection is maintained, albeit with the gradual shallowing of the Nieuwe Waterweg, requiring an equally gradual reorganization of the port. The port cluster, including the maritime manufacturing sector around the Drechtsteden, remains connected.
- Urban: Tailor-made local solutions create differentiated urban environments. Where necessary, substantial local ground raising must go hand in hand with careful timing. Area development becomes an advanced undertaking.
- Nature: System restoration toward a robust estuarine ecosystem that no longer needs to be protected like a hothouse plant but will ultimately protect us. Ecological engineering becomes an advanced undertaking.

If we take a step back and look at the combined outcomes of the three research by design projects, each of which explored these distant futures from its own perspective, it becomes clear that strategic decisions about flood safety, spatial planning, and port organization are closely interconnected. Decisions in each of these three domains cast a long shadow over the future. Our research also shows, however, that during the current DPRD policy period, no irreversible decisions need to be made that would lock the region into either of these two directions.

Dirk Sijmons, Lodewijk van Nieuwenhuijze, and Jelmer Teunissen
– Lead Designers, January 2026

‘The two approaches are associated with fundamentally different spatial planning perspectives.’



Photo: Jannes Linders, from the series 'Tussen stad en zee'.

2 The Polder Strategy
De Urbanisten

2.1 Flood Safety
2.2 Port and Shipping
2.3 Freshwater
2.4 Urban Design
2.5 Landscape
2.6 Area Studies
2.7 Transition Pathway
2.8 Conclusions

2 The Polder Strategy

The core of the flood safety strategy described in this chapter – the Polder Strategy – is protection against flooding from the sea and rivers through a continuous ring of dunes, dikes, and flood defenses. Under this strategy, Rotterdam and Dordrecht, among other places, would be located behind locks. The strategy builds on the centuries-long Dutch tradition of hydraulic engineering, in which living with water and protecting against its hazards go hand in hand.

Along many stretches, this strategy still requires higher and wider dikes, for example along the Haringvliet and Merwede rivers. However, by closing off key waterways with dams and locks, complex dike reinforcement projects with major spatial impacts can largely be avoided – for example in Rotterdam, Dordrecht, Krimpenerwaard, and Alblasserwaard. After all, these stretches could then meet much lower safety standards.

Under the Polder Strategy, many areas now located outside the flood defense system would be brought behind permanent flood defenses and would therefore be permanently protected against flooding. This is particularly important for densely built-up and heavily populated areas outside the flood defense system in Rotterdam and Dordrecht.

Inside the enclosed area, river water levels can be regulated and maintained at the desired level. River water is discharged to the sea either by sluicing or pumping. This means that more water will be discharged to the sea via the Waal and Haringvliet. Water levels in the Haringvliet rise in step with sea-level rise.

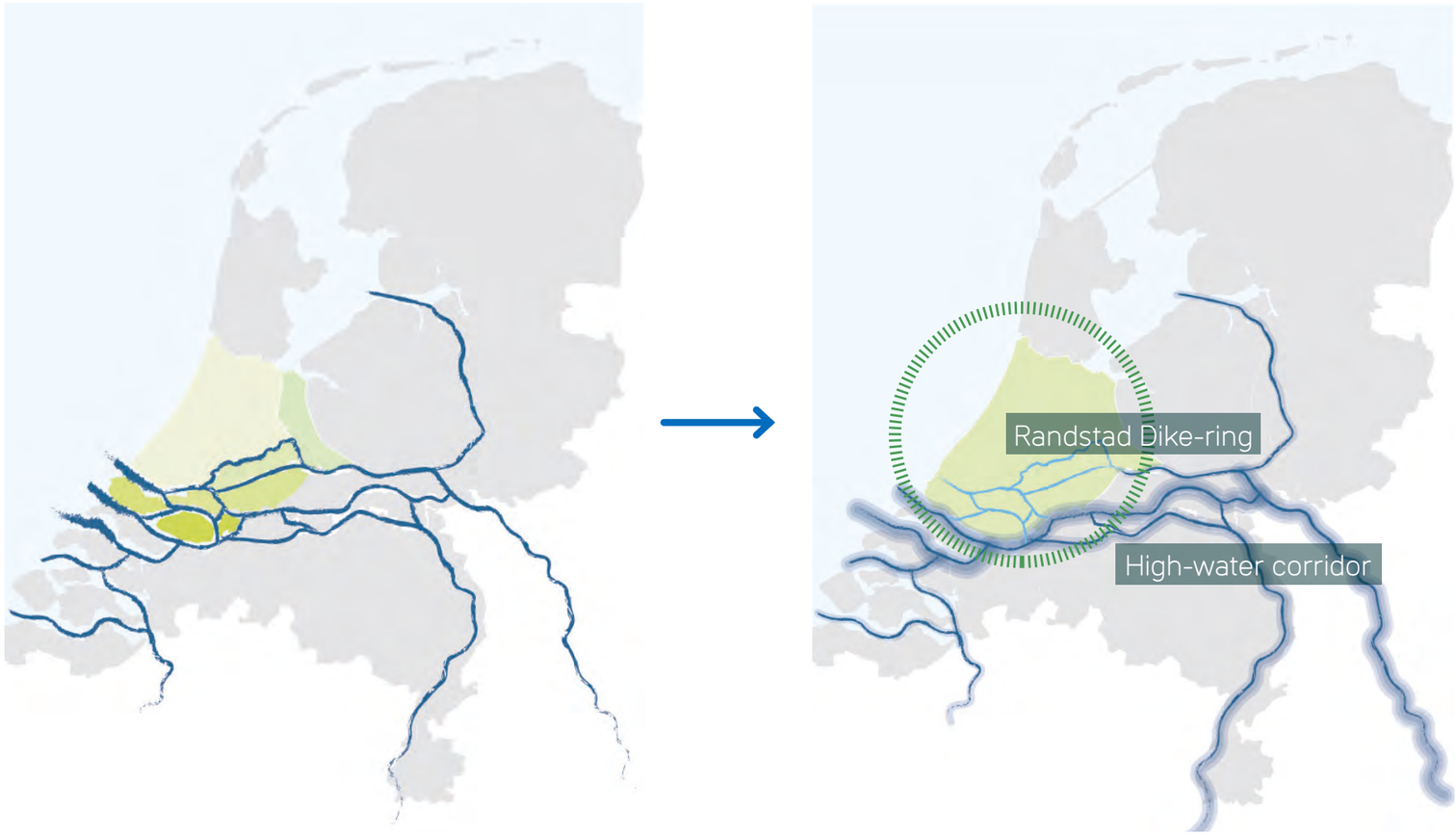
Under this strategy, the ditches, waterways, boezems (dispersed reservoirs), and rivers located inside the flood defense system form a single integrated water system. In this system, the Nieuwe Maas and Oude Maas function as a large freshwater basin and provide water storage during periods of extreme rainfall. Freshwater availability in the polder is safeguarded because locks in the Nieuwe Waterweg and Hartelkanaal prevent saltwater intrusion. As a result, Rhine water no longer needs to flow via the Nieuwe Waterweg to the sea to push back the salt wedge.

The Polder Strategy requires adjustments to the distribution of discharge among the Rhine branches, with discharge via the Lek reduced. More Rhine water can flow out to sea via the Waal, Merwede, and Haringvliet.

This would allow the Haringvlietdam to remain open more frequently and for longer periods, increasing tidal dynamics and promoting the associated estuarine habitats. Around Dordrecht, it would also create opportunities for riverine nature development in the Biesbosch area.

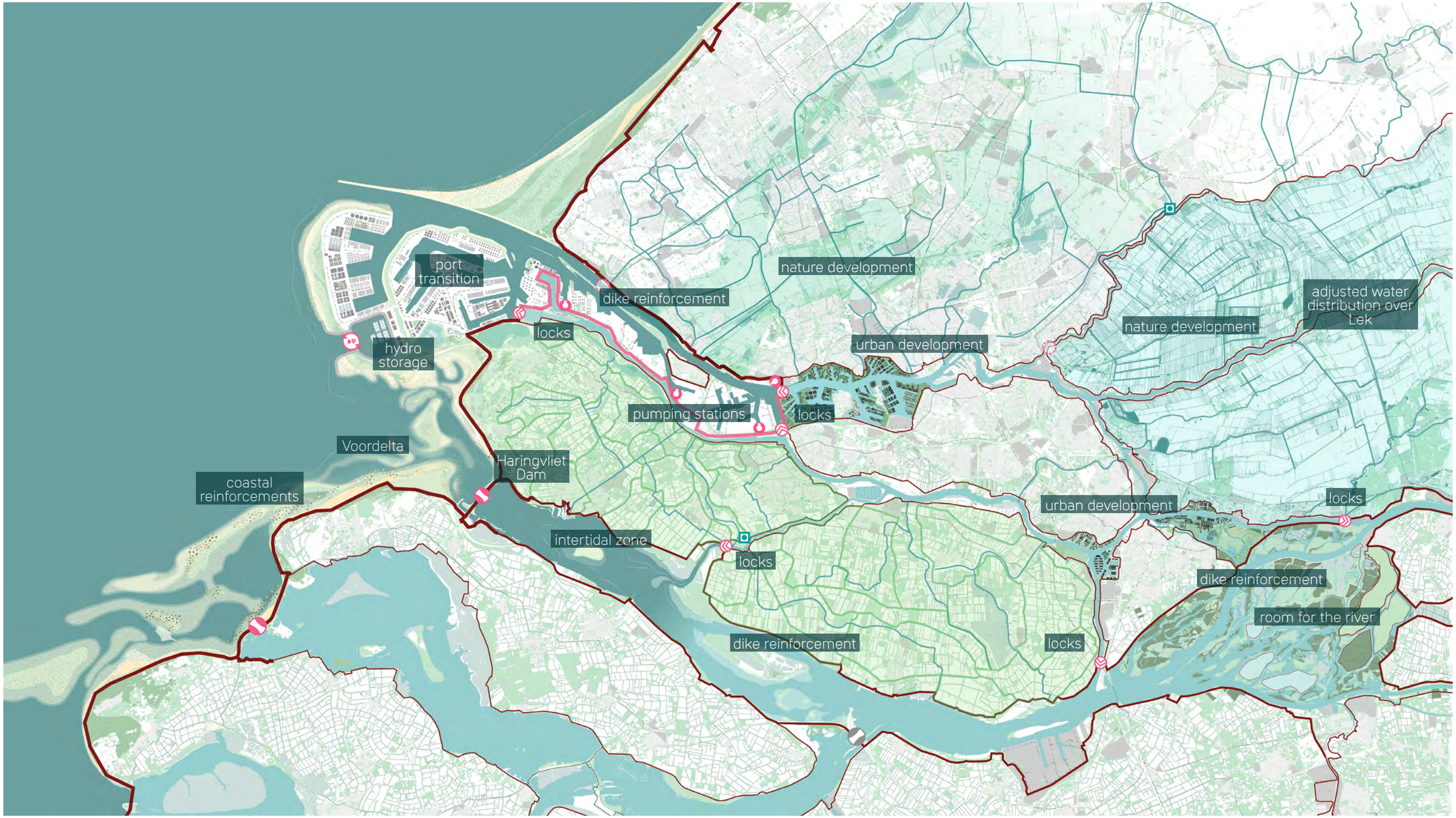
Under the Polder Strategy, the Rijnmond ports would undergo a transition toward a post-fossil port economy, including the construction of a third Maasvlakte. The locks would have a major impact on the ports. Oceangoing vessels would remain outside the locks, while inland vessels and smaller seagoing vessels could continue to reach the hinterland after passing through the locks. This would require different storage and transshipment methods.

The transformation of extensive port and industrial areas would free up space for attractive new urban waterfront areas, while regional landscapes along major inland waters and in the deep polders could be further developed.



Transition from the Current Strategy to the Polder Strategy (De Urbanisten)

Polder Strategy Map



Strategy Map – Polder Strategy (De Urbanisten)

2.1 Flood Safety

For flood safety, the Polder Strategy takes the Protecting–Closed approach as its point of departure. A system of dunes, dikes, and hydraulic structures protects the region against flooding from both the sea and the rivers. Merging several existing dike rings creates a single continuous Delta Dike Ring.

River branches and estuaries are closed off by fixed dams and lock complexes, including at the Nieuwe Waterweg, Hartelkanaal, Oude Maas, Spui, Dordtse Kil, and Beneden Merwede.

Robust dike reinforcements are required along the Haringvliet and Hollands Diep, and farther upstream along the Merwede and Waal. In most cases, these are technically feasible and can be well integrated into the landscape.

At several locations across the region, new stretches of primary flood defenses are proposed. The flood defense along the Hartelkanaal is relocated to the north side, bringing the Hartelkanaal inside the flood defense system, behind the locks. Near Dordrecht and Werkendam, the dike is set back and raised, creating more room for the river in the Biesbosch and Land van Altena areas.

The main waterways – including the Oude Maas, Nieuwe Maas, and Boven Merwede – can be maintained at a regulated target water level, for example NAP +1 meter. Because water levels can be controlled, a more natural water-level regime becomes feasible, benefiting both water storage and the freshwater ecology of the polders.

Discharge via the Lek is reduced in order to keep pumping capacity around Rotterdam manageable. A combination of new and existing control structures at the Pannerdense Kop and IJsselkop bifurcations and near Arnhem is intended to create a new distribution of water during periods of both high and low river discharge. The high-water corridor along the Waal directs more Rhine water toward the Hollands Diep and Haringvliet, via the south of Dordrecht, making it possible to open the Haringvlietdam more frequently.

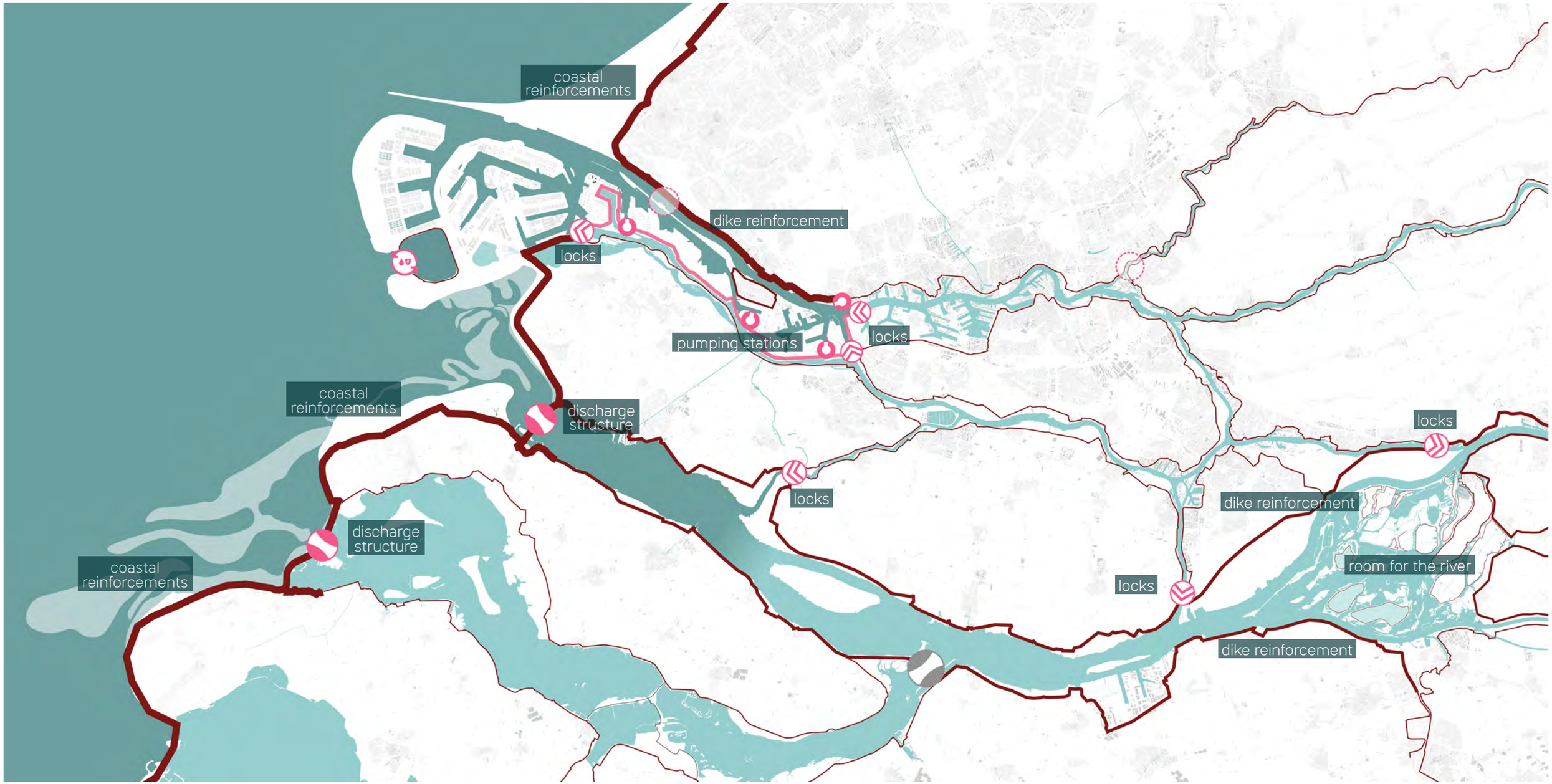
In terms of flood safety, the Delta Polder brings areas currently outside the flood defense system behind permanent flood defenses, thereby providing them with permanent protection. Complex dike reinforcement projects in densely built-up areas are no longer required, sparing historically valuable and densely populated parts of cities such as Rotterdam and Dordrecht.



Scenario B2 with Delta Polder and High-Water Corridor (Kennisprogramma Zeespiegelstijging, 2024, p. 34).

The Delta Polder long-term strategy is the starting point for the Polder Strategy (HKV, 2025, p. 10; image: Waterstudio Ties Rijcken).

Flood Safety

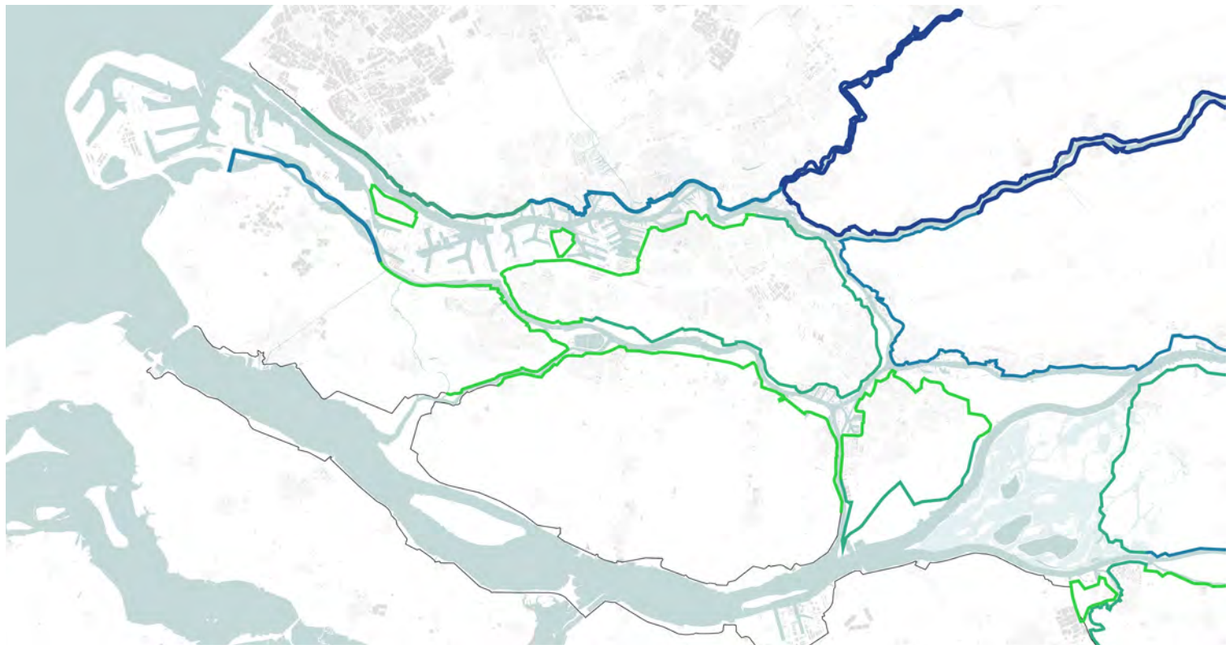


Legend:

New lock
Pumping station
Hydropower
New dike or dam
Saltwater/freshwater
New discharge structure
Removed control structure
Exisiting discharge structure
Exisiting dike:
The thicker it is, the more difficult it is to reinforce

Building blocks for flood safety – Polder Strategy (De Urbanisten)

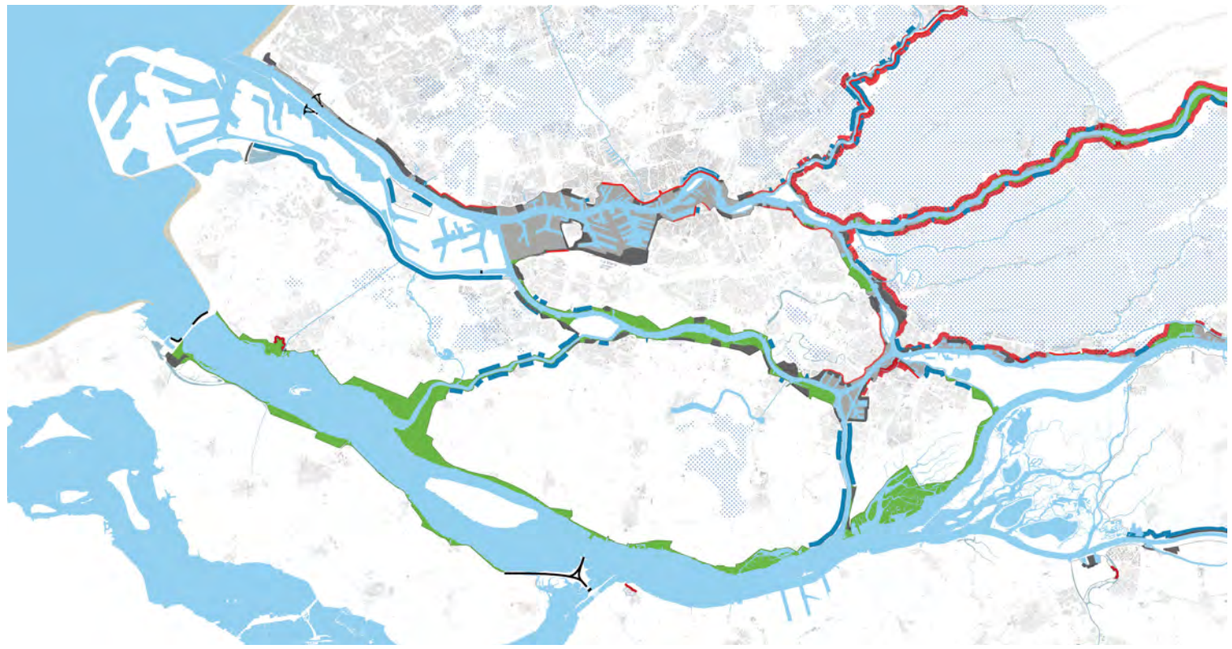
The Polder Strategy Avoids Complex and Highly Disruptive Dike Reinforcements



Impact of land subsidence on dike reinforcements with 2 meters of sea-level rise by 2200 (HKV, 2025, p. 20).

Legend:

- no information
- 0 < x < 0.10 m
- 0.10 < x < 0.25 m
- 0.25 < x < 0.50 m
- 0.50 < x < 0.75 m
- 0.75 < x < 1.00 m
- 1.00 < x < 1.50 m
- > 1.50 m



Complex Spatial Dike Reinforcement Projects (De Urbanisten).

Legend:

Characteristics that make dike reinforcement complex:

- primary access infrastructure
- secondary infrastructure
- land subsidence

Potential opportunities offered by areas outside the dikes:

- designated Delta Dike
- designated foreland
- green foreland



Voorstraat (Dordrecht)



Dakpark, Vierhavenstraat (Rotterdam)



Central Rotterdam (e.g., Boompjes)



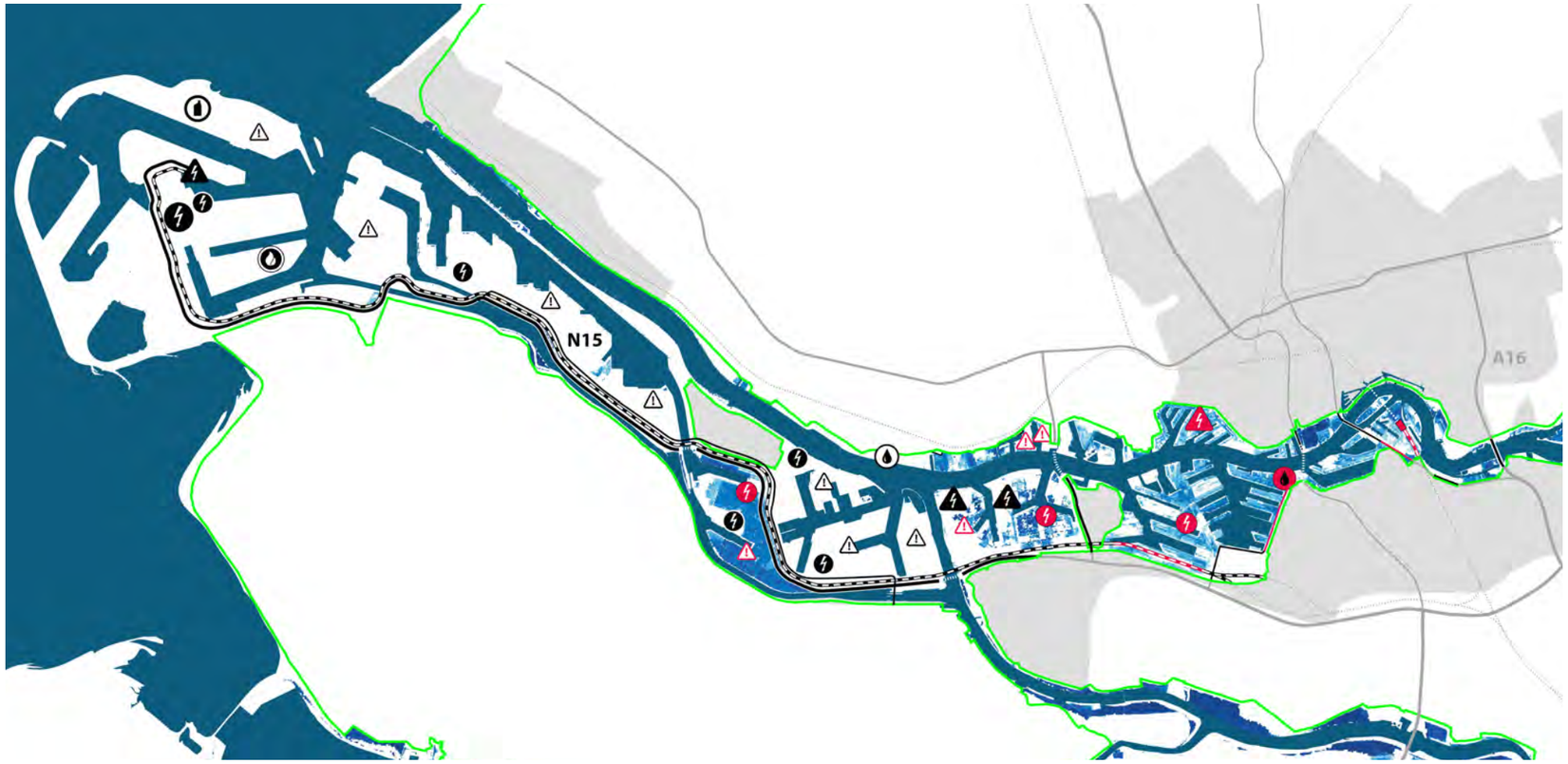
IJsseldijk (Hollandse IJssel)



Lekdijk (De Lek)

Examples of locations requiring complex and disruptive dike reinforcement (De Urbanisten; images: Google Maps)

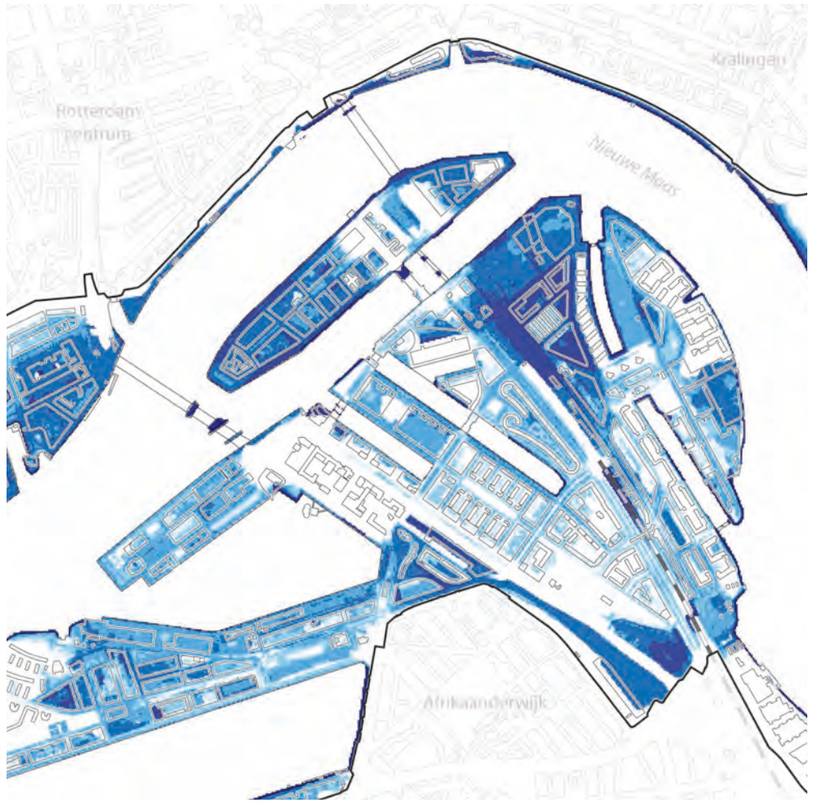
The Polder Strategy Safeguards Flood Safety in Areas Outside the Flood Defense System



Flooding of areas outside the flood defense system in Rotterdam – Climate Scenario 2100 W+, 1-in-1,000-Year Event (Rotterdam Climate Initiative et al., 2013, p. 40; image: De Urbanisten)

Legend (flood depths):

1 - 10 cm
10 - 25 cm
25 - 50 cm
50 - 100 cm
100 - 200 cm
200 - 550 cm



Flooding of areas outside the flood defense system in Rotterdam (Rotterdam Climate Initiative et al., 2013, p. 72; image: Deltares)



Scheepvaartkwartier (Rotterdam)



Wilhelminapier (Rotterdam)



M4H (Rotterdam)



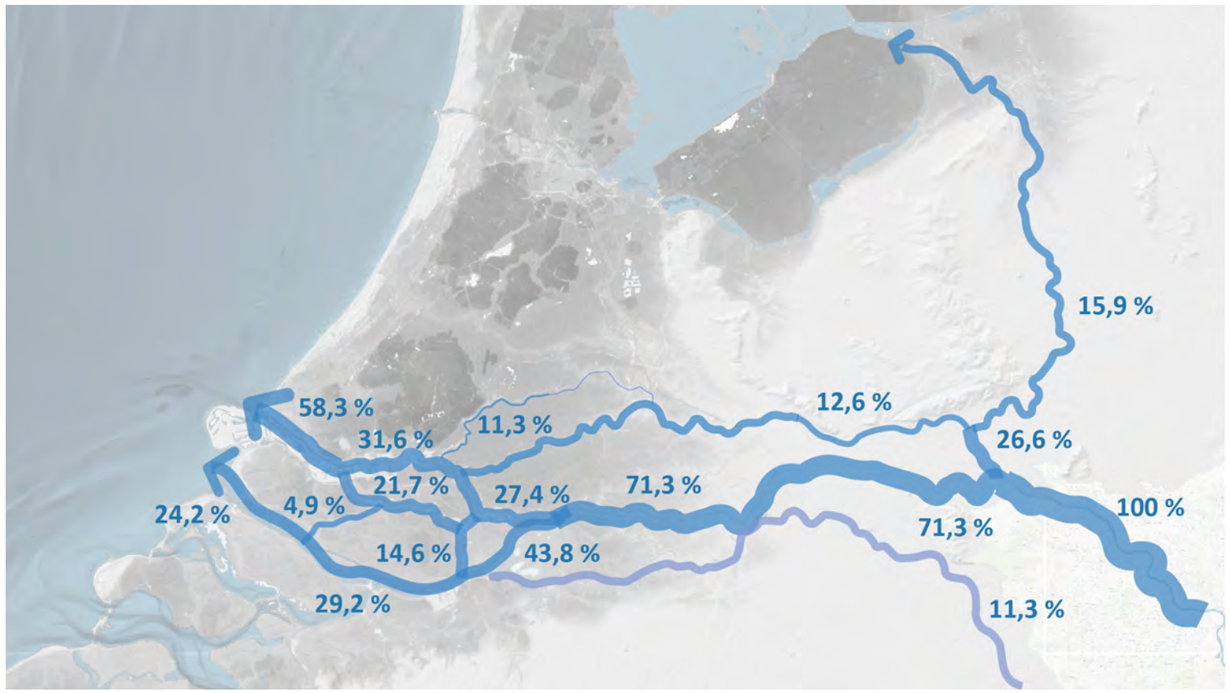
Area outside the flood defense system (Dordrecht)



Noordereiland (Rotterdam)

Examples of locations where flood safety in areas outside the flood defense system can be safeguarded (De Urbanisten; images: Google Maps)

The Polder Strategy redistributes Rhine Water: Less via the Lek, More via the Waal



Current distribution of river discharge (De Urbanisten)



Reduced discharge via the Lek during high river discharge – High-water corridor via the Waal (De Urbanisten)



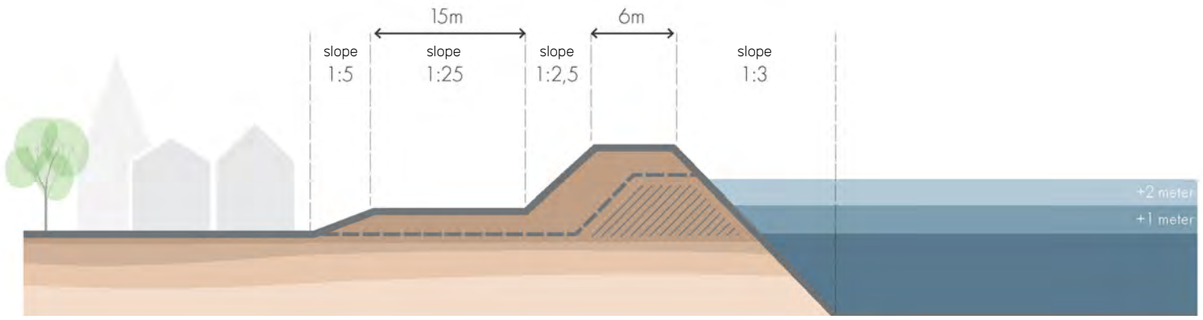
New control structure near Arnhem to further reduce discharge via the Lek (De Urbanisten; image: Google Maps)

The Polder Strategy requires a different distribution of Rhine water, with discharge via the Lek reduced in order to keep pumping capacity around Rotterdam manageable. New control structures at the Pannerdense Kop, the IJsselkop, and near Arnhem provide a new distribution of water.

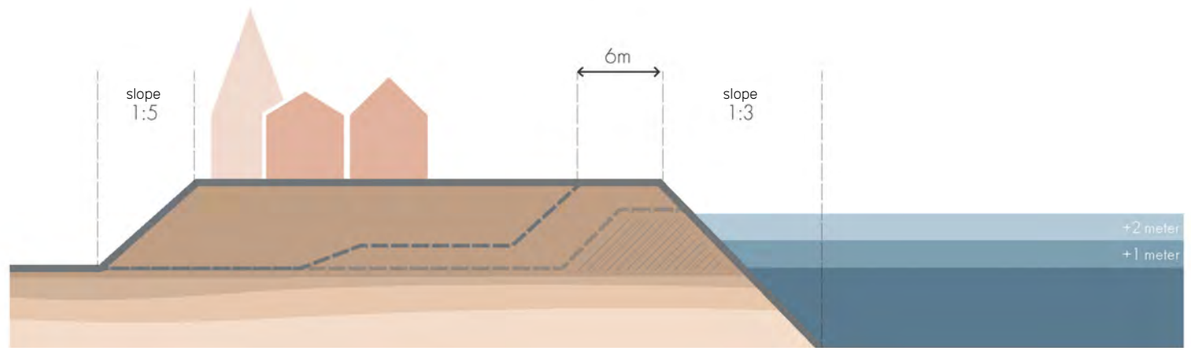
The high-water corridor along the Waal directs more Rhine water toward the Hollands Diep and Haringvliet via the south of Dordrecht, making it possible to open the Haringvlietdam more frequently – or even permanently.

Dikes Can Be Integrated into the Landscape Almost Everywhere Under the Polder Strategy

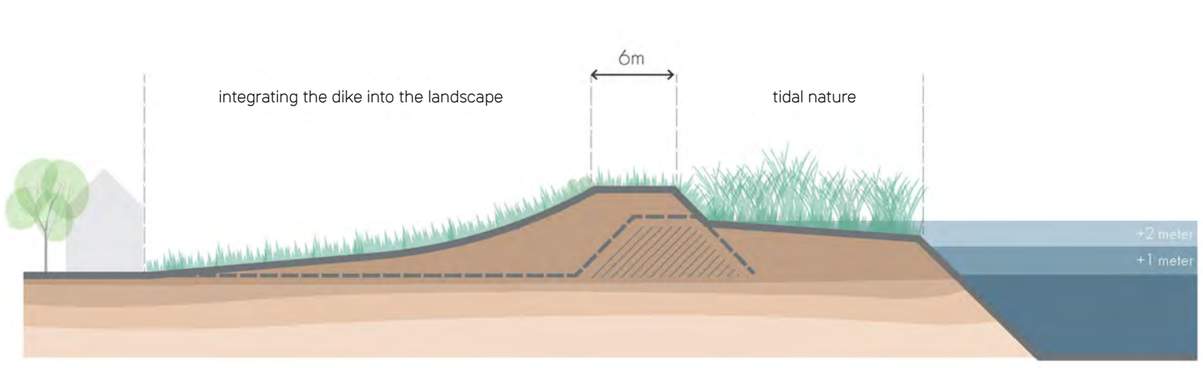
possible almost everwhere



Breach-proof delta dike

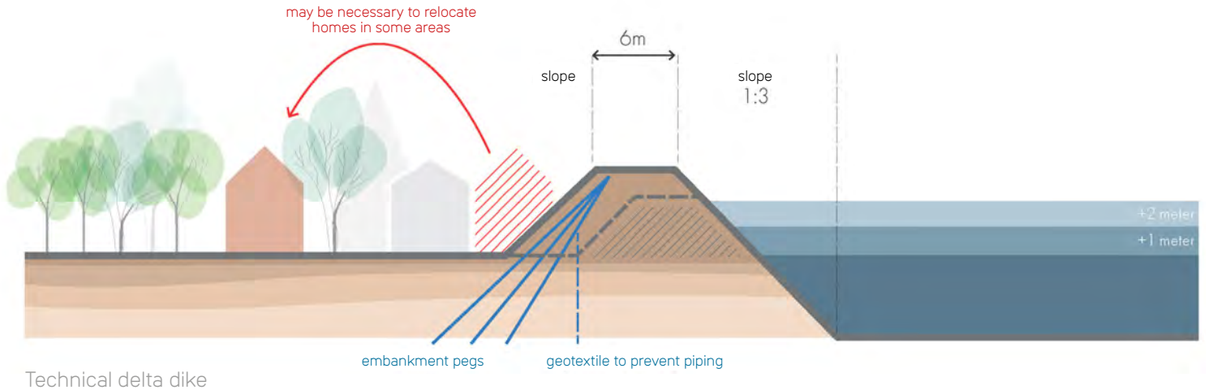


Multifunctional delta dike



Landscape delta dike

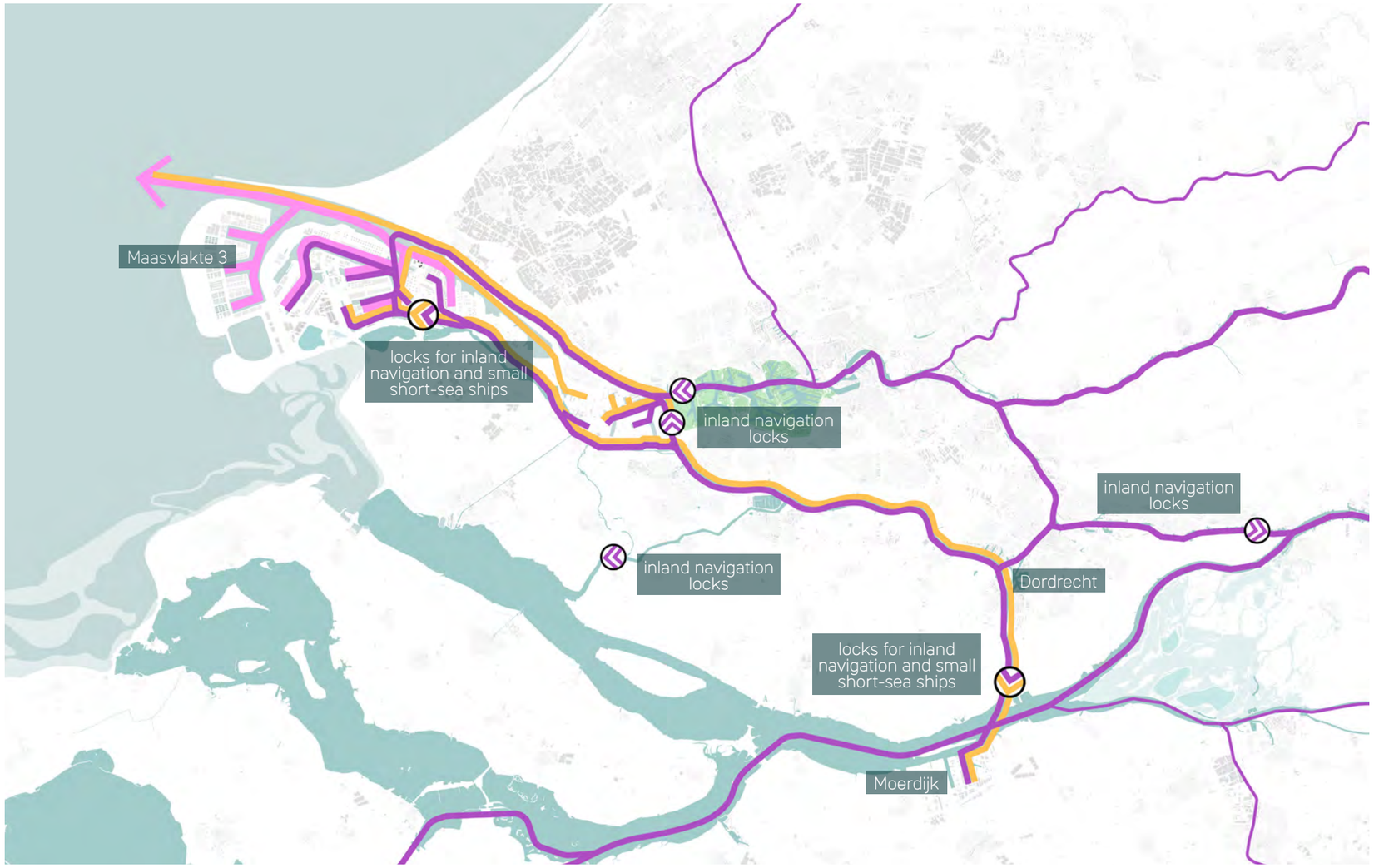
can be avoided almost everywhere



Technical delta dike

Dike reinforcement – Polder Strategy (De Urbanisten)

Robust dike reinforcements are required along the Haringvliet and Hollands Diep, and farther upstream along the Merwede and Waal. In most cases, these are technically feasible and can be well integrated into the landscape. Technically complex dike reinforcement can be avoided almost everywhere.



Key shipping routes and lock complexes – Polder Strategy (De Urbanisten)

Legend:

- Short-sea and inland navigation lock
- Inland navigation lock
- Oceangoing transport
- Short-sea transport
- Inland navigation transport

2. 2 Port and Shipping

The Polder Strategy provides for a system of dams and locks that protect against flooding from the sea, including at the Nieuwe Waterweg, Hartelkanaal, and Oude Maas. As a result, the unrestricted open connection between the Port of Rotterdam and the hinterland disappears. The Polder Strategy would therefore have a major impact on the Port of Rotterdam and the other ports in the area.

Direct access to the hinterland for oceangoing vessels would disappear; only inland vessels and smaller seagoing vessels would be able to pass through the lock complexes. Large oceangoing vessels would remain outside the locks, and their quays would therefore also lie outside the polder. This partial separation of maritime and inland shipping would require new and different methods of transshipment, with modes of transport other than shipping potentially becoming more important. Moerdijk would no longer be accessible to large oceangoing vessels. Under this strategy, the port-industrial complex would, over time, have to prepare for a transition to a future without an open connection to the sea.

Because many port sites are located outside the flood defense system, they are vulnerable to flooding under conditions of extreme sea-level rise. To protect them against flooding, port sites outside the flood defense system would be gradually raised. Areas such as the Waalhaven, Eemhaven, and Petroleum Ports would be brought behind the locks and could then more readily be transformed into urban areas. To compensate for the loss of port space, the strategy provides for a third Maasvlakte, including a large pumped-storage reservoir.

The proposed adaptation measures would be coordinated and implemented in stages in conjunction with mitigation measures, allowing the Port of Rotterdam to gradually transform into a post-fossil port and industrial complex based on renewable energy production and storage, sustainable logistics, and clean shipping.

Port Transition



Perspective on the Port of Rotterdam in 2100 – Transition to a post-fossil port (LOLA Landscape Architects, De Urbanisten, RoyalHaskoningDHV, 2022, p. 23; image: LOLA Landscape Architects)



Freshwater supply bottlenecks map (Rijnmond-Drechtsteden Delta Program, 2013, p. 12)

Legend:

System
- freshwater system
- relocation of intake point due to salinization (implementation Haringvliet sluice opening policy)
- freshwater supply
- salinization
- saltwater intrusion under normal conditions
- saltwater intrusion under very low water levels
- Tolhuissluis route
- small-scale water supply (KWA)
- additional freshwater intake

Freshwater sources / abstraction
- Brielse meer
- Hollandse IJssel
- Lek / Nederrijn
- Hollandsch Diep
- Volkerrak-Zoommeer
- Maas
- River area
- Lower river area
- Haringvliet

- agricultural intake
- intake for functions and water-level management above the local level
- intake point unusable due to salinization
- drinking water – dune water abstraction point (150 mg Cl/l)
- drinking water – surface water intake point (150 mg Cl/l)
- drinking water – emergency surface water intake point (150 mg Cl/l)
- drinking water – groundwater abstraction point (150 mg Cl/l)
- storage reservoir

2. 3 Freshwater

During dry periods and periods of low river discharge, large volumes of Rhine water are required to prevent saltwater intrusion via the Nieuwe Waterweg. Under present conditions, approximately 900 m³/s of freshwater is discharged to the sea for this purpose alone, without being available for use elsewhere. Even so, intake points such as Gouda and Bernisse are already vulnerable to salinization.

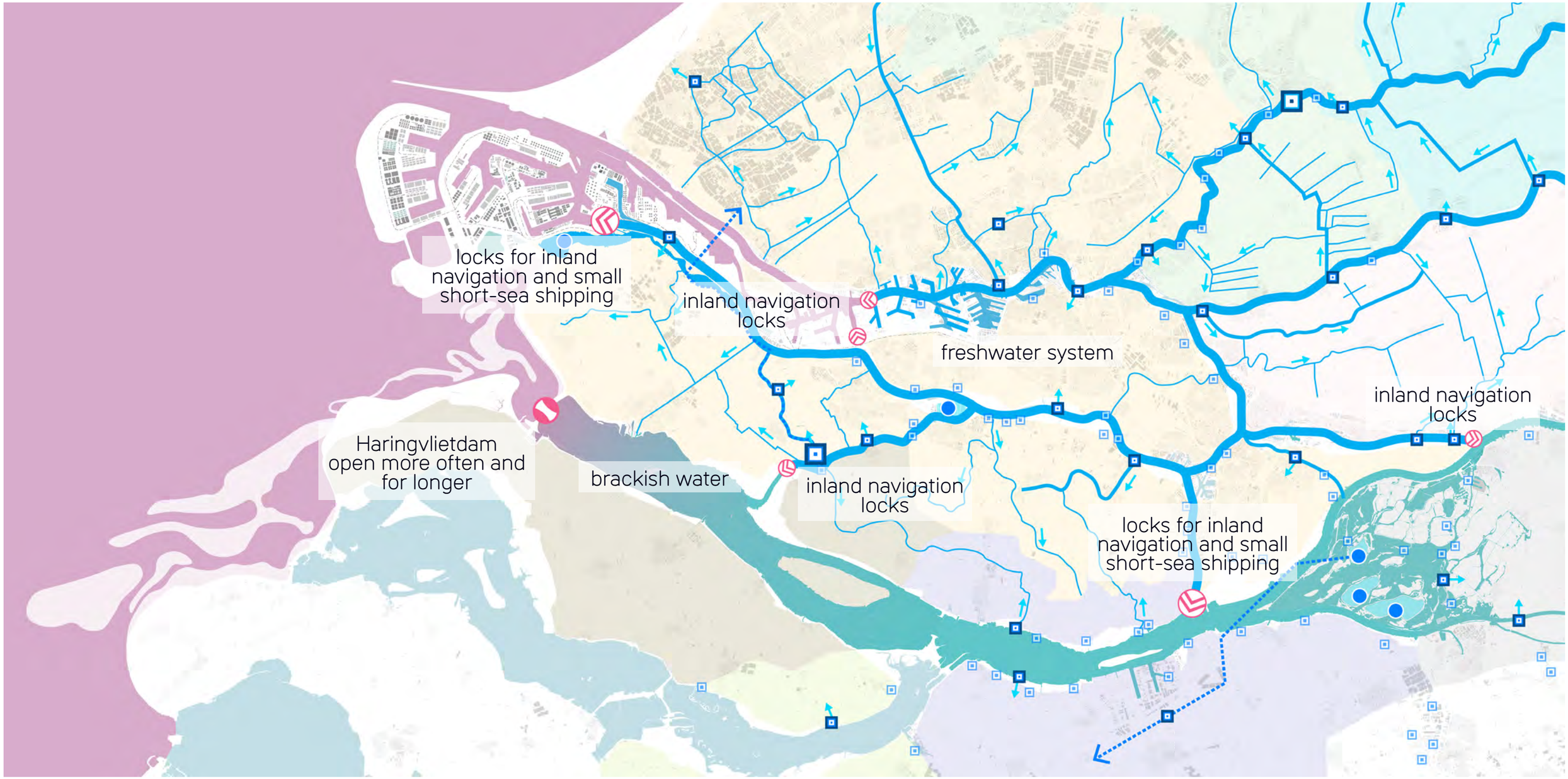
The Polder Strategy prevents saltwater intrusion through dams and locks in the Nieuwe Waterweg, Hartelkanaal, and Oude Maas. As a result, discharging freshwater via the Nieuwe Waterweg is no longer necessary.

The Polder Strategy provides for a single integrated freshwater system, supplied primarily with water via the Lek, while increasing the discharge of water to the sea via the Waal. This allows the Haringvlietdam to remain open more frequently and for longer periods, creating a larger intertidal zone and bringing ecological restoration within closer reach.

In this modified freshwater system, water can circulate more effectively through boezems (dispersed reservoirs), channels, waterways, and ditches, even during dry periods. This improves water quality, benefits nature, and reduces the impact of saline seepage on vulnerable agricultural areas.

A crucial condition is that the freshwater intake points at Gouda and Bernisse are safeguarded. This would enable a reliable freshwater supply to be maintained for approximately five million people, as well as for regional industry.

Freshwater

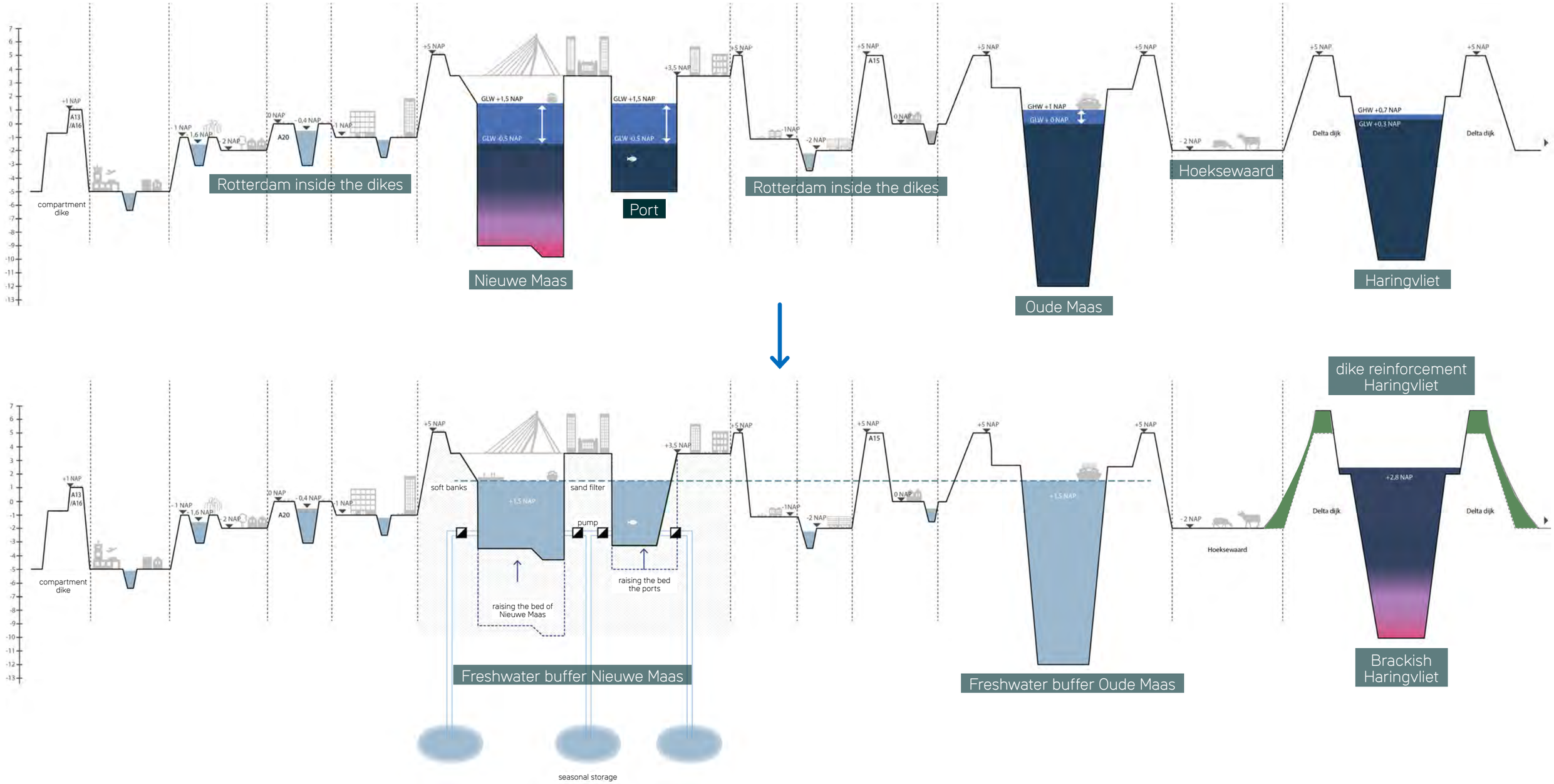


Legend:

- Freshwater system inside the dikes
- Freshwater distribution
- Lock
- Saltwater
- Freshwater rivers
- Freshwater
- Hollandsch Diep
- River area
- Hollandsche IJssel
- Volkerak-Zoommeer
- ARK / Kromme Rijn
- Maas
- Lower river area
- Haringvliet
- Intake for regional functions and water-level management
- Agricultural intake
- Water reservoir

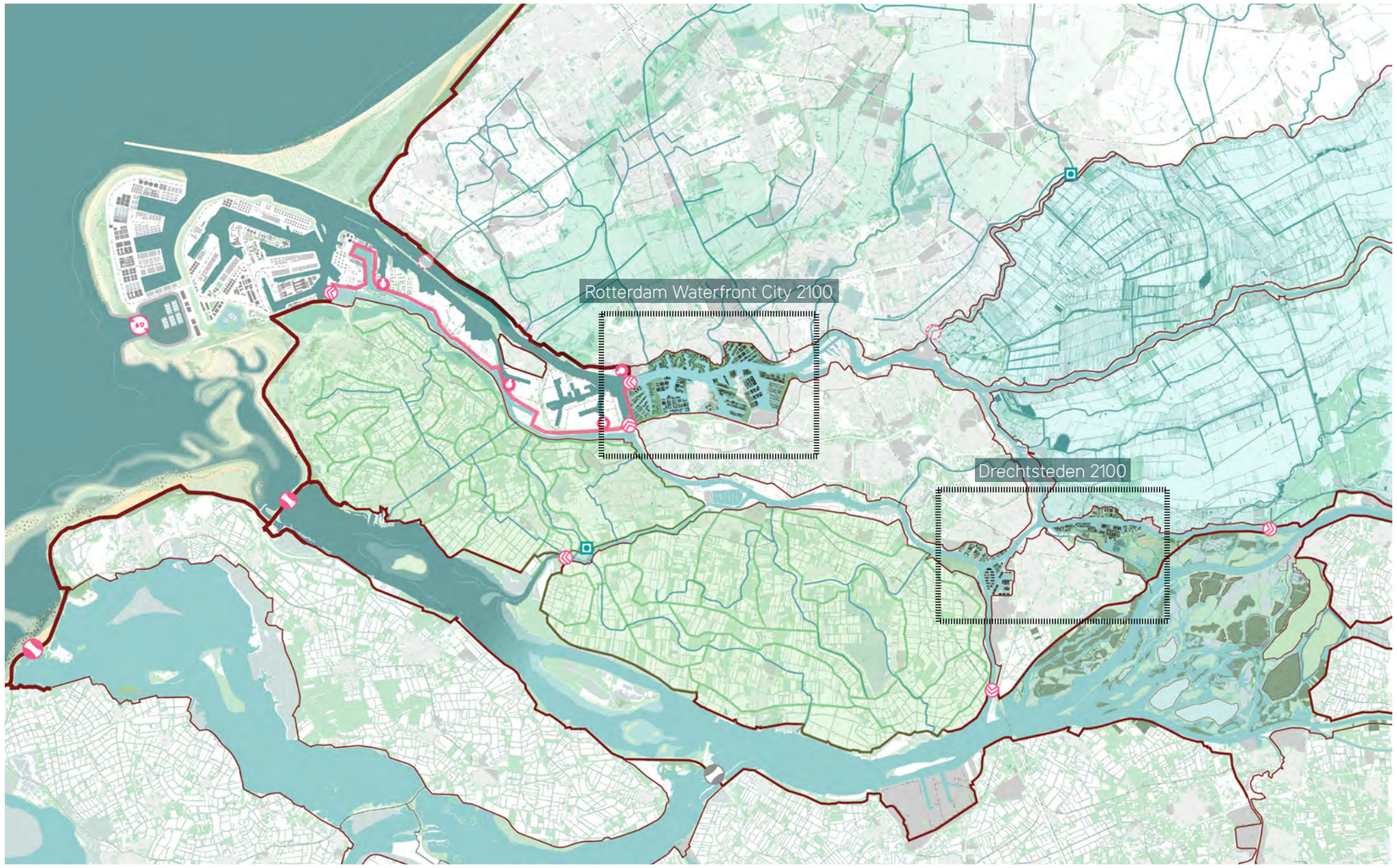
Freshwater system – Polder Strategy (De Urbanisten)

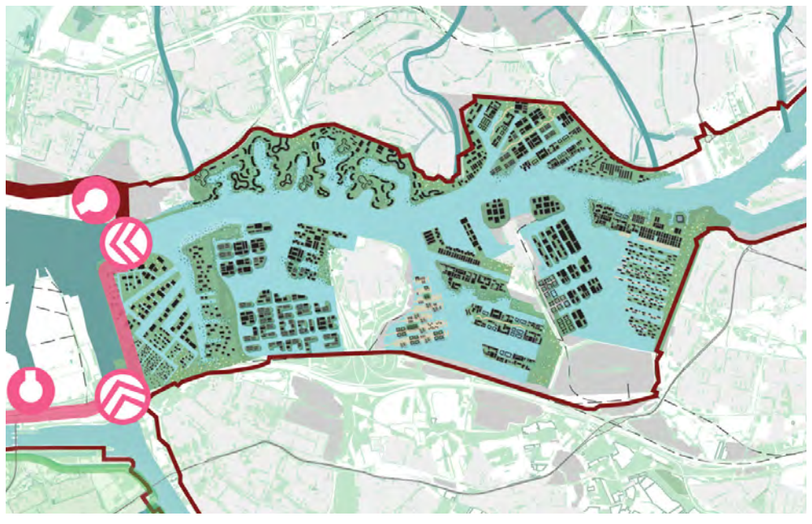
Freshwater

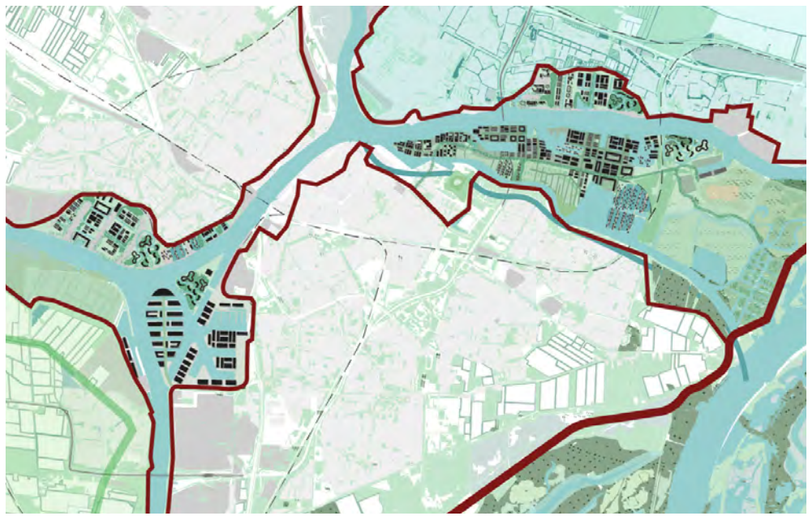


Schematic cross sections of the Rhine-Maas Estuary: Transformation of Rotterdam's current water system (top) into a new freshwater system (bottom) – Polder Strategy (De Urbanisten)

The Polder Strategy provides for a single integrated freshwater system that can be supplied with water via the Lek. In this modified freshwater system, water can circulate more effectively through boezems (dispersed reservoirs), channels, waterways, and ditches, even during dry periods. The Nieuwe Maas, Oude Maas, and other waterways become a freshwater buffer. Water discharge to the sea via the Waal is increased. Dike reinforcement remains necessary along the Haringvliet. The Haringvlietdam can remain open more frequently, creating a brackish intertidal zone.







Transformation of former port areas into a new waterfront city – Polder Strategy (De Urbanisten)

2. 4 Urban Development

For the city, the absence of tides in the Nieuwe Maas and Oude Maas means that Rotterdam can gradually develop into a genuine waterfront city, establishing a stronger and more direct relationship with the freshwater of its rivers and ports.

The former port sites outside the flood defense system, which would become part of the polder, offer enormous development potential, comparable in scale to the existing city. These urban ports could accommodate a rich variety of water-oriented urban living environments, inspired by cities such as Copenhagen, Stockholm, Venice, and Amsterdam.

A major advantage of the Polder Strategy is that complex dike-raising projects in densely built-up parts of Rotterdam, such as along Boompjes, would no longer be necessary.

In Dordrecht, too, the need for extremely complex reinforcement of the flood defenses in the historical city center (Voorstraat) and in areas outside the flood defense system would disappear, while opportunities would emerge to transform the port sites along the Dordtse Kil.

Urban Development



Rotterdam connects with the Nieuwe Maas through an extensive waterfront park and urban development on and along the water (De Urbanisten & Deltares, 2023, p. 26; image: De Urbanisten)



The major landscapes of the Polder Strategy (De Urbanisten)

Legend:

- New lock
- New discharge structure
- Floodplains - saltwater
- Floodplains - brackish water
- Floodplains - freshwater
- Peat meadow
- Dunes and beach
- Agricultural land
- Rewetted peat meadow / marsh
- Marshes
- Freshwater network
- Primary flood defence / dike
- green corridor inside the dikes

2. 5 Landscape

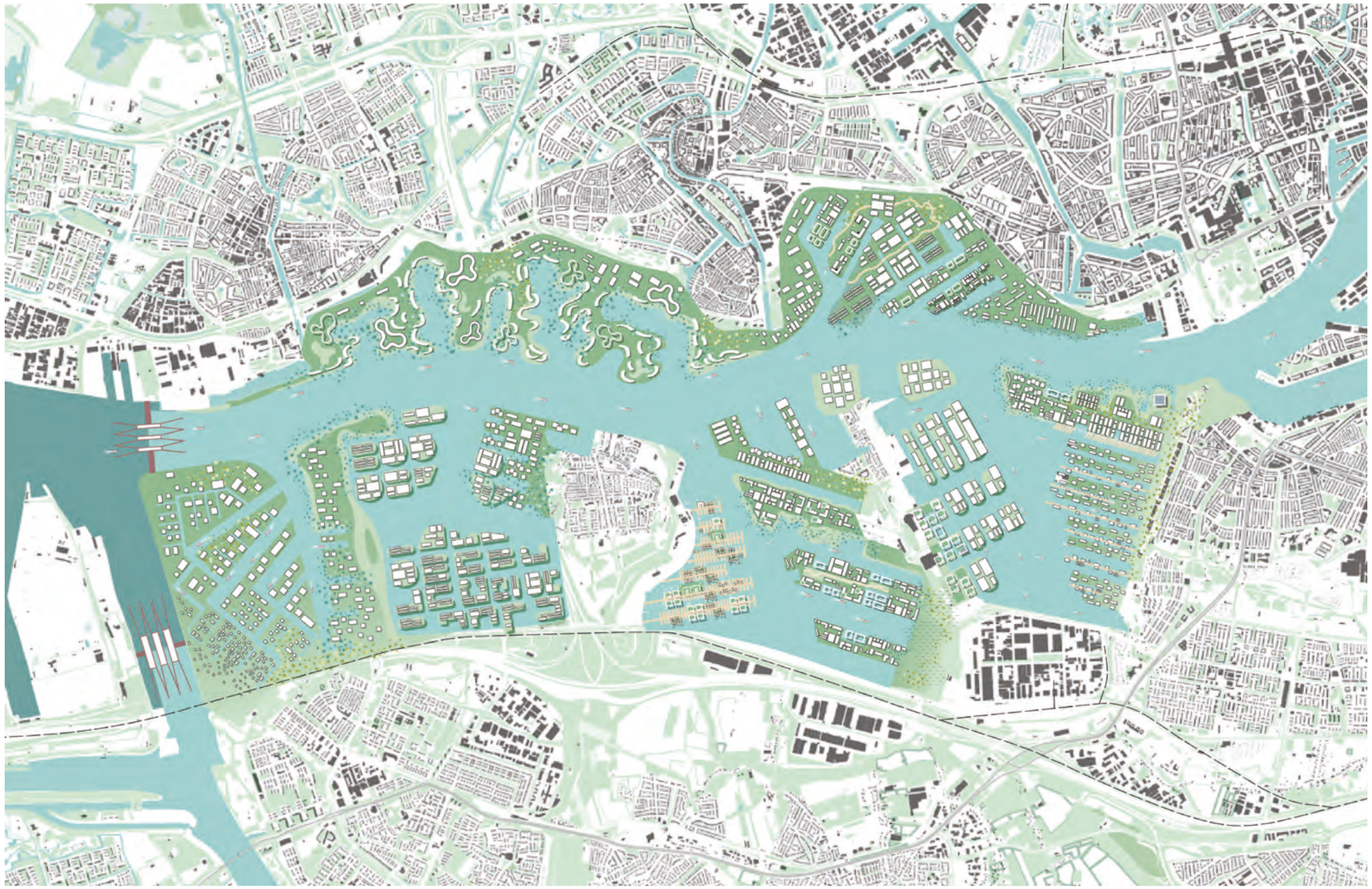
In terms of nature, the Polder Strategy follows two tracks. The first focuses on creating more room for the Waal and Merwede rivers toward the Haringvliet and the sea. This allows the Haringvlietdam to remain open more frequently and for longer periods, shifting the dynamics toward this part of the Southwestern Delta, creating more intertidal areas, improving fish migration, and allowing the Voordelta to develop further into a genuine Wadden-type landscape.

Dike reinforcements along the Haringvliet and Hollands Diep can go hand in hand with landscape development both outside and inside the flood defense system, for example at the mouth of the Spui and in the Biesbosch area. Farther upstream, additional studies are needed, including in the Land van Altena region.

The second track focuses on developing nature and landscape within the polder system: a system without tides but with a large 'Binnenmaas' as a waterfront park, where urban freshwater nature can develop.

Krimpenerwaard and Alblasserwaard could function as regional parks, where rewetting and freshwater supply contribute to nature development, recreation, and climate buffering. Midden-Delfland could also develop into a regional sponge park.

'The Rhine-Maas estuary is rich in wetland landscapes: dunes and tidal flats, Wadden-type landscapes, marshes, and a regional waterfront park.'



Area study of urban ports inside the flood defense system: transformation of former port areas behind the locks into a new Rotterdam waterfront city – Polder Strategy (De Urbanisten)



The urban ports offer many possibilities for water-oriented housing typologies (De Urbanisten & Deltares, 2023, p. 26; image: De Urbanisten)

2. 6 Area Studies

Urban Ports Inside the Flood Defense System

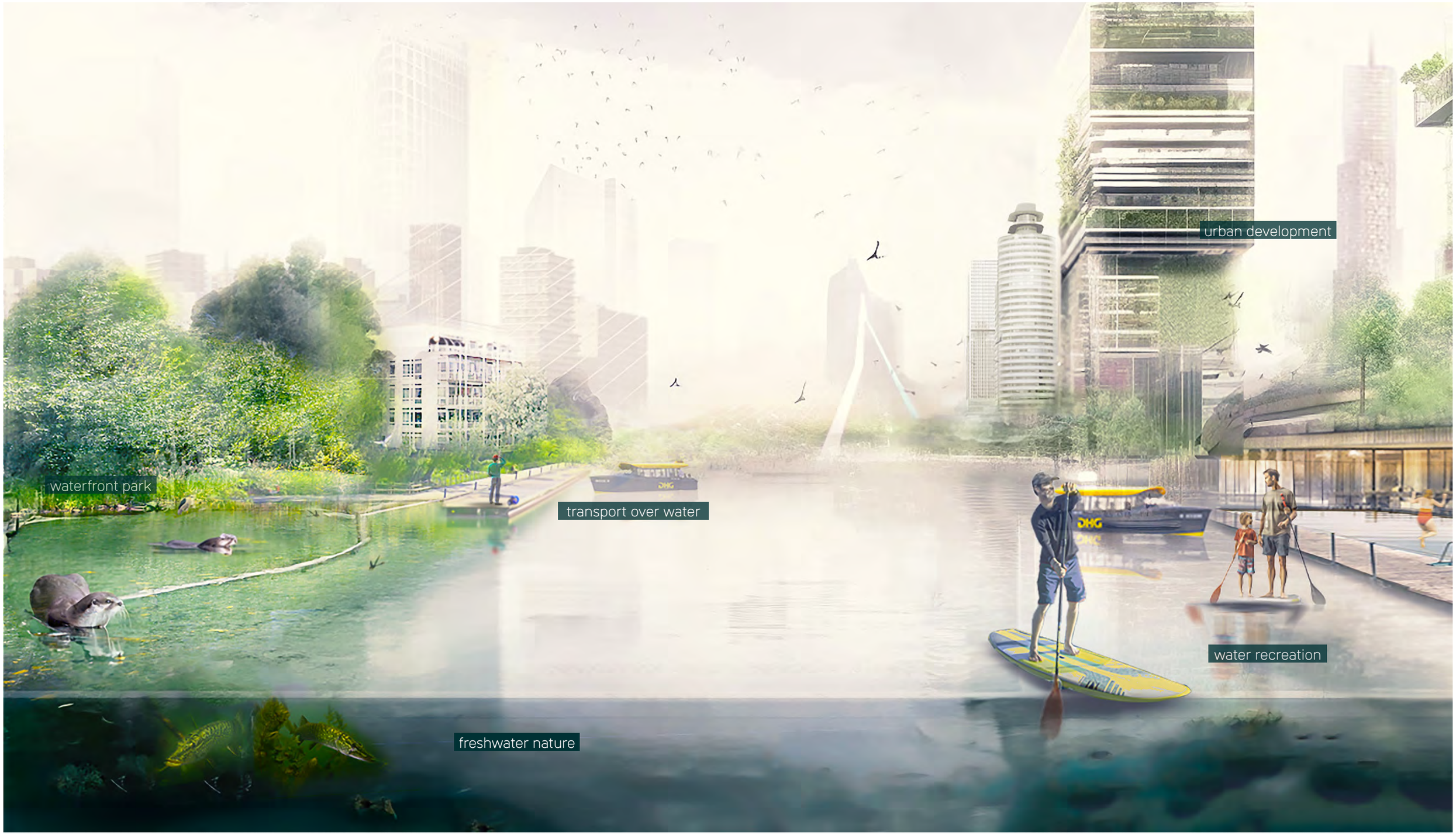
Behind the locks of Rijnmond-Drechtsteden, port and industrial areas can be transformed step by step. This can be seen as the next phase in a Rotterdam tradition in which the port expands and modernizes westward toward the sea, while old port basins become available for urban development.

These extensive areas, with a strong interface between land and water, can be transformed into new urban waterfront districts. Waalhaven and Eemhaven, for example, could provide space for the development of a rich variety of water-oriented urban environments for decades to come.

Numerous water-related housing typologies are conceivable in the extensive port basins and port sites. Many are familiar from other European waterfront cities (Copenhagen, Amsterdam, Venice, Stockholm), such as floating districts, urban islands, water blocks, water courtyards and water towers, houseboats, and piers.

The controlled water level inside the locks allows for much more direct contact with the water and its banks. This creates many opportunities for recreation along and on the water. Swimming could once again be possible in the Nieuwe Maas and the port basins. Recreational boating could make full use of an extensive and interconnected network of rivers and waterways. Old ports become the new marinas.

Urban Ports Inside the flood defense system



The controlled water level behind the locks allows for much more direct contact with the water and its banks, creating many opportunities for experiencing nature and recreation along and on the water (De Urbanisten & Deltares, 2023, p. 23; image: De Urbanisten)

Urban Ports Inside the flood defense system



Behind the locks of Rijnmond-Drechtsteden, port and industrial areas can be transformed step by step. These areas, with a strong interface between land and water, can be transformed into new urban waterfront districts. Waalhaven and Eemhaven, for example, could provide space for the development of a rich variety of water-oriented urban environments for decades to come (De Urbanisten & Deltares, 2023; image: De Urbanisten)



The third Maasvlakte creates space for the growth of the post-fossil port, including sites for energy production and storage. The Voordelta can continue to accumulate sand (De Urbanisten)

Third Maasvlakte and Voordelta

The Polder Strategy envisages the Port of Rotterdam expanding primarily seaward, with a third Maasvlakte. This creates space for the growth and further development of the post-fossil port, with sites for energy production and energy storage, as well as deep port basins and quays for transferring goods from clean seagoing vessels to other modes of transport. Inland shipping continues to play an important role, although logistical connections with the hinterland will also rely on other infrastructure.

The third Maasvlakte includes a large pumped-storage reservoir, specifically for energy generated by offshore wind and brought ashore here.

The construction of a third Maasvlakte is combined with large-scale nature development in the Voordelta. The Voordelta is already an ecologically rich and highly valuable natural area at the boundary between sea and rivers and between salt and fresh water. The Voordelta can continue to accumulate sand and become shallower, gradually developing into the Voornse Wadden.



Holland Hydrogen I hydrogen plant. Image: Port of Rotterdam Authority, 2022



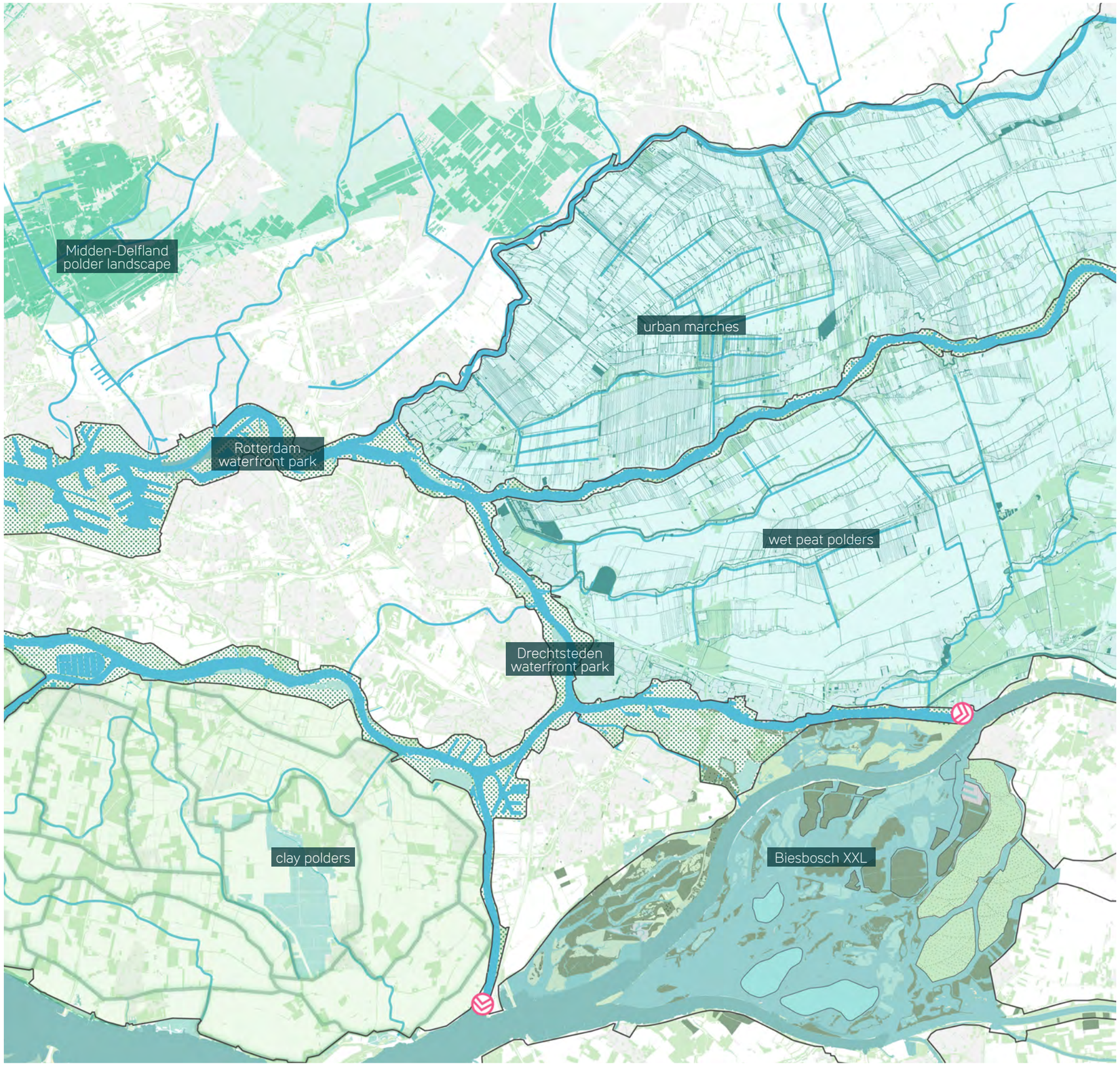
Offshore Center Maasvlakte. Image: Port of Rotterdam Authority, 2017



AWE 1-GW green hydrogen plant. Image: Port of Rotterdam Authority, 2023



De Slikken van Voorne, Oostvoorne. Photo: Jelmer Teunissen



Area study of regional landscape parks – Polder Strategy (De Urbanisten)

Regional Landscape Parks

The enormous opportunities for urban development in the former ports allow the surrounding landscapes – free from urbanization pressure – to develop into a series of regional landscape parks, guided and supplied by a sustainable freshwater system of rivers, boezems (dispersed reservoirs), waterways, and ditches. Over time, marshes and wet peat landscapes can develop around the cities.

Rewetting Krimpenerwaard and Alblasserwaard would create a landscape of reed marshes, hay fields, quaking bogs, and new areas of open water. Together, these would form a water-rich, species-rich marsh mosaic that is ecologically much closer to the former peat landscape that existed before intensive drainage.

The Oude Maas and Nieuwe Maas can be developed into a large, continuous waterfront park, with soft, natural banks and ample space for recreation and experiencing nature along, on, and in the water.

Near Dordrecht, the river is given ample room, creating a Biesbosch XXL.

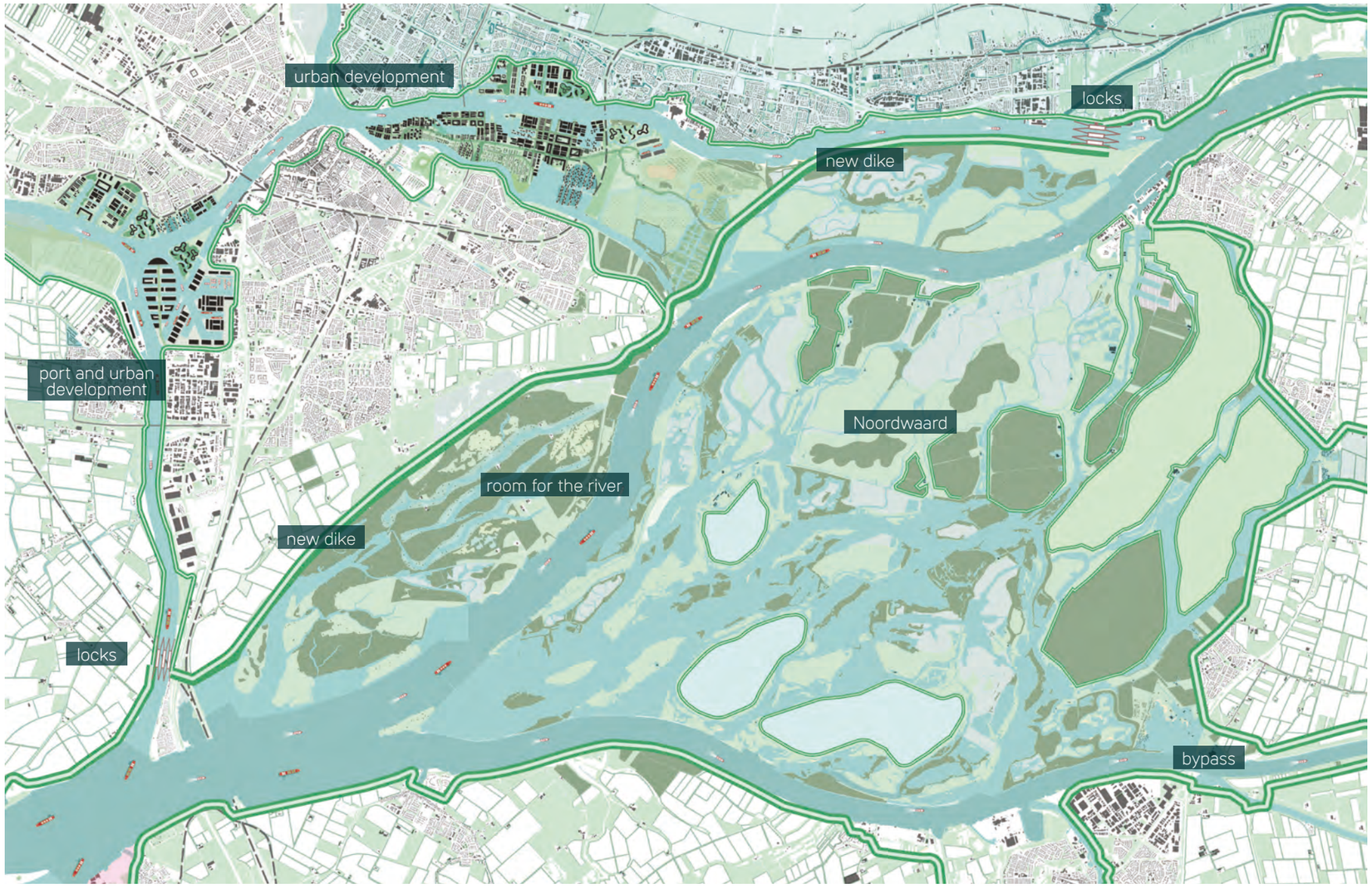


Polder den Hoek, east of Lekkerkerk. Photo: Ikreis (2020), CC BY-SA 4.0

Regional Landscape Parks



Deep polders such as Krimpenerwaard can develop into wet peat landscapes with marshes, quaking bogs, and areas of open water (De Urbanisten & Deltares, 2023; image: De Urbanisten)



Area study of Dordrecht and the Biesbosch – Polder Strategy (De Urbanisten)

Dordrecht and the Biesbosch

Under the Polder Strategy, Dordrecht is safely located behind the primary flood defenses. This avoids extremely complex and far-reaching dike reinforcements in the historical city center (including Voorstraat). Far-reaching measures to address flooding in parts of Dordrecht outside the flood defense system are also no longer necessary.

Dordrecht's ports and maritime industries are located inside the polder locks. As a result, they are no longer accessible to large seagoing vessels. Dordrecht becomes an inland shipping port, without heavy seaborne transshipment and industry. At the same time, Dordrecht can grow as a regional logistics hub for inland shipping, distribution, and sustainable transport solutions. Dordrecht could serve as a testing ground for electric or hydrogen-powered inland vessels and ship innovation, and as a center for green logistics.

Port areas that may become available in the Drechtsteden can also be redeveloped for new businesses and innovative, cleaner activities, as well as for water-oriented residential environments.

To the south and east of Dordrecht, there will be more room for the river. By setting back dikes on the Island of Dordrecht, expanding the Noordwaard, and creating a bypass south of Werkendam, the Biesbosch area can develop further into an extensive marsh landscape with ample opportunities for nature and recreation.



The Biesbosch. Photo: Paul van de Velde (2017), CC BY 2.0



Tongplaat. Photo: Paul van de Velde (2015), CC BY 2.0



The Biesbosch. Photo: G. Lanting (2018), CC BY 4.0



The study 'De Grote Deltazoom' by BoschSlabbers outlines a landscape-based approach to dike reinforcement along the Haringvliet and Hollands Diep, including inhabitable superdikes and new rows of dunes in the Voordelta (image: BoschSlabbers Landscape Architects, 2012)

Haringvliet

The Polder Strategy and the associated additional river discharge via the Waal and Merwede to the sea make it possible to open the Haringvlietsluizen more frequently and for longer periods. Opening the dam more frequently will gradually turn the Haringvliet back into a brackish estuary, with greater ecological value and improved fish migration. Migratory fish such as salmon, sturgeon, and eel can swim in and out more easily as the hard boundary between fresh- and saltwater disappears and the Haringvliet remains open more frequently and for longer periods. Ecological quality improves particularly in the zones where ebb and flood tides and saltwater and freshwater alternate.

Saltwater may penetrate farther inland. Because freshwater is guaranteed to be available in the polder, this salinization of the Haringvliet does not have to pose a threat to the regional freshwater supply.

Because of the higher river discharge and the Haringvliet water level rising in step with sea-level rise, the dikes along the Haringvliet and Hollands Diep are subjected to structurally greater loads under the Polder Strategy, meaning that they will eventually have to be raised and reinforced. This reinforcement is feasible almost everywhere. There is sufficient space, as well as opportunities for nature development both outside and inside these Delta Dikes. In 2014, landscape architecture firm BoschSlabbers already developed several strong proposals for this.



New dunes (image: BoschSlabbers Landscape Architects, 2012)

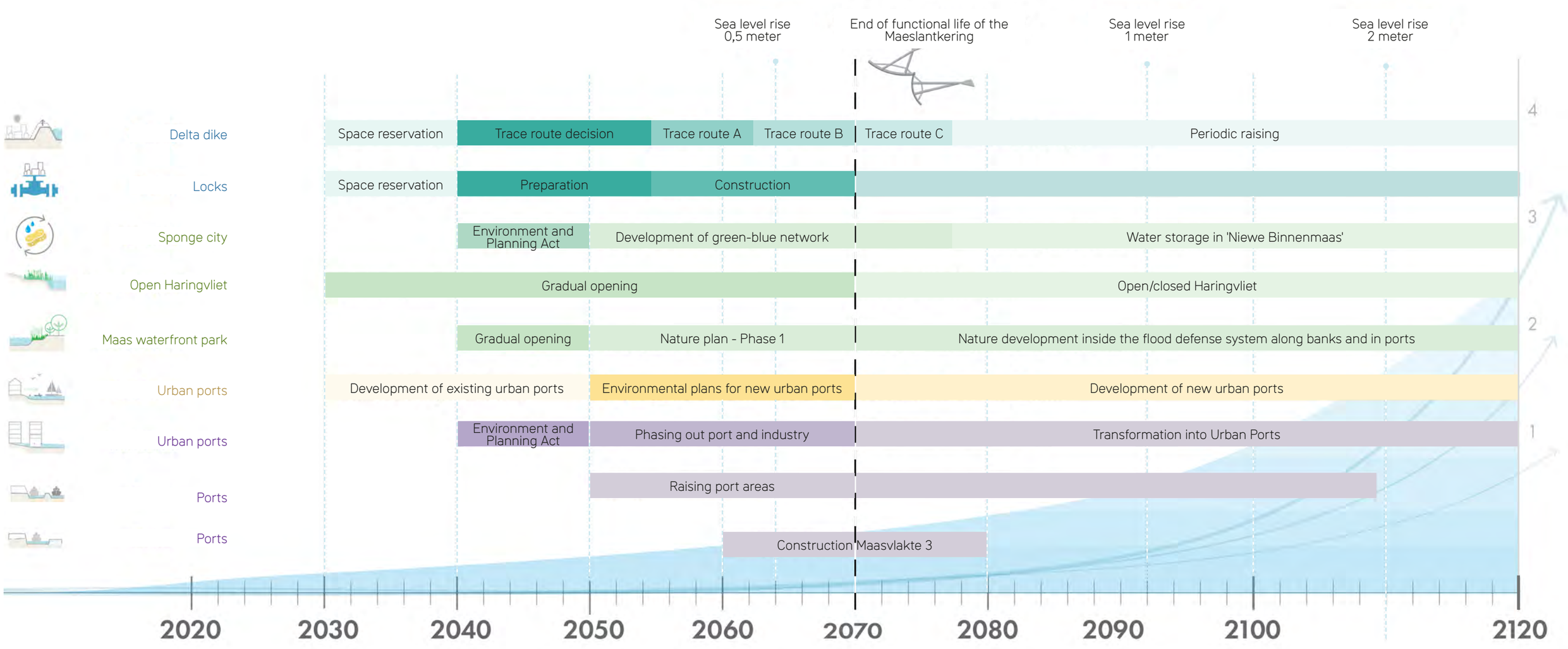


Superdike along the Haringvliet (image: BoschSlabbers Landscape Architects, 2012)



De Grote Deltazoom (image: BoschSlabbers Landscape Architects, 2012)

Transition Pathway



Transition pathway – Polder Strategy (De Urbanisten)

2. 7 Transition Pathway

Implementing the Polder Strategy requires an adaptive pathway that builds on the current flood safety strategy and responds to the pace of sea-level rise. In the coming decades, the emphasis will be on making current investments future-proof, reserving space for future flood defenses and locks, and preparing for system choices.

As sea-level rise approaches 1 meter, the need to shift from optimization to more system-oriented measures increases. Further upscaling of the existing system becomes increasingly less feasible, and phased implementation of the Polder Strategy becomes part of the adaptation pathway.

Along this pathway, investments in complex dike reinforcements in densely built-up areas and the long-term protection of functions outside the flood defense system are particularly critical, because they increase the risk of lock-ins and can complicate a later system transition.

In the planning process, the point at which the Maeslantkering reaches the end of its functional life (approximately 2070) represents an important decision point. This moment can serve as a pivot for deciding whether to continue investing in the existing system or to transition to a more closed and controllable water system such as the Polder Strategy.

By explicitly organizing this transition along adaptation pathways with clear decision points, adjustments can be made in time, lock-ins can be avoided, and room for maneuver in governance and financing can be maintained. The Polder Strategy therefore functions not as a fixed end state, but as an adaptive long-term perspective that guides decision-making over the long term.

2. 8 Conclusions

The study described and illustrated above shows that the Polder Strategy can provide a realistic, coherent, and future-proof perspective for flood safety, enabling the Rijnmond-Drechtsteden region to remain safe and livable even with approximately 2 meters of sea-level rise.

The strength of the Polder Strategy is that flood safety is no longer based on increasingly extensive and complex local dike reinforcements, but on a manageable and predictable water system with a continuous 'Delta Dike Ring.' This not only provides structural flood protection for the area inside the flood defense system but also safeguards flood safety in areas outside the flood defense system.

Moreover, the Polder Strategy strengthens freshwater security by preventing saltwater intrusion and creating a single robust freshwater system that remains reliable even as drought increases, guaranteeing freshwater availability for all relevant functions, including agriculture and nature.

By eliminating the open connection to the hinterland, the strategy entails a far-reaching transformation of the ports, the associated maritime manufacturing industry, and logistics, with major economic impacts. At the same time, the strategy opens up an attractive prospect for long-term, water-oriented urban development on former port and industrial sites.

Finally, the Polder Strategy aims to provide lasting protection against flooding from the sea and rivers through dikes and flood defenses. The strategy is therefore a natural continuation of the centuries-old Dutch tradition of hydraulic engineering – a tradition in which living with water and protecting against its dangers go hand in hand. Despite its enormous impact, the Polder Strategy could therefore count on understanding and support from society.

The Polder Strategy requires long-term consistency in governance, substantial investment, and strong coordination between water management, spatial planning, port development, and ecology. Insufficient coordination can lead to fragmentation or lock-ins caused by investments that are not future-proof. The success of the Polder Strategy therefore depends not only on technical feasibility, but above all on timely decision-making, adaptive phasing, and sustained political and public support.

'The strategy is a natural continuation of the centuries-old Dutch tradition of hydraulic engineering – a tradition in which living with water and protecting against its dangers go hand in hand.'

‘The Polder Strategy requires long-term consistency in governance, substantial investment, and strong coordination between water management, spatial planning, port development, and ecology.’



Photo: Jannes Linders, from the series Between City and Sea

3 The Estuarine Strategy

H+N+S Landscape Architects

3. 1 Flood Safety
3. 2 Port and Shipping
3. 3 Freshwater
3. 4 Urban Development and Rural Areas
3. 5 Landscape and Ecology
3. 6 Area Studies
3. 7 Transition Pathway
3. 8 Conclusions



Tidal nature on Brienenoord Island, Rotterdam. Photo: Marijne Kreulen

3 The Estuarine Strategy

The flood safety strategy described in this chapter – the Estuarine Strategy – explores the potential of restoring sediment capture to enable areas outside the flood defense system in the Rhine-Maas Estuary to keep pace with sea-level rise, and how these areas can be adapted accordingly. To achieve this, the mouths of the Haringvliet and Nieuwe Waterweg are brought as close as possible to 'morphological equilibrium,' with channel depths corresponding to the volumes of water flowing in and out as a result of tidal action and river discharge. This means that, once they reach the end of their technical service life, the Haringvlietdam and Maeslantkering would not be replaced.

Under this strategy, flood safety along the river mouths is primarily provided by flood-defending landscapes: areas outside the flood defense system that keep pace with sea-level rise through sedimentation, backed by a storm-surge-resistant dike. The more urbanized areas outside the flood defense system and adjacent dike zones receive additional protection from relatively small and simple storm surge barriers, reducing the extent to which both the areas outside the flood defense system and the dikes themselves need to be raised. In these areas, ground levels are raised primarily by systematically dredging sediment deposited in the rivers and placing it on sites outside the flood defense system.

The strategy combines several overarching principles for the Rhine-Maas Estuary as a whole with local interventions developed in collaboration with local stakeholders and residents. This creates a basis for developing a wide variety of water-oriented residential and working environments. The strategy also embodies a spatial policy that seeks to align economic development as closely as possible with the dynamics of natural systems. For example, the spatial transformation of the Botlek, which is still dominated by the fossil industry, is linked to the transformation of the Nieuwe Waterweg into a more natural, sediment-capturing river mouth.

‘Under this strategy, flood safety along the river mouths is primarily provided by flood-defending landscapes: areas outside the flood defense system that keep pace with sea-level rise through sedimentation, backed by a storm-surge-resistant dike.’



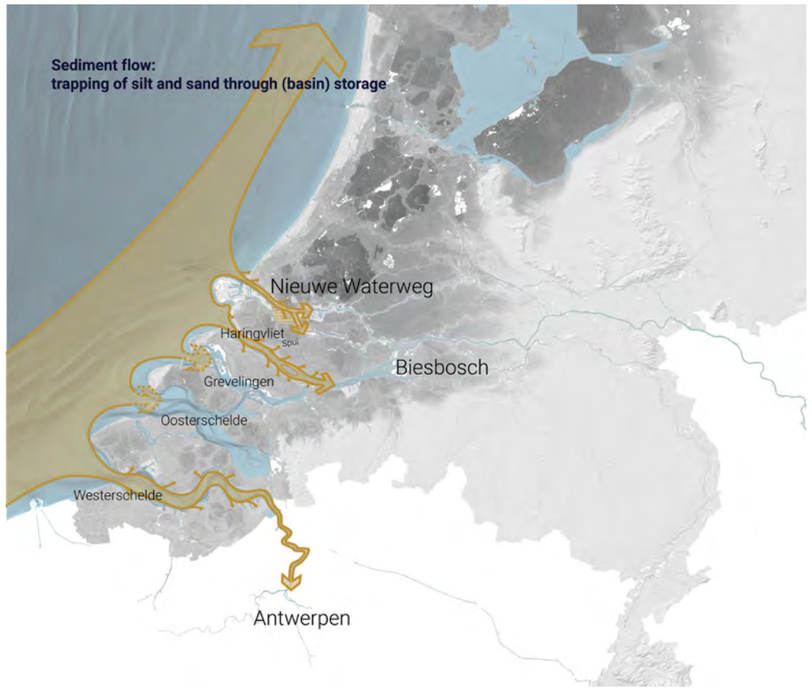
Tidal nature on Brienenoord Island, Rotterdam. Photo: Linde Keip

Background

Coastal morphological systems such as the Rhine-Maas Estuary have a natural capacity to keep pace with sea-level rise by capturing sediment from the sea (and through the accumulation of vegetation) – a process referred to as ‘keeping pace with sea-level rise.’ Once the rapid Holocene sea-level rise slowed to its present rate of 2 to 3 millimeters per year, the coastline even began to expand seaward (Berendsen, 1996). Around the beginning of the Common Era, the Rhine-Maas Estuary formed when the course of the Rhine shifted southward and joined the Maas estuary. During the Early Middle Ages, however, the estuary gradually filled with sand and silt. Through dike construction – initially on a small scale and, from the thirteenth century onward, systematically – the land-building capacity of this system became confined to areas outside the flood defense system. Since the construction of the Delta Works, keeping pace with sea-level rise has been possible only in the coastal zone. The closure of the estuaries by the Delta Works therefore represents a relatively recent interruption of a process spanning millennia, during which land was able to keep pace with sea-level rise. For most of that period, the primary flood safety strategy consisted of retreating to higher ground during periods of high water.

The historical development of the Rhine-Maas Estuary shows that natural sedimentation has always been able to keep pace with the current rate of sea-level rise. This capacity has consistently depended on the availability of sediment and the degree to which the coastal zone is enclosed. Annual longshore sediment transport amounts to approximately 0.5 million cubic meters of sand and 10 to 14 million tons of silt, whereas the rivers contribute virtually no sand and only 1 to 2 million tons of silt annually (Steenstra et al., 2025). Of the silt transported along the coast, approximately 1.5 million tons are deposited each year in the largely enclosed Southwestern Delta (Nieuwe Waterweg, Haringvliet, Oosterschelde, and Westerschelde). Measurements from the Westerschelde, for example, show that an estuary with an open connection to the sea can capture large quantities of sediment, with sedimentation rates that substantially exceed the current rate of sea-level rise.

Our growing – and continually advancing – knowledge of water management may now enable us to once again make keeping pace with sea-level rise part of our flood safety strategy, despite increasing urbanization. A hybrid strategy that combines the controlled restoration of the estuarine character of the Rhine-Maas Estuary with additional protection for the most vulnerable parts of the water system can make maximum use of the natural dynamics of the transition zone between land and water to develop nature-inclusive flood-defending landscapes. Without this system restoration, this transition zone will continue to narrow as sea levels rise and ultimately disappear. In addition to losing a natural buffer against high water and waves, we would also lose an ecosystem of global significance.



Sediment flow – Estuarine Strategy (H+N+S Landscape Architects)

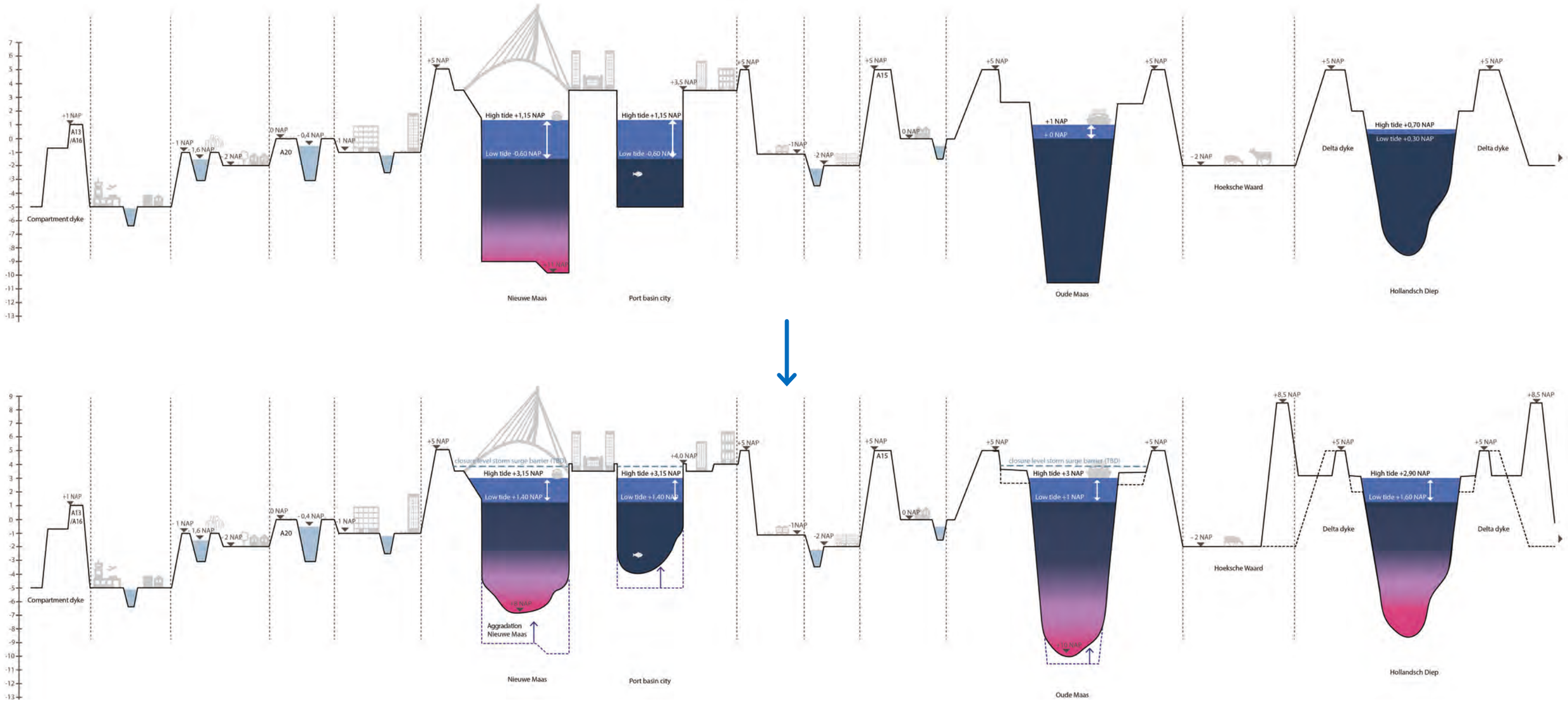
Strategy

The Estuarine Strategy places maximum emphasis on capturing sand and silt. In this exploration, that also means fully restoring the system's natural estuarine dynamics – in other words, fully restoring the open connection between the rivers and the sea. This is most effective if the connections between the sea and both the Haringvliet and the Nieuwe Waterweg are kept as open as possible. This open connection would be established in phases.

In the first phase, the existing Haringvlietdam and Maeslantkering would remain in place, but the gates in the Haringvlietdam would be opened as much as possible. This would allow more silt to enter the area. A higher secondary dike would also be constructed behind the existing dikes along the Haringvliet. The newly created inter-dike zone would immediately be developed as an extension of the intertidal area, comparable to Plan Tureluur on Schouwen-Duiveland and Waterdunen in Zeeuws-Vlaanderen. Naturally, integrating (historical) waterside towns such as Hellevoetsluis and Willemstad would require site-specific solutions. In the second phase, once the secondary dike has been completed along its full length, it would take over the flood defense function of the existing dike. The area between the dikes would then become entirely available as a flood-defending landscape that keeps pace with sea-level rise. At that point, the Haringvlietdam and the Maeslantkering could be removed. During storm surges, water would then be pushed farther into the Rhine-Maas Estuary, which is why the setback dike would need to be higher than the original dike.

There is also room for wide flood-defending landscapes along parts of the Nieuwe Waterweg. Along the more urbanized river branches, such as the Oude Maas and Nieuwe Maas, space is limited and dike reinforcement is generally a complex undertaking (IenM & Municipality of Rotterdam, 2012). This is why the strategy provides for a number of relatively small storm surge barriers that protect the northern part of the Rhine-Maas Estuary against extremely high water levels caused by storm surges. These include replacements for the existing storm surge barriers in the Nieuwe Waterweg and Hartelkanaal, which would be relocated, as well as new storm surge barriers in the Dordtse Kil and Beneden Merwede. The closure level of these storm surge barriers would partly depend on the rate at which ground levels in the areas outside the flood defense system behind the storm surge barriers can be raised and would eventually be higher than the current closure level of the Maeslantkering.

Restoring tidal dynamics in the Haringvliet and allowing the Nieuwe Waterweg to become shallower would restore the morphological balance between the Haringvliet and the Nieuwe Waterweg. As a result, a tidal divide is expected to develop in the Spui, causing this channel to silt up naturally over time. The strategy anticipates this by closing off the Spui in advance, thereby providing better protection for the hinterland against storm surges while creating a freshwater connection between Hoeksche Waard and Voorne-Putten.



Schematic cross sections of the Rhine-Maas Estuary: transformation of Rotterdam's current water system (top) into a new water system (bottom) – Estuarine Strategy (H+N+S Landscape Architects, based on De Urbanisten)



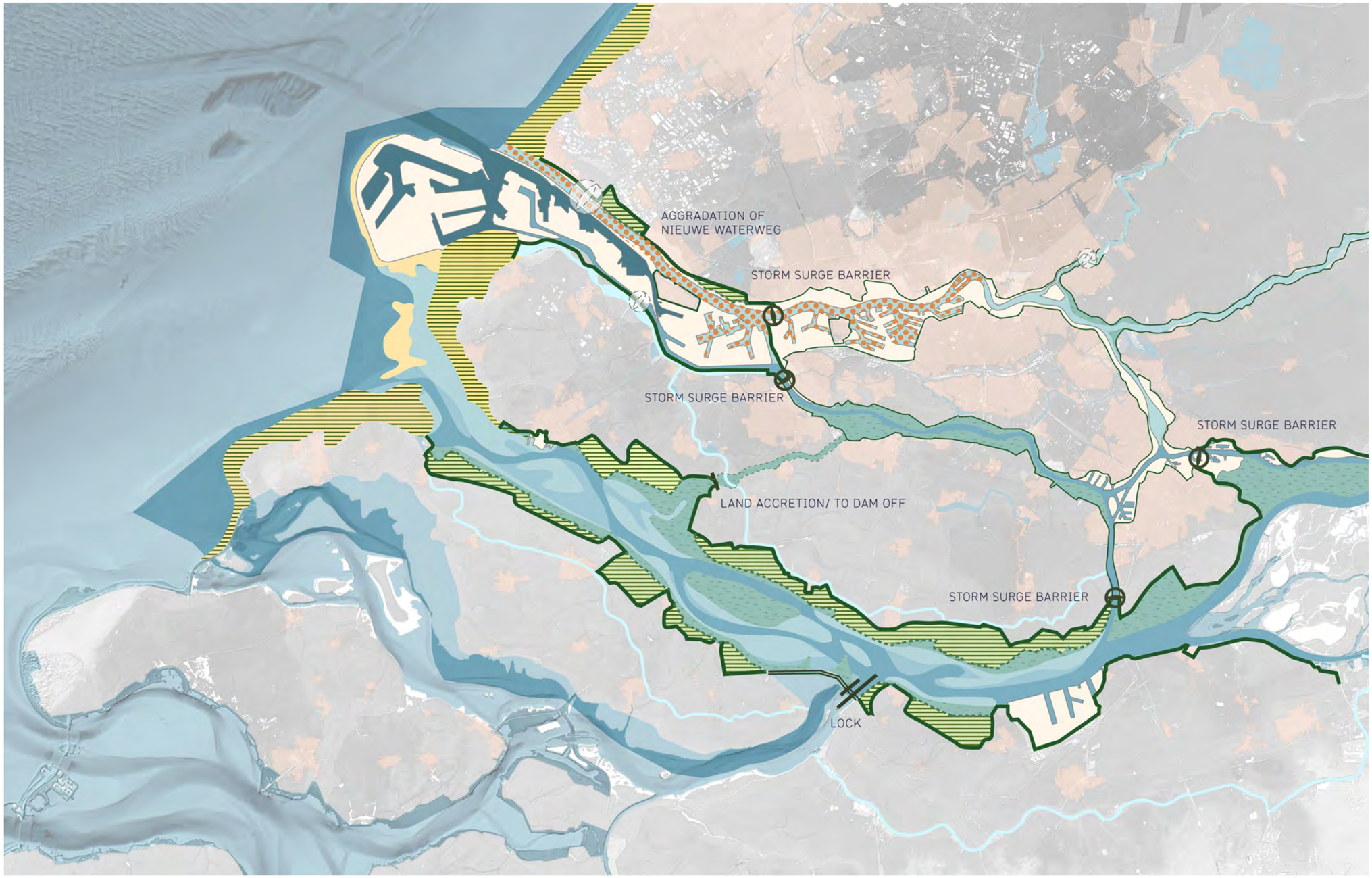
Landscape that keeps pace with sea-level rise at Landtong Rozenburg. Photo: Tineke Dijkstra, 2021

3.1 Flood Safety

Flood safety is ensured through a combination of relatively shallow river mouths – resulting from sediment capture and the resulting moderation of high water levels – and a flood defense zone consisting of robust flood-defending landscapes and relatively small, simple storm surge barriers, comparable to the storm surge barrier in the Hollandse IJssel. These new storm surge barriers are sited as far inland as possible to allow as much sediment from the sea as possible to enter the Rhine-Maas Estuary. The proposed locations are in the Scheur, north of Vondelingenplaat, and in the Oude Maas near Spijkenisserbrug. Additional storm surge barriers are proposed in the Dordtse Kil and Beneden Merwede, while the Spui, which under the new hydromorphological conditions would become a tidal divide and gradually silt up, would be closed off entirely. This would significantly reduce the length of the dikes along the South Holland islands that would require reinforcement.

Behind the storm surge barriers, a system of generally more urbanized – and therefore more complex – flood-defending landscapes protects the most vulnerable areas inside the flood defense system, such as Dike Ring 14. These landscapes consist of dikes and, in most cases, areas outside the flood defense system that are artificially raised using locally dredged sediment. Storm surges would not reach these dikes, but they must nevertheless be high enough to accommodate, among other things, river water when the storm surge barriers are temporarily closed.

Flood Safety



Legend:

Flood protective constructions

- new storm surge barrier
- decommissioned storm surge barrier
- delta dike
- dike behind storm surge barriers
- decommissioned dike (setback dike)
- decommissioned dike (through sedimentation)

Flood protective landscapes

- dunes
- expanded foreshores
- rising tidal landscape
- aggradation of Nieuwe Waterweg
- raised unembanked areas

Water depth

- >20m deep
- >10m deep
- >8m deep

Flood safety – Estuarine Strategy (H+N+S Landscape Architects)

‘Depending on the location in the system, natural sedimentation is capable of keeping areas outside the flood defense system one or two meters above the rising sea level.’

Areas Outside the Flood Defense System

Under the Estuarine Strategy, areas outside the flood defense system are transformed into flood-defending landscapes through natural sedimentation or artificial raising of the ground level. Where these landscapes lie below the design high-water level, functions located outside the flood defense system must be able to withstand periodic inundation, and these areas will require a dike, or the retention of an existing dike, on the side facing the polders behind them. Both these flood-defending landscapes and the dike will continue to keep pace with sea-level rise. Natural ground-level raising occurs only in locations that are regularly inundated with sediment-rich water. Depending on the location in the system, this natural sedimentation is capable of keeping areas outside the flood defense system one or two meters above the rising sea level.

In higher-lying areas outside the flood defense system, sediment deposited naturally in nearby channels and intertidal areas would be dredged and artificially applied to raise the ground level. Naturally, this is only possible where raising the ground level is compatible with the existing use or where the site is undergoing transformation, with the function changing or being adapted through renovation to meet new requirements or preferences. The ground level is then raised to a new, future-proof development level. Buildings constructed on the raised ground would be designed to allow relatively easy adaptation to subsequent ground-level raising.

There are several ways in which flood-prone areas and functions outside the flood defense system can either be protected against or adapt to periodic inundation. Functions can also adapt to the natural or artificial ground-level raising that may accompany this. The following situations are distinguished (see also the key on page 54):

- (Historical) city centers. These are largely located behind storm surge barriers. Once these areas fall below the closure level of the storm surge barriers, which rises with sea level, carefully integrated quay walls and movable barriers will be required to protect them against high water levels.

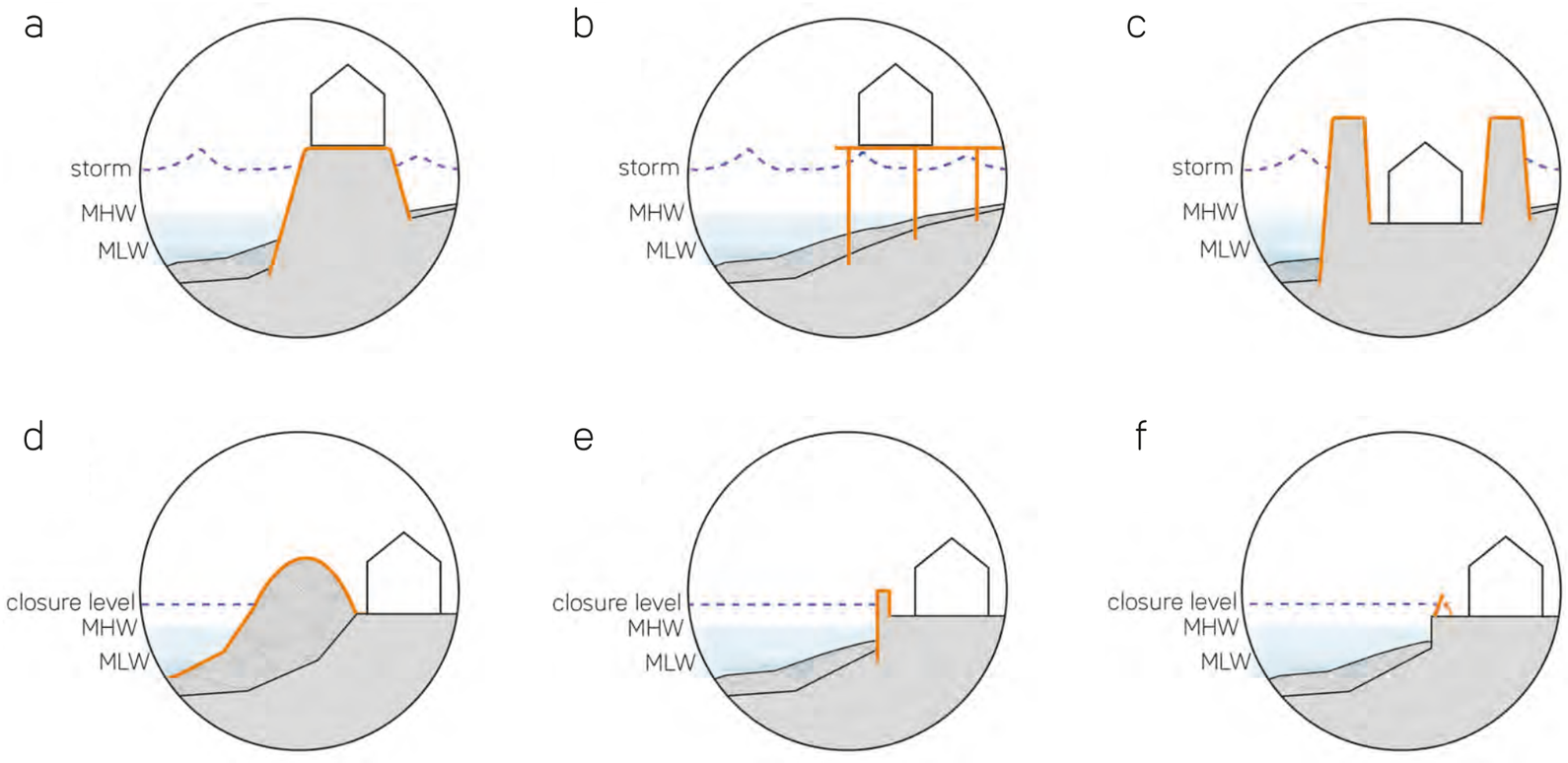
- Redeveloped urban districts. These are also, for the most part, located behind storm surge barriers. Here, a combination of partial ground-level raising and the protection or adaptation of low-lying areas can be applied. Suitable measures in the latter category include robust quay walls and barriers, and water-resilient site design.

- Transformation areas. Areas outside the flood defense system undergoing redevelopment in the coming decades should have a raised ground level from the outset. Where raising the site is not feasible, water-resilient site design can be applied, possibly in combination with natural sedimentation.

- Tidal nature and tidal parks. Here, the primary mechanism is the natural capacity of sedimentation to keep pace with sea-level rise. Where necessary, this can be supplemented by artificial ground-level raising.

- Landscapes that keep pace with sea-level rise. Here, natural ground-level raising through sedimentation is the guiding principle. Where specific new functions, such as housing, require it, sites can be raised locally. Quay walls can be constructed around existing vulnerable functions.

- Foreshore areas. These are natural areas that are already located outside the flood defense system. Ground-level raising occurs through sedimentation, and no development measures are undertaken apart from any erosion-control measures that may be required.



The exact development and flood protection of areas outside the flood defense system will require site-specific solutions. Alongside the constraints imposed by the water system, local preferences and interests will be the primary drivers. This is expected to result in a rich and diverse range of water-oriented residential and working environments. In this respect, the present study is limited to developing a number of building blocks for the flood protection of vulnerable functions, particularly in urban areas outside the flood defense system. The principal building blocks are:

- Natural sedimentation as the dominant process, with vulnerable functions located on mounds (a), piles (b), or protected by ring dikes (c).

- Protection of low-lying areas outside the flood defense system through adaptive flood-defending shorelines constructed from locally sourced sediment (d).
- Protection through quay walls (e) and barriers that are deployed during periods of high water (f).

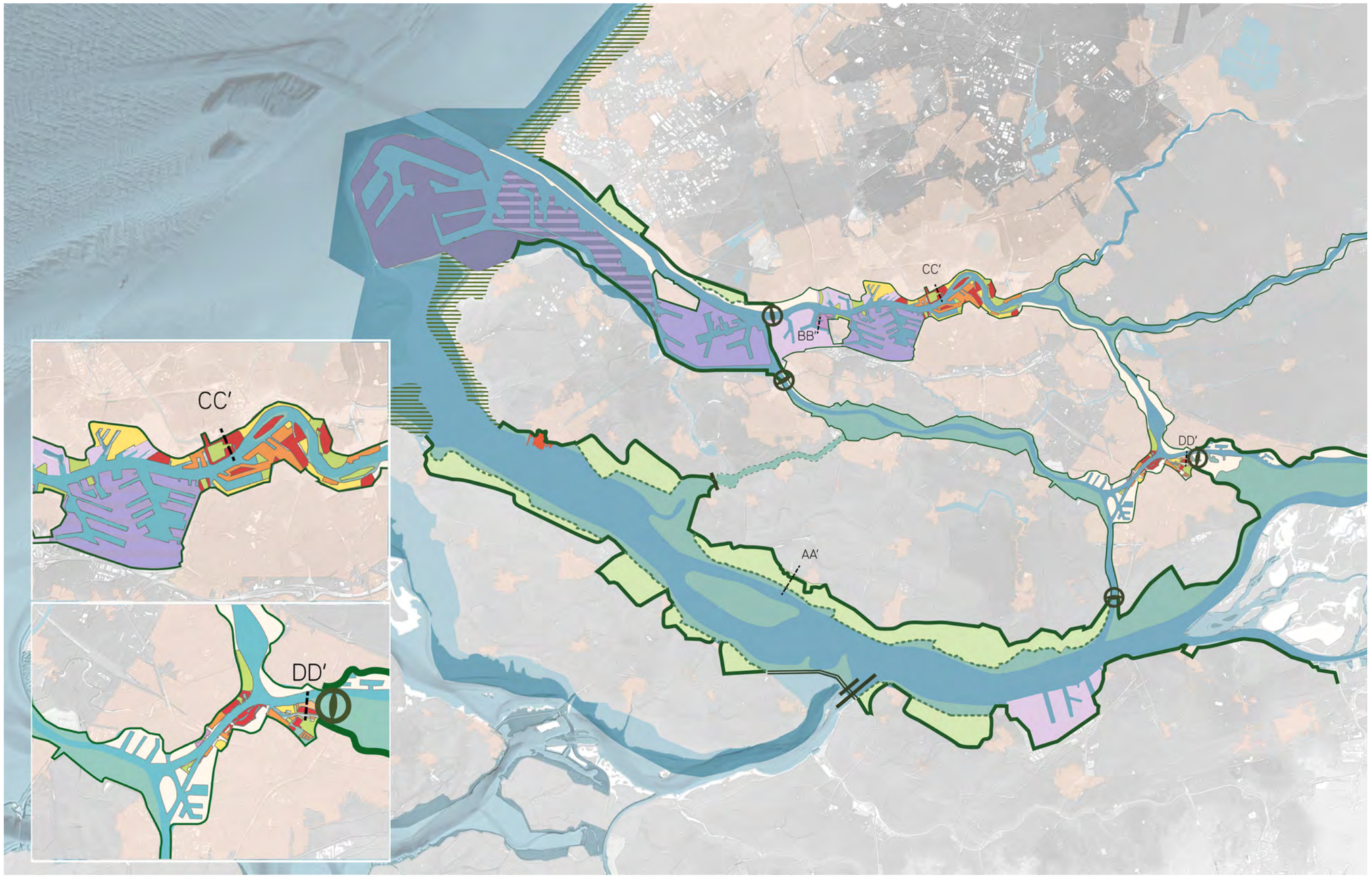
- Water-resilient spatial design, in which ground-floor functions are either flood-resistant (g) or can eventually be relocated to the first floor, allowing the ground floor to be removed or assigned a different water-resilient function (h).

- Artificial raising of the entire ground level to a new development level through the placement of locally dredged sediment (i).

- When the current function is no longer appropriate at a given location: discontinuation of urban development (j).

To illustrate the possible application of these adaptive strategies and building blocks, example designs have been prepared for four representative locations in the region (see 3.6 Area Studies).

Areas Outside the Flood Defense System



Areas outside the flood defense system – Estuarine Strategy (H+N+S Landscape Architects)

‘Under the Estuarine Strategy, the entire area outside the flood defense system forms part of the flood defense zone. In this proposal, this flood-defending landscape has a width of 500 to 2,000 meters.’

Flood Defense Zone

Under the Estuarine Strategy, the entire area outside the flood defense system forms part of the flood defense zone. In this proposal, this flood-defending landscape has a width of 500 to 2,000 meters (Steenstra et al., 2025). Its boundaries are based in part on earlier estimates of the willingness of farmers in the region to participate in dike setback (Van Belzen et al., 2021). Through natural sedimentation, the area between the dikes reaches an elevation of approximately 2 meters above the current sea level. Because the design high-water level will almost always exceed the elevation of even artificially raised areas outside the flood defense system, a dike extending above the ground level of these areas and keeping pace with sea-level rise will always be required at the boundary between the flood defense zone and the area inside the flood defense system. Where the flood defense zone is not additionally protected by a storm surge barrier, this dike must take the form of a Delta dike capable of holding back severe storm surges. It would have a height of approximately 6.5 meters above sea level. With 2 meters of sea-level rise, these Delta dikes would therefore need to be raised to approximately NAP +8.5 meters. The location of the toe of the new Delta dike would be fixed for the very long term so that, during future reinforcements, the crest of the flood defense would always shift toward the area outside the flood defense system.

The wide flood-defending landscape offers several advantages over a conventional flood defense. The relatively high-lying areas outside the flood defense system ensure that waves break before they reach the dike, even at design water levels, when these areas are inundated. Because wave run-up is substantially reduced, the flood defense itself does not need to be as high or as strong. In the event of a dike breach, the gap created in the flood defense would also be much shallower than in the case of a flood defense without an elevated foreshore. As a result, the area inside the flood defense system behind the flood defense would inundate less rapidly, giving people and animals more time to reach safety while also reducing the rate at which the breach widens (Van Belzen et al., 2021).
The flood defense zone is not only generously dimensioned but also multifunctional. The boundary between land and water provides an attractive setting for both human and non-human activities. In the highly productive flood-defending landscapes along the Haringvliet and Nieuwe Waterweg that are not protected by storm surge barriers, the landscapes created in part through dike setback primarily accommodate nature and food production. Food production would focus on flood-tolerant crops, which in the western part of the Rhine-Maas Estuary would also need to be salt-tolerant. These flood-defending landscapes are also attractive for small-scale and recreational housing.

In the generally more urbanized areas outside the flood defense system located behind the storm surge barriers, inundation by water levels above the closure level of the storm surge barriers will, in principle, not occur. This creates opportunities for more capital-intensive functions, such as large-scale housing, water-related businesses, and industry. Dikes located behind areas outside the flood defense system do not need to be nearly as high as Delta dikes that are not additionally protected by storm surge barriers, since they are not exposed to storm surges. A height of approximately 2 meters above the closure level of the storm surge barriers will probably be sufficient.



Salt marsh in Vlieland. Photo: Pim Kupers, n.d.

Flood Defense Zone (Haringvliet and Nieuwe Waterweg)



Flood defense zone – Estuarine Strategy (H+N+S Landscape Architects)



Clay Ripening Facility pilot in the Ems-Dollard Estuary, Delfzijl. Photo: EcoShape, 2018

3. 2 Port and Shipping

As indicated above, this scenario represents a spatial policy that seeks to better align economic development with the dynamics of natural systems. This does not affect the total area of the port, but it does affect how different parts of the port can develop in the future. We apply a principle that could be described as 'the riverbed as a guiding principle': the natural morphology of the estuary becomes one of the guiding factors in the spatial development of the port. The shallowing of the Nieuwe Waterweg is linked to the transition of the Botlek and Vondelingenplaat in particular, from fossil industry to manufacturing industry. This means that, within this scenario, the fact that both port complexes will become less accessible to deep-draft oil tankers over time as a result of the shallowing will be less significant than it would be under present-day conditions.

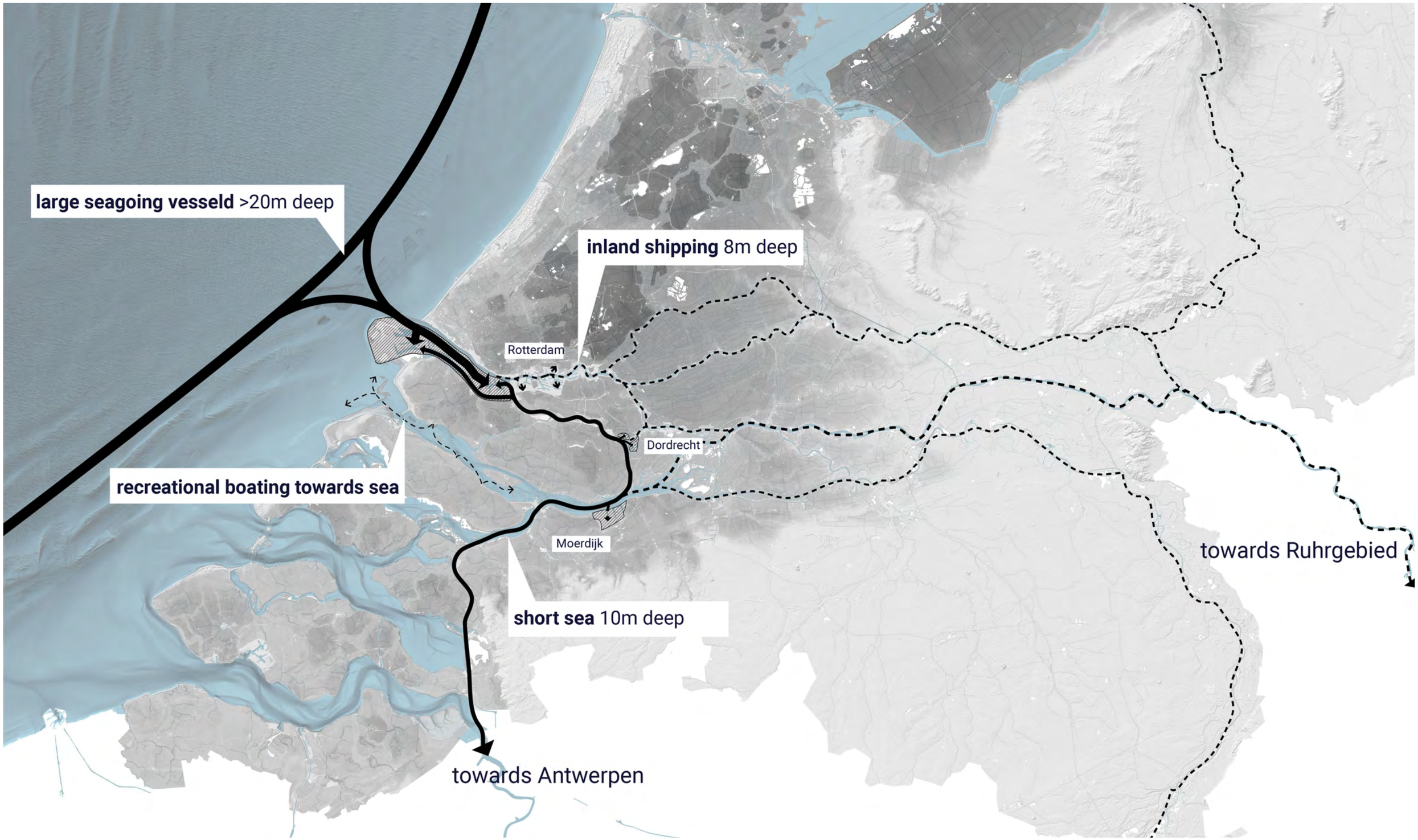
This does not alter the fact that the interventions proposed under this strategy will affect nautical accessibility and, consequently, the development opportunities of the port. The extent to which deep-draft oceangoing vessels can reach certain parts of the Port of Rotterdam will be limited by the shallower Nieuwe Waterweg. This mainly affects the currently deep navigation channels and port basins of the Botlek and Vondelingenplaat.

Access to the more easterly ports of Rotterdam, Dordrecht, and Moerdijk, as well as access to the hinterland, remains largely unchanged under the Estuarine Strategy. The connection to the hinterland is particularly important for the strategic position of the Port of Rotterdam. No new locks are introduced, although several new storm surge barriers are proposed. During storm surges, these barriers will be closed, temporarily restricting access to the hinterland. As sea level rises, the closure level of the barriers will be reached sooner, gradually increasing the frequency of closures and causing increasingly frequent disruptions to shipping. However, as the areas outside the flood defense system behind the storm surge barriers are gradually raised, the closure level can also keep pace with sea-level rise. Moreover, the proposed shallowing of the Nieuwe Waterweg will reduce the tidal range and, consequently, lower design water levels (Hensen, 2021). As a result, the storm surge barriers are expected to require closure less frequently than they would if the Nieuwe Waterweg were maintained at its current depth. Further research is required to determine how these positive and negative effects balance out overall.

For the largest and deepest-draft oceangoing vessels, the port remains accessible via the Calandkanaal, which would continue to be maintained at its current depth. However, this canal does not extend as far east as the Nieuwe Waterweg. Although the Calandkanaal is connected to the Oude Maas and the hinterland via the Hartelkanaal, the width of this route and the clearance beneath its bridges limit access for larger vessels.

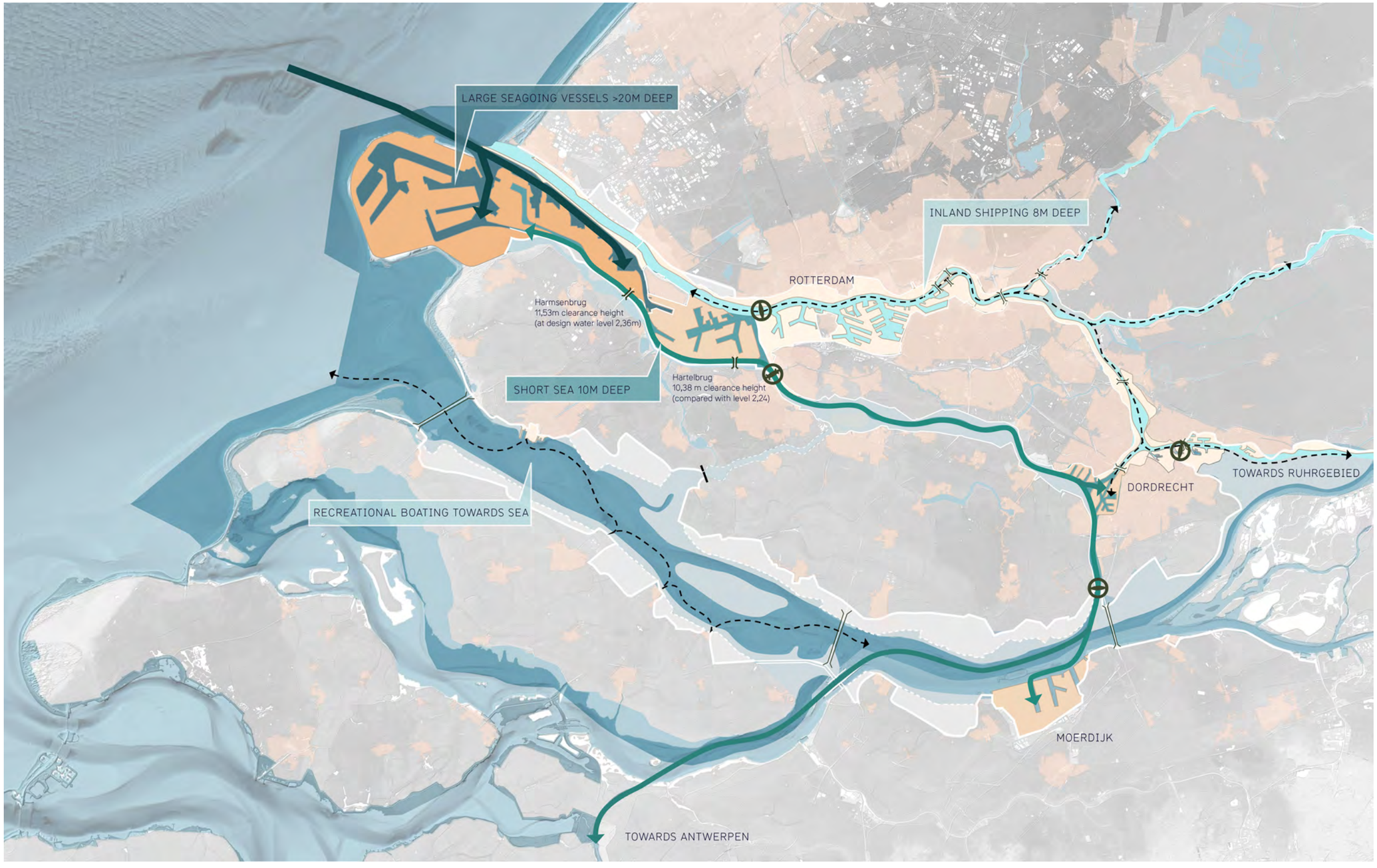
Under current conditions, most of the silt accumulating in the Port of Rotterdam – approximately 1.6 million cubic meters per year – settles in the port basins of Maasvlakte 2 and the Botlek area (Buro Waterfront & Deltares, 2024). This silt could potentially be used for the proposed raising of areas outside the flood defense system in the Port of Rotterdam, with the Botlek in particular serving as a silt depot. In that case, silt would be captured and stored either on land or in port basins. This would save the costs of offshore disposal and avoid the need for the environmental permits required for it. After dredging, the sediment would first need to mature on land into firm clay before it could be used as fill material. This approach is already being tested in the Ems-Dollard Estuary (shown on the left). Further research is needed into the time required for the silt to consolidate and the quality of the resulting material.

Shipping connections

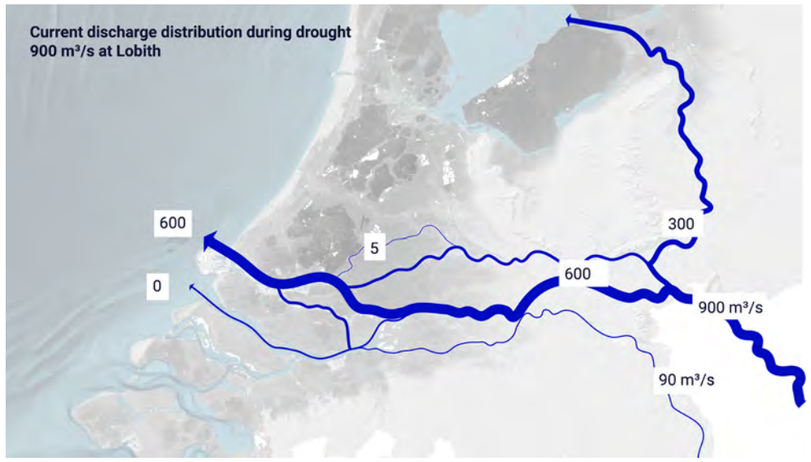


Shipping connections – Estuarine Strategy (H+N+S Landscape Architects)

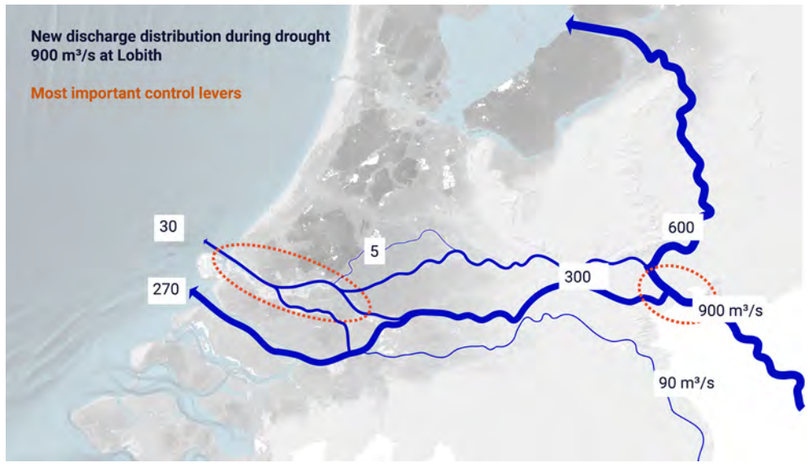
Port and Shipping



Port and shipping – Estuarine Strategy (H+N+S Landscape Architects)



Current discharge distribution during drought (discharge below 900 cubic meters per second at Lobith) (H+N+S)



Proposed discharge distribution during drought (discharge below 900 cubic meters per second at Lobith), with the main control points circled in orange (H+N+S)

3. 3 Freshwater

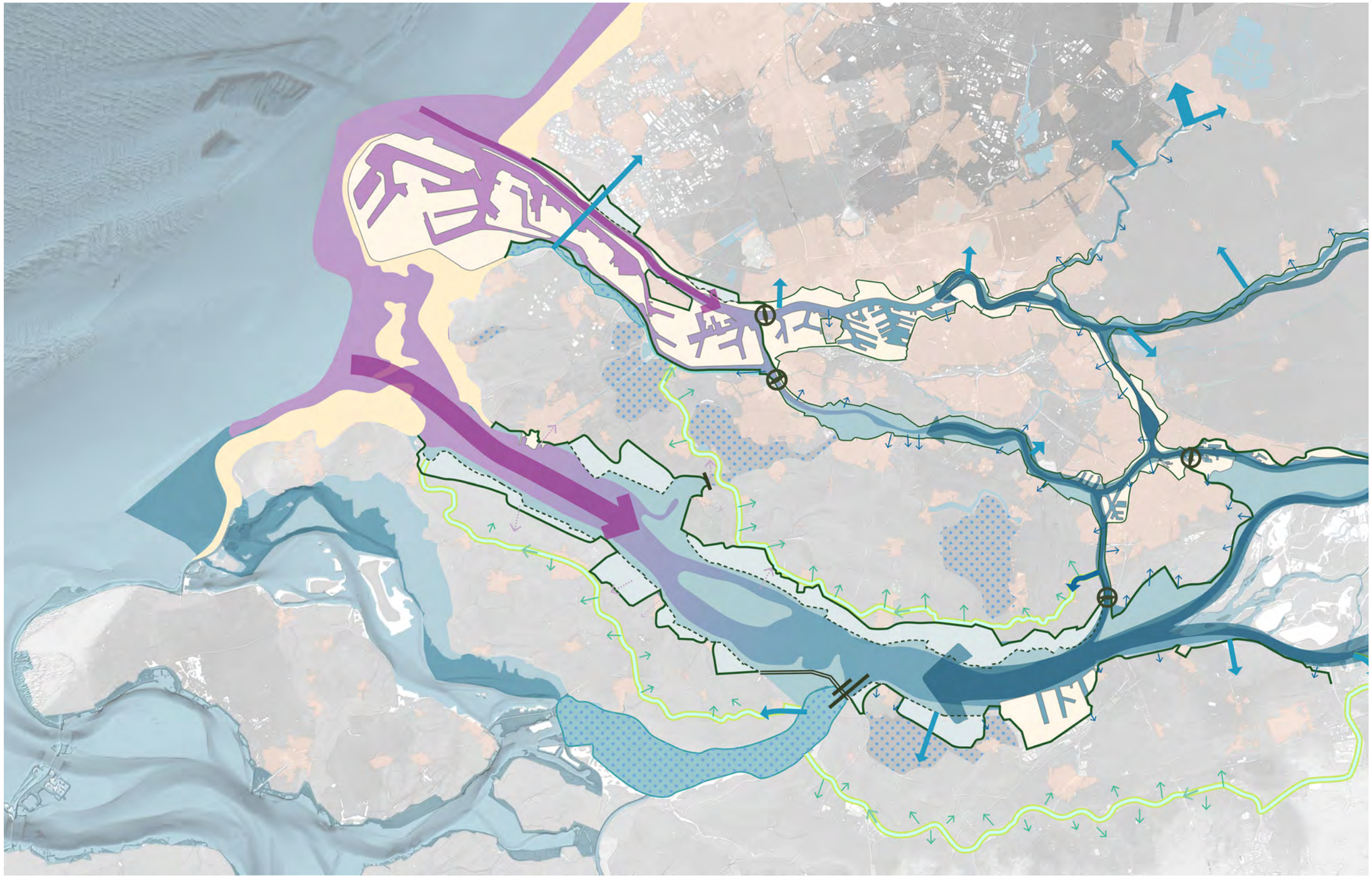
The Estuarine Strategy assumes a revised distribution of discharge from the major rivers. Particularly during periods of low river discharge – less than 900 cubic meters per second at Lobith – substantially less water would be discharged via the Nieuwe Waterweg and more via the Haringvliet than under present-day conditions. This is possible because the shallowing of the Nieuwe Waterweg not only attenuates storm surges but can also substantially reduce saltwater intrusion into the Nieuwe Maas. It is estimated that each meter of shallowing will push the salt wedge back by approximately 1 kilometer (Hensen, 2021). The salt boundary, which under average river discharge is currently located near the Botlek, could therefore be kept at approximately its current location if the Nieuwe Waterweg were allowed to become shallower to a depth of 8 meters while sea level rises by 1 meter. The proposed shallowing of the Nieuwe Waterweg can therefore largely compensate for saltwater intrusion here.

This strategy also affects freshwater distribution at the scale of the Dutch Rhine branches. Under current conditions, approximately 60 percent of the freshwater entering the Netherlands via the Rhine is directed toward the Nieuwe Waterweg during periods of low river discharge in order to push back the salt wedge. This places enormous demands on freshwater availability at the national level. If the amount of freshwater that must be directed to the Nieuwe Waterweg during periods of low river discharge can be substantially reduced through shallowing, this creates scope for optimizing the distribution of river discharge at the national scale. The optimal distribution of discharge between the shallower Nieuwe Waterweg, an open Haringvliet, and the IJssel remains a political decision to be made at the national level.

Under this strategy, however, the Haringvliet changes from an almost completely closed system to a fully open one. As a result, seawater will penetrate farther into the Haringvliet at high tide and during periods of low river discharge. The freshwater-saltwater gradient shown on the map is based on research by Kind et al. (2019). With a sea-level rise of 0.85 meters, the salt boundary under average river discharge would shift approximately 8 kilometers farther east than under current conditions. During periods of lower river discharge, salinization would then reach the Hollandse IJsselkering, affecting freshwater availability at the upstream intake point at Gouda. During ebb tide, however, the salt wedge would again be pushed seaward by the increased volume of river water under this strategy. In any case, freshwater intake points farther west along the Haringvliet would no longer be viable. As a result, an alternative freshwater source would have to be found, particularly for Voorne-Putten – and consequently also for the Brielse Meer and the associated water supply for the port and parts of the Westland – as well as for the western parts of Goeree-Overflakkee and the Hoeksche Waard.

One possible solution would be to transport freshwater westward through a channel connected to the relatively high-lying flood defense zone. The proposed closure of the Spui would make it possible to create a continuous freshwater supply from the Hoeksche Waard to Voorne-Putten and beyond. Even with this freshwater supply system, however, the marine clay polders of the Rhine-Maas Estuary will become saline over time, regardless of the flood safety strategy adopted. This is primarily due to increasing upward pressure from saline groundwater as sea levels rise. A gradual transition to salt-tolerant crops, nature development, and water storage – beginning with the lowest-lying polders – will therefore be unavoidable over time. This trend can be anticipated by proactively transforming the lowest parts of the polders, such as Oudeland van Strijen, into areas more oriented toward water storage. This would create local freshwater buffers that could help agriculture withstand relatively short periods of drought.

Freshwater



Freshwater – Estuarine Strategy (H+N+S Landscape Architects)





Visualizations of flood-defending riverbank zones in Rotterdam under various weather conditions (H+N+S Landscape Architects et al., 2023; image: H+N+S Landscape Architects)

3. 4 Urban Development and Rural Areas

The Estuarine Strategy allows for urban development in areas outside the flood defense system, provided that ground levels are raised. Depending on their position within the urban fabric, such developments may take place on either a large or a small scale. In particular, areas outside the flood defense system that are well connected to existing urban centers are suited to this type of development. Farther from the city, more rural and nature-oriented forms of living, working, and recreation are appropriate. If extreme sea-level rise were to threaten the continued viability of polders in the low-lying parts of the Netherlands, such raised locations would be among the relatively safest places in the Rhine-Maas Estuary.

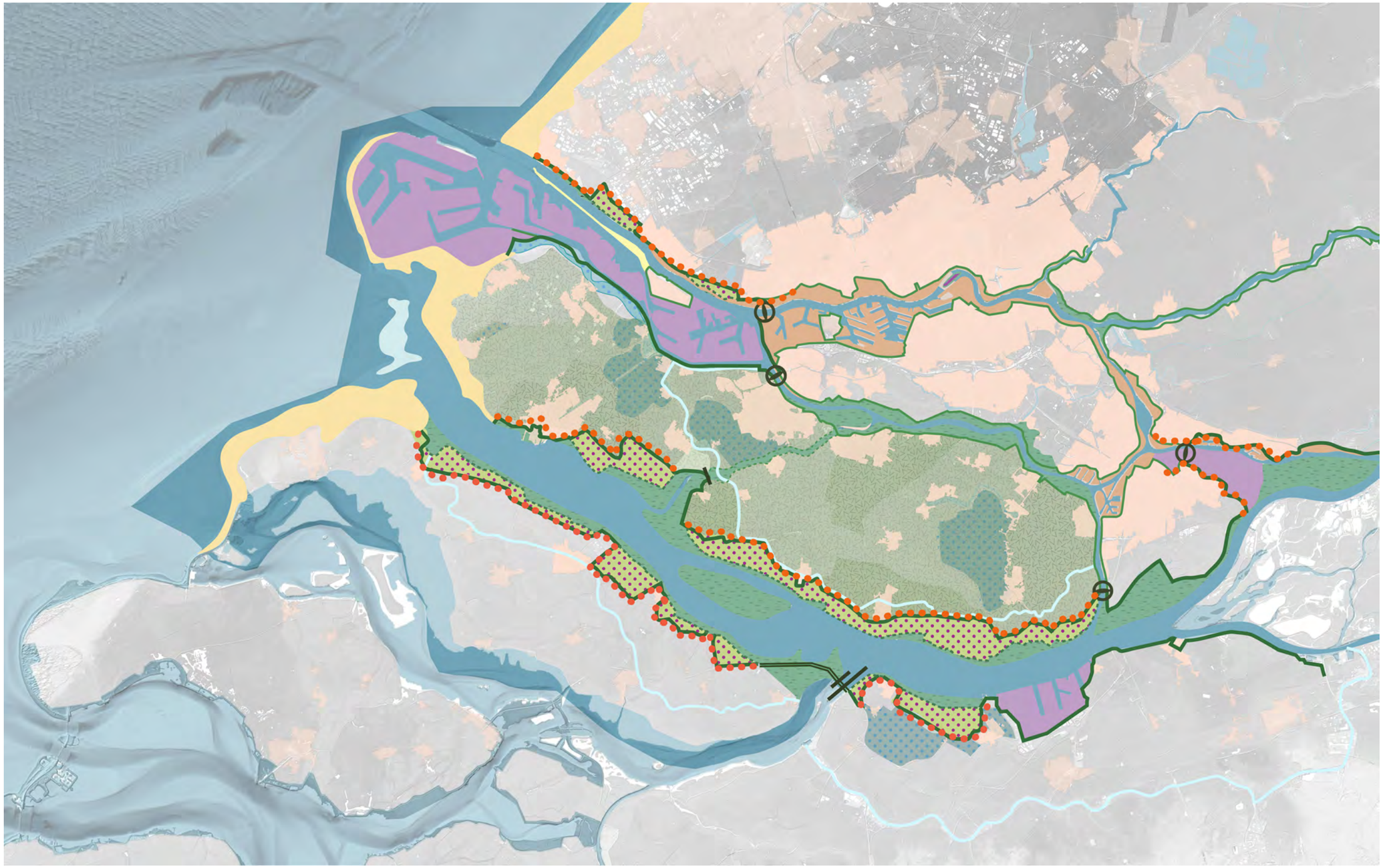
Under any flood safety strategy, the rural areas of the Rijnmond-Drechtsteden region will increasingly be affected by saline seepage as a result of sea-level rise and saltwater intrusion. Under the Estuarine Strategy, this will occur primarily around the Haringvliet, and to a greater extent than under closed strategies such as the Polder Strategy. To compensate for this greater saltwater intrusion and the loss of freshwater intake points, the strategy provides for a freshwater supply system. Nevertheless, sea-level rise will lead to increasing saline seepage. This means that the agricultural sector, particularly in the lowest-lying and westernmost polders in the region, will have to prepare for these conditions – for example, by gradually switching to more salt-tolerant crops and saline cultivation.

3. 5 Landscape and Ecology

Through its proposed sediment strategy, the Estuarine Strategy seeks to restore the estuarine character of the Rhine-Maas Estuary. Such large-scale system restoration is by far the most robust strategy for improving the ecological quality of the region. An open Haringvliet, for example, can function as a crossroads for two major migration flows. As the potential principal mouth of the Rhine and Maas rivers, the Haringvliet can serve as the main gateway to this river basin for migratory fish such as salmon, eel, and sturgeon, which migrate farther upstream to spawn. It would form a brackish, nutrient-rich estuary that provides habitat for various species of migratory fish at different stages of development. As a connecting link along the East Atlantic Flyway, the Haringvliet is also an indispensable foraging, resting, and breeding area for coastal birds and waterbirds that follow the Atlantic coastline between their wintering, rearing, and breeding grounds. The Haringvliet therefore forms an essential link in the chain of coastal wetlands along this bird migration route.

Opening the Haringvliet could increase the tidal range by as much as 130 centimeters (Hannon et al., 2019). Under the current partially open management regime (Kierbesluit), the Rhine-Maas Estuary has the potential to support 6,513 hectares of intertidal habitat. Partially opening the gates – resulting in a tidal range of up to 80 centimeters – would already increase the potential area of intertidal nature to 7,774 hectares, an increase of 19 percent. The greatest potential for tidal nature lies in the Haringvliet and Biesbosch. To maximize the inflow of sediment needed to enable these landscapes to keep pace with sea-level rise, the Haringvlietdam would ideally be removed entirely. Since the social feasibility of such a measure is, of course, open to debate, it is also worthwhile to investigate possible structural modifications to the Haringvlietdam. The main consideration is that the structure of the dam forms a sill behind which most of the sediment remains trapped, even when the gates are open.

City and Countryside



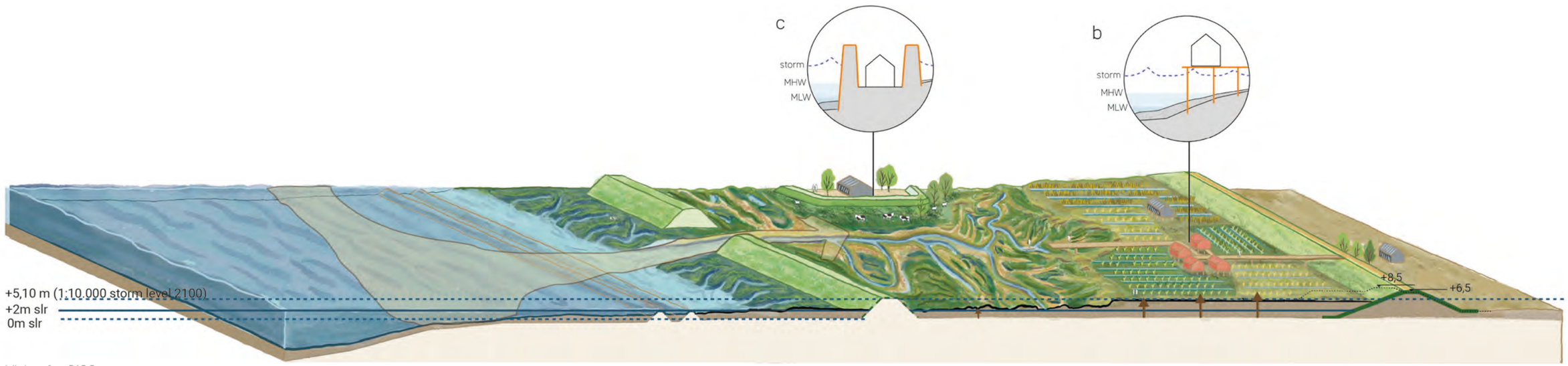
City and countryside – Estuarine Strategy (H+N+S Landscape Architects)

Nature and Ecology

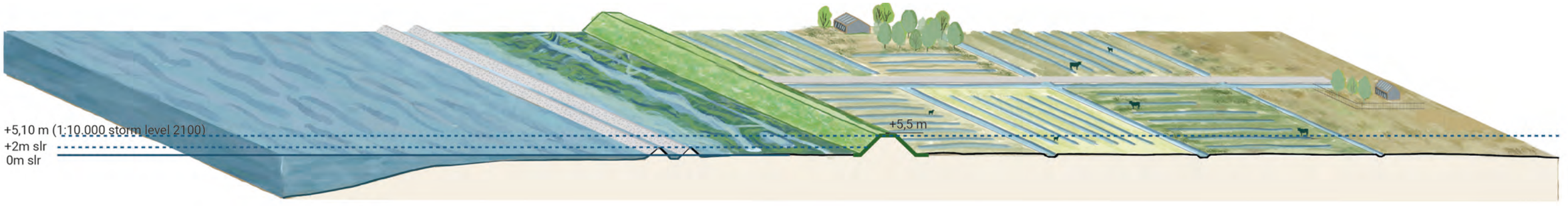


Nature and ecology – Estuarine Strategy (H+N+S Landscape Architects)

3. 6 Area Studies



Vision for 2100

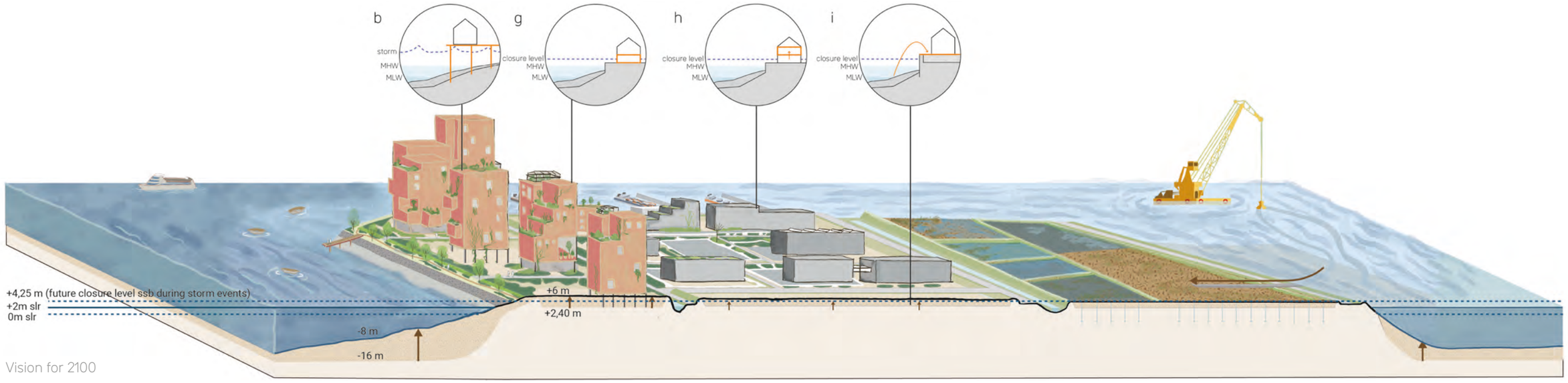


Current situation

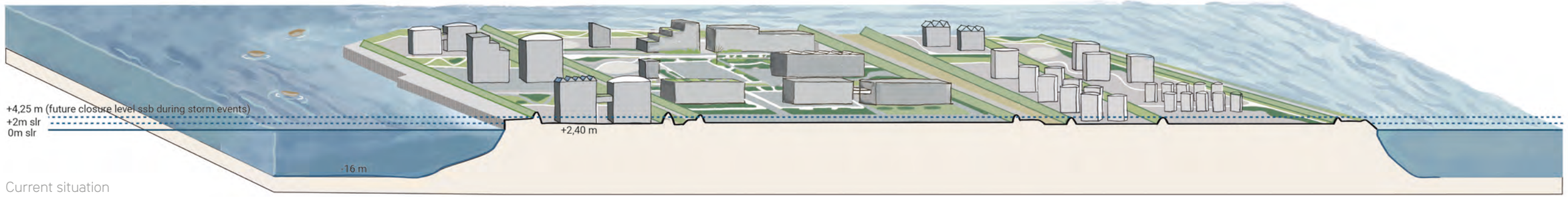
Area study: Haringvliet – Estuarine Strategy (H+N+S Landscape Architects)

3. 6. 1 Haringvliet

The example site is a polder on the north side of the Haringvliet, where the natural area in front of the dike is not wide enough to be transformed into a fully functioning flood-defending landscape. In this example, a new dike is therefore constructed behind the existing dike to take over its flood defense function. The strip of land between the old and new dikes is exposed to tidal influence and to sediment carried in by the tide through an opening in the old dike. This enables the land to keep pace with sea-level rise. Initially, this flood-defending landscape will primarily serve as a natural area, but as sediment continues to accumulate, certain forms of agriculture – such as extensive livestock grazing and salt-tolerant crops – may also come to characterize the landscape. Existing residential and commercial buildings, where present, would be protected against flooding by means of ring dikes until the time comes for their replacement. Replacement buildings could then be constructed on mounds at the same location or relocated elsewhere within or outside the area. New residential development is preferably located adjacent to the dike, on compact, raised ground at a development level to be determined. Regardless of future dike raising, the landward toe of the new dike would be permanently fixed in the same location and would also accommodate the freshwater supply channel serving the polder.



Vision for 2100

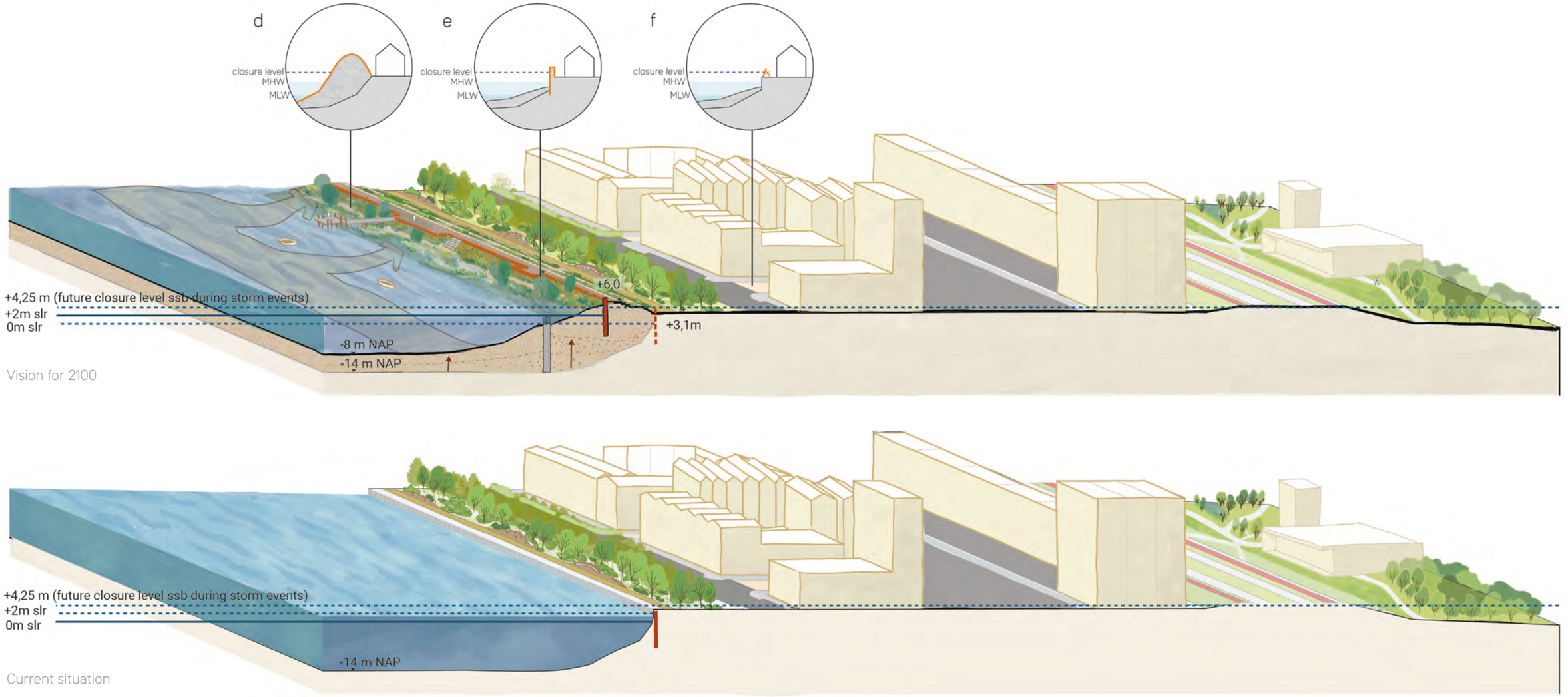


Current situation

Area study: Vondelingenplaat (Botlek) – Estuarine Strategy (H+N+S Landscape Architects)

3. 6. 2 Vondelingenplaat

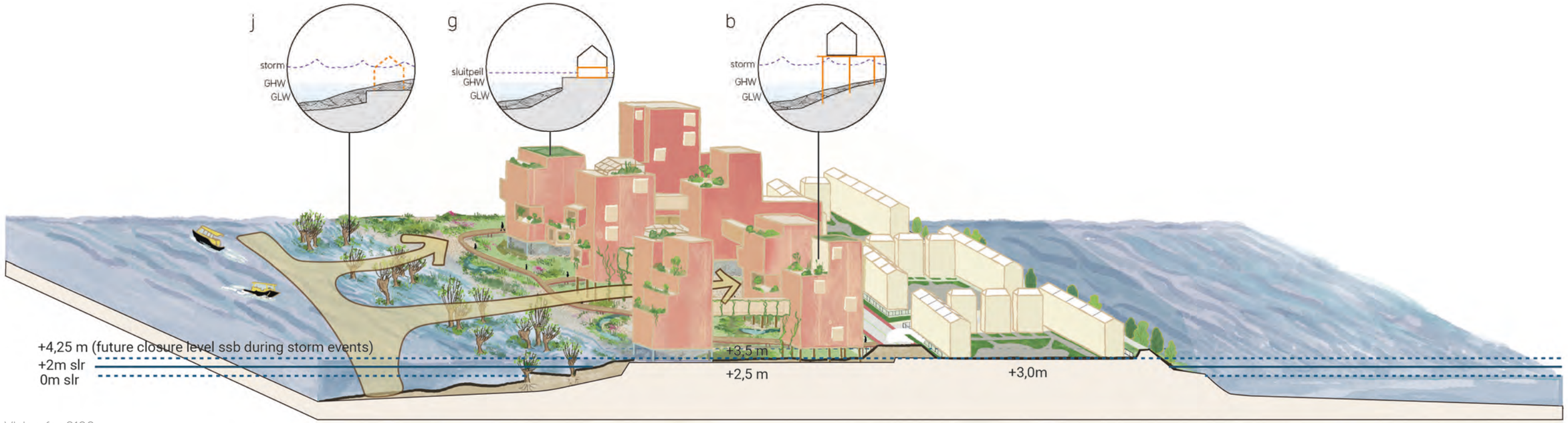
This example location represents the port industry in transition, where fossil industry will eventually give way to, for example, more sustainable manufacturing industry and, in certain locations, residential and office development. In this example, the transition from one function to another is used to allow the development level to keep pace with sea-level rise. Depending on the dynamics of the new function and the sea-level rise projection at that time, a new development level is established, and the ground is artificially raised to that elevation. The design of the raised ground takes future raising into account. Through the application of adaptive design and construction methods, the new functions can keep pace with periodic ground-level raising, so that future raising no longer depends on the timing of subsequent transitions. It should be noted that flood safety measures are already required in the highest parts of the port today. High water that causes flooding therefore cannot be ruled out even under the strategy proposed here and will continue to require local measures. Here too, activities outside the flood defense system mean living more intensively with water.



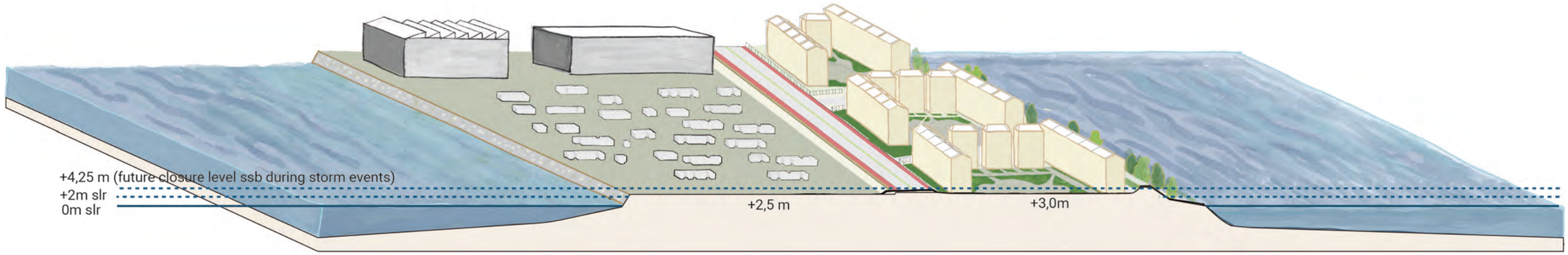
Area study: Rotterdam (Westerdijk – Westerkade) – Estuarine Strategy (H+N+S Landscape Architects)

3. 6. 3 Rotterdam (City Center)

At some locations outside the flood defense system, transformation of the built environment is not yet readily imaginable. It is therefore entirely conceivable that large parts of these areas will, in the near future, lie below the closure level of the storm surge barriers. These locations will then require protection against high water by means of a new flood defense. In this example, an adaptive flood-defending riverbank zone is proposed, consisting primarily of locally available sediment and designed as a continuous natural corridor along the Oude Maas that is accessible for recreation. Where the existing quays follow an especially irregular alignment because of port basins, the length of the flood defense could be significantly reduced by closing off certain sections with, for example, a small storm surge barrier. Should transformation take place in the more distant future, the ground level behind the flood-defending riverbank zone could be raised throughout, after which the riverbank zone would no longer have a flood defense function. Existing residential areas outside the flood defense system can be equipped with additional flood-defending elements such as masonry quay walls, stop logs, or self-closing flood walls, as is already being done in Antwerp.



Vision for 2100



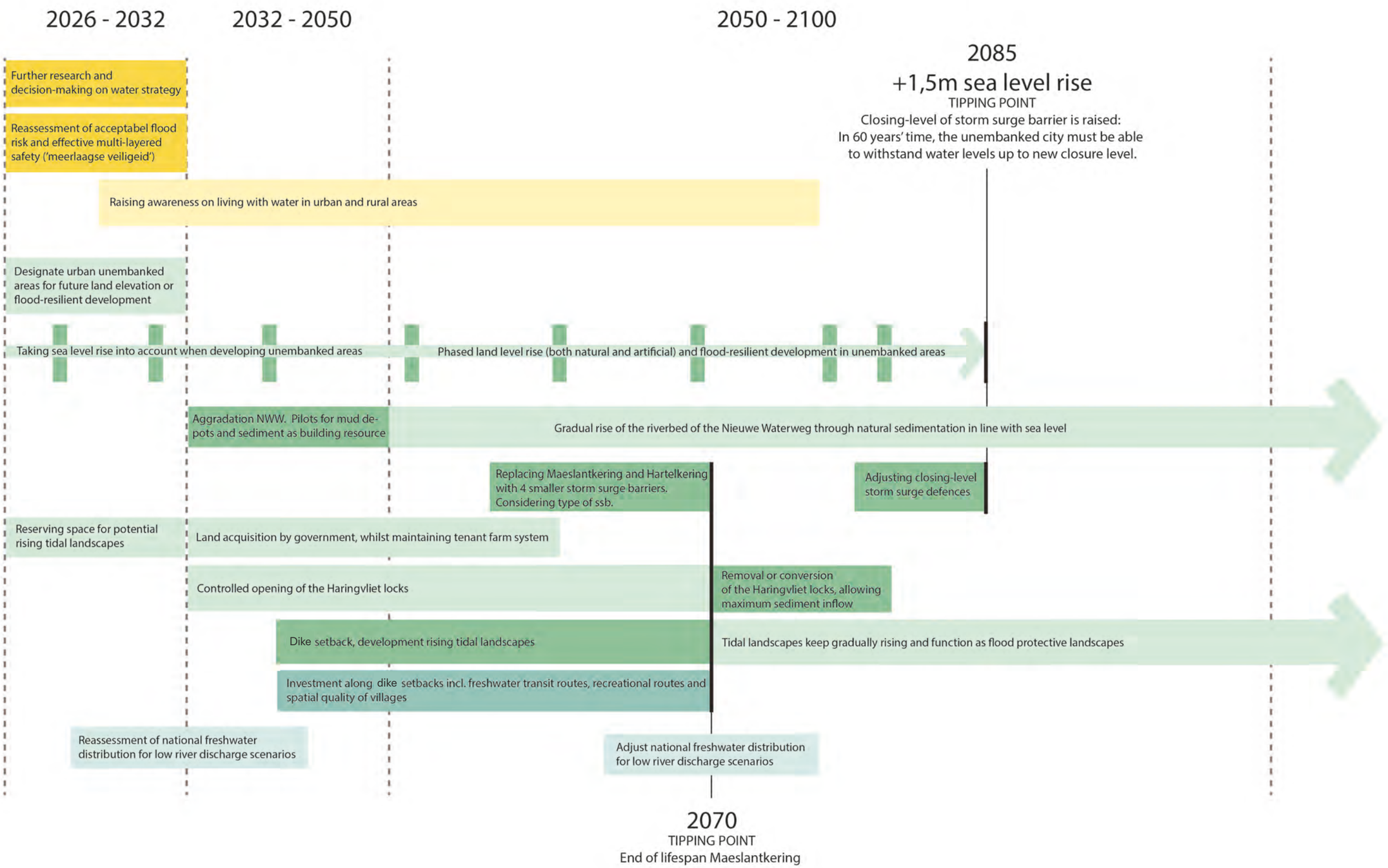
Current situation

Area study: Dordrecht (De Staart) – Estuarine Strategy (H+N+S Landscape Architects).

3. 6. 4 Dordrecht (de Staart)

At a number of locations outside the flood defense system, areas following different transition pathways will be situated close together. Careful consideration will therefore be required to determine which areas can be raised, at what time, and where this may not yet be possible before the closure level of the storm surge barriers exceeds the ground level. For the latter category, it must be determined whether additional flood safety measures should be temporary or permanent. The measures will be temporary if transformation through urban development is expected in the near future. In that case, the area will be raised at a later stage. Permanent additional flood safety measures will mainly be required where an area has a high heritage value that would be compromised too severely by raising the ground level throughout the area.

Transition Pathway



Transition pathway – Estuarine Strategy (H+N+S Landscape Architects)

3. 7 Transition Pathway

The transition pathway (shown on the following page) shows that a transition to an open strategy such as the Estuarine Strategy requires careful preparation and a long lead time. This begins with the implementation of a research agenda, which should first involve further research into a number of the hydromorphological effects of an open strategy described in this chapter. During this period, research should also examine how flood protection levels could be adapted to future urban development in the Rhine-Maas Estuary and how multilayer safety could be implemented in this context. Based on the results of this research, the necessary spatial reservations can be made for potential landscapes that keep pace with sea-level rise and for areas outside the flood defense system that will either be raised or developed with flood-resilient buildings.

Research should also examine when and how the open strategy described in this chapter could potentially transition to a closed strategy (as described in Chapter 2), as well as how elements of both strategies could reinforce one another. It is important that spatial interventions are selected in such a way that a possible transition from one strategy to the other is not precluded.

The research phase is followed by a period of small-scale experimentation with promising solutions. The purpose is not only to assess how these solutions perform in practice, but above all to align generic approaches with local interests and preferences, thereby exploring how appropriate site-specific solutions can be developed.

This is followed by the actual transition period, during which the spatial interventions required for the Estuarine Strategy are prepared, while flood safety continues to be provided by the current system of dams, storm surge barriers, and dikes. This period will largely coincide with the transition of the port. During this phase, the Nieuwe Waterweg will gradually become shallower, while the gates in the Haringvlietdam will be opened progressively wider. The largest construction challenge during this period will be the construction of the new Delta dikes and small storm surge barriers.

‘During the transition period, the Nieuwe Waterweg will gradually become shallower, while the gates in the Haringvlietdam will be opened progressively wider. The largest construction challenge during this period will be the construction of the new Delta dikes and storm surge barriers.’

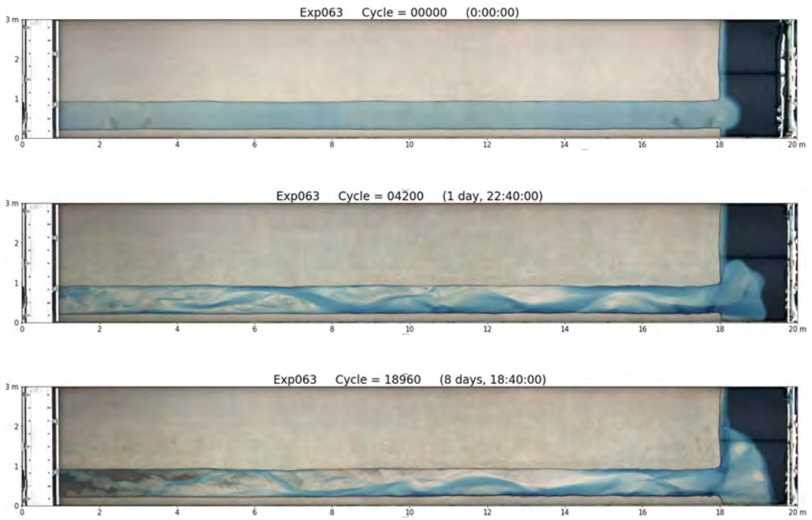
The crucial moment comes when the Haringvlietdam and the Maeslantkering are dismantled to achieve optimal sediment dynamics. This moment must coincide with the point at which both structures reach the end of their technical or functional service life. By that time, the reinforced Delta dikes in the flood-defending landscape behind these structures must have been completed. If this is not the case, the Haringvlietsluizen and the Maeslantkering will have to be replaced, extending their service life and effectively postponing the transition to an open strategy.

3. 8 Conclusions

This study of the Estuarine Strategy shows that, with the necessary adaptations to dikes and the locations of storm surge barriers, restoring the open connection between the rivers and the sea makes it possible for sufficient sediment to enter the system to enable areas outside the flood defense system in the Rhine-Maas Estuary to keep pace with rising sea levels. In this way, the area outside the flood defense system is transformed into a flood-defending landscape that reduces wave run-up, thereby lowering the required height of the dikes behind it and slowing the rate at which the area behind the flood defense would inundate in the event of a dike breach. The area studies also show that this approach creates a wide variety of attractive and safe living and working environments. Last but not least, estuarine ecosystems also benefit from this form of system restoration.

Not all areas outside the flood defense system are suitable for being raised entirely through natural processes. Densely built-up urban and industrial port areas, in particular, will generally have to be raised artificially, although the required sediment would still be supplied naturally and, after any necessary maturation, put to use. This artificial raising requires site-specific solutions, with timing being especially critical in relation to urban transformations that are either imminent or expected only in the more distant future. Low-lying urban areas such as Rotterdam and Dordrecht that are not expected to undergo transformation in the near term deserve particular attention. These will probably require additional measures such as constructing masonry quay walls or installing self-closing flood defenses. At the same time, it is precisely these local, site-specific solutions that can ultimately result in high-quality urban development.

‘With the necessary adaptations to primary flood defenses and storm surge barriers, natural processes can enable areas outside the flood defense system in the Rijnmond-Drechtsteden region to keep pace with rising sea levels.’



Simulation of natural sedimentation in the Nieuwe Waterweg in ‘De Metronoom’ (a research instrument that simulates tidal flow and sediment transport at scale; image: Kleinhans et al., 2026)

Research Agenda

This research by design not only outlines a future strategy but also contributes to the research agenda associated with the Estuarine approach. The study concludes by identifying a number of research priorities.

The Estuarine Strategy focuses on capturing sediment that is transported primarily from the sea. Along the Haringvliet in particular, this sediment is used to create flood-defending landscapes that keep pace with sea-level rise and to allow the artificially deepened channels of the Nieuwe Waterweg, Scheur, and Nieuwe Maas to become shallower. Sediment captured in these channels is subsequently used to artificially raise low-lying areas outside the flood defense system. Further research is needed into the exact rate at which flood-defending landscapes along the Haringvliet, Hollands Diep, and parts of the Nieuwe Waterweg will rise through natural sedimentation. Lessons can be drawn from projects in open systems where reclaimed land has been returned to nature, such as the Hedwigepolder. Additional research by design should also explore architectural and urban development concepts that are compatible with enabling areas outside the flood defense system in the Rhine-Maas Estuary to keep pace with sea-level rise.

For the Nieuwe Waterweg area, further research is required into the process of siltation and sediment accretion if dredging were to cease, and into the rate at which this would occur. An initial exploration has already been carried out by Utrecht University (Kleinhans et al., 2026). Valuable lessons about preparing sites raised with dredged material for development can be drawn from experiences with the Kleirijperij (Clay Ripening Facility) in the Ems-Dollard region. The shallowing of the Nieuwe Waterweg is expected to result in less extreme high-water levels near Rotterdam, a further retreat of the salt wedge, and a significant increase in biodiversity. A first assessment of these effects has already been presented in the progress report De Rijnmond als Estuarium (Meyer et al., 2022). Further research is needed to determine the precise extent to which shallowing reduces high-water levels and, consequently, the urgency of raising dikes and areas outside the flood defense system. The same applies to the extent to which the salt wedge is pushed back in the river branches and which plant and animal species benefit from the shallowing process.

Finally, we should investigate whether the Haringvlietdam and Maeslantkering could eventually be replaced by storm surge barriers that allow sediment entering from the sea to pass through with as little obstruction as possible. Because of their abutments and sills, the existing storm surge barriers allow substantially less silt and virtually no sand to pass. An innovative future storm surge barrier that would permit sediment to pass almost unhindered while also having a significantly lower probability of failure than the current storm surge barriers could substantially reduce the need for dike reinforcement, particularly along the Haringvliet and Nieuwe Waterweg. Even if this proves impossible, the dike setback proposed in this scenario along the Haringvliet, Hollands Diep, and Nieuwe Waterweg should not be regarded as a blueprint for the future flood defense zone. Here, too, site-specific solutions will be required. In some cases, this may include transforming the foreshore in front of the existing dikes into a flood-defending landscape that keeps pace with sea-level rise.

‘This strategy embodies a spatial policy that seeks to align economic development as closely as possible with the dynamics of natural systems.’

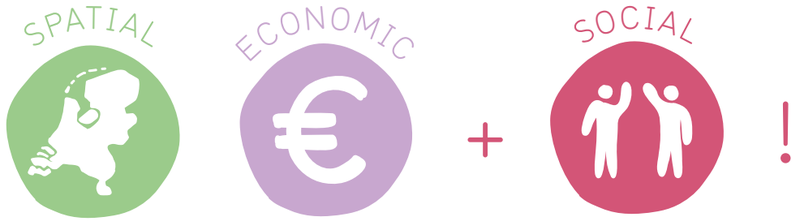


Photo: Jannes Linders, from the series Between City and Sea

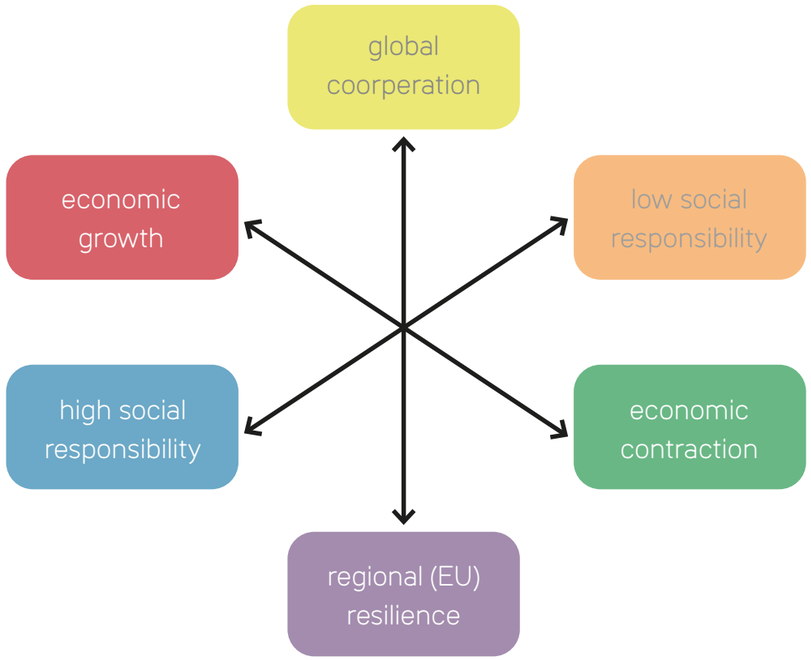
4 Reflection on the Spatio-Economic Implications

PosadMaxwan

4. 1 Assessment Framework Based on Scenario Thinking
4. 2 Opportunities and Risks of the Polder Strategy
4. 3 Opportunities and Risks of the Estuarine Strategy
4. 4 Summary of Reflections



Three perspectives for guiding decisionmaking on water safety (PosadMaxwan)



Worlds of tomorrow in perspective of economy, collaboration, and social resposibility (PosadMaxwan)

4 Reflection on Spatio-Economic Implications

The previous chapters explored two flood safety strategies. The issue of flood safety in the Rijnmond-Drechtsteden region is urgent not only because of the major challenges related to water management, but also because of its broader, complex interactions with society. The region is densely populated, and the Port of Rotterdam is of major economic importance, not only to the region but also nationally (3.2 per cent of Dutch GDP) and globally. Approximately 28,000 seagoing vessels and 91,000 inland vessels pass through the port each year (Port of Rotterdam, n.d.). A flood safety strategy must therefore encompass a coordinated approach that takes into account its implications for the economy, numerous spatial interests and people.

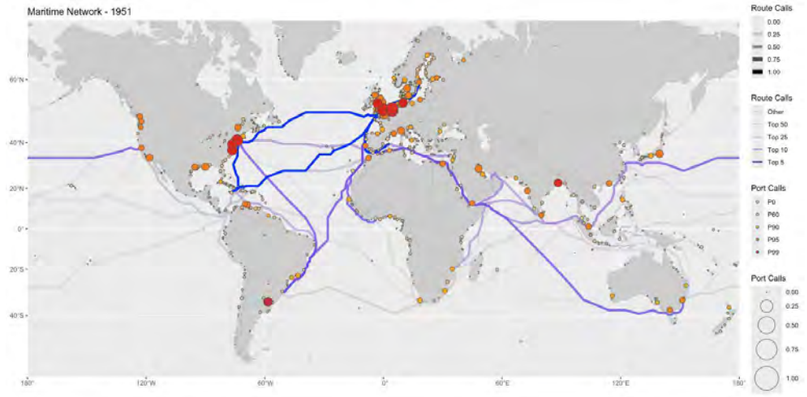
The aim of this chapter is to use scenario thinking to provide an overview of possible futures from a perspective beyond flood safety, and then to examine what these future scenarios, in combination with the flood safety strategies explored, could mean for the region in economic, spatial and social terms. What are the potential opportunities and risks of the strategies explored under different scenarios? Working with outlines of possible future scenarios offers a practical way of thinking about the future while also providing a framework for complex, uncertain and diverse contexts. It should be noted that this approach does not yet include quantitative figures. Further quantification will be included as an important research question in the final part of the report. This chapter is not about determining which flood safety strategy is 'better' or 'preferable' – both strategies are physically feasible and have their strengths and challenges – but aims to help decision-makers navigate the complex implications of the flood safety strategies through an assessment framework.

Particular consideration is given to the region's interconnectedness with the global context: because of the importance of the port complex to the national, EU and global economy, any intervention in its functioning has far-reaching consequences. Conversely, shifts in the geopolitical landscape, the global economy and the way agreements with partners are managed have a major impact on this area and how it functions. These vulnerabilities and dependencies contribute substantially to the uncertainty of the future. The resources we expect to have available to achieve our objectives – financially, but also in terms of political and social support – depend heavily on the world in which we find ourselves.

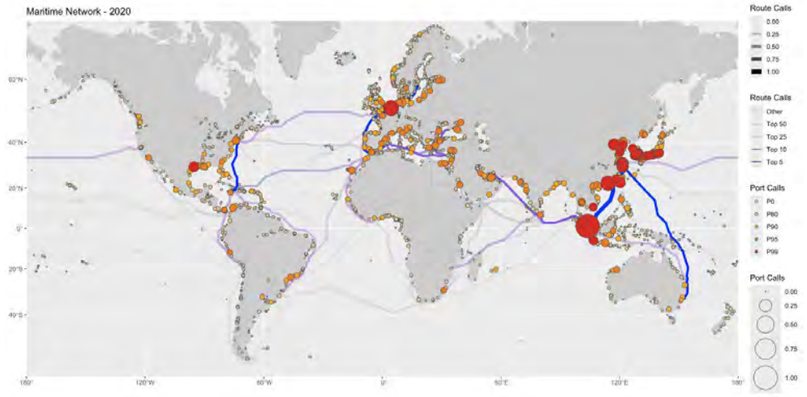
The port complex itself is in the midst of several transitions: from fossil-based and linear systems to renewable, biobased and circular ones. More space and flexibility are needed to allow these systems to operate in parallel during the transition period, but even afterward – if the global economy grows – there is no indication that demand for space will decrease. At the same time, the Rijnmond-Drechtsteden region has faced intense competition for available space for decades: economic activity and industry, housing, agriculture, nature and water all make claims on space here. Determining what should take priority and where is becoming increasingly complex.

To help decision-makers navigate this complexity, a scenario model has been developed based on varying degrees of societal responsibility, cooperation and economic development. The two flood safety strategies are compared within this context.

Finally, the focus here is not just on the space and the economy, which have dominated this area for decades, but also on the people: the people who live and work here – now, in 2100 and beyond. For years, the province has ranked lowest in the Netherlands in terms of both life expectancy and healthy life expectancy based on self-perceived health. This is just one way of illustrating the importance of including social implications in the assessment framework.

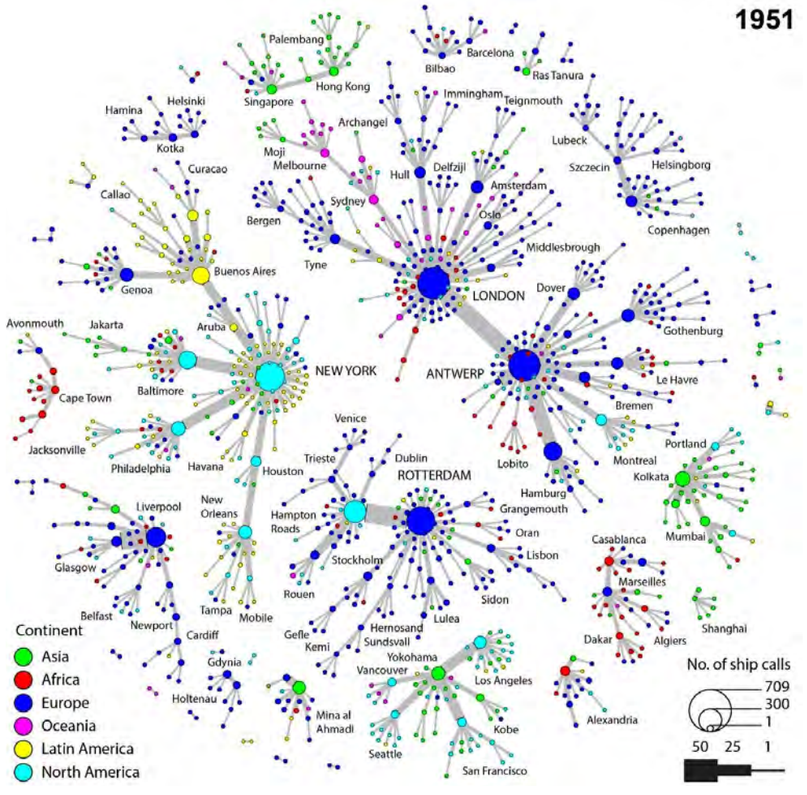


Map of the global maritime network in 1951 (Ducruet et al, 2025).

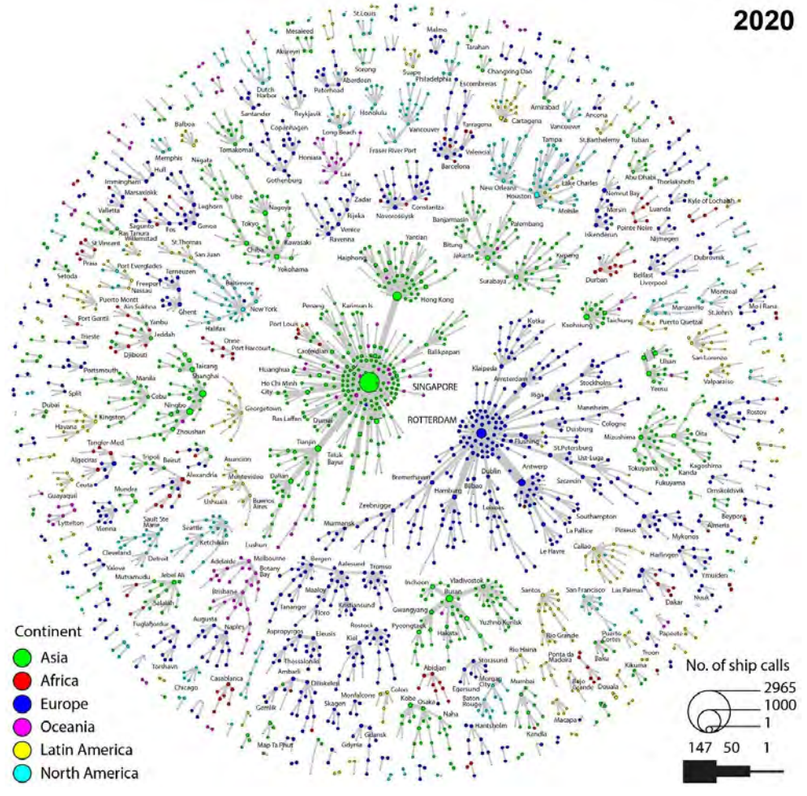


Map of the global maritime network in 2020 (Ducruet et al, 2025).

The global interconnectedness of the Rotterdam port complex (including Moerdijk, Dordrecht and Antwerp) means that any intervention in the functioning of this area has consequences for the national, EU and global economy. Conversely, geopolitical and macroeconomic shifts have a major impact on how this area functions. Although the port is in the midst of several transitions, it is clear that demand for space will only increase. Given the key role of the port complex in the EU economy, making it more sustainable should not be a national matter alone. Sustainability efforts here have a major impact on the EU's total CO_2 emissions: if there is one place for strategic investment, it is here.

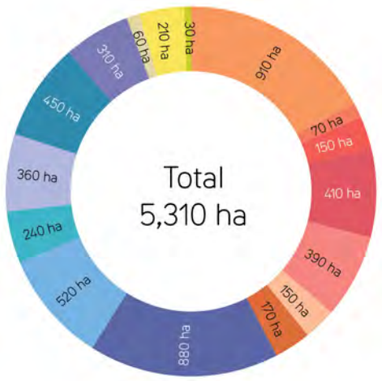


Port nodes and connections in the global maritime network in 1951 (Ducruet et al, 2025).

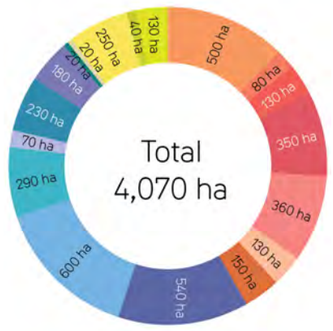


Port nodes and connections in the global maritime network in 2020 (Ducruet et al, 2025).

'Sustainability efforts here have a major impact on the EU's total CO_2 emissions: if there is one place for strategic investment, it is here.'



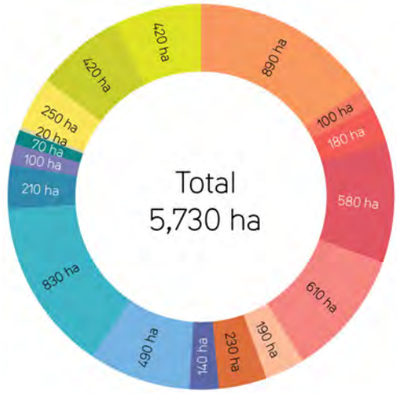
Current land use



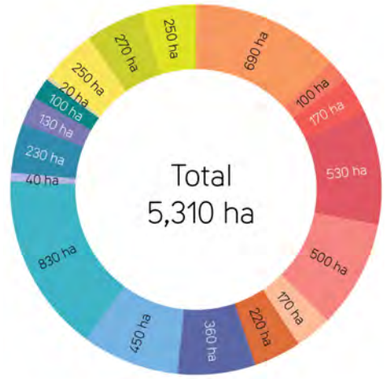
Protected Markets



Regional Wellbeing



Connected Deep-Green



Wake-Up Call



Current land use in the Port of Rotterdam by sector (map: NOVEX Rotterdamse haven et al., 2025, p. 22; adapted by PosadMaxwan) and estimated land use in four future scenarios (charts: FABRICations, 2025a; adapted by PosadMaxwan).

Legend:

Goods
- Deepsea
- Shortsea
- RoRo
- Breakbulk
- Distribution
- Empty depots
- Other goods

Carbon chains
- Refineries
- Chemical industry
- Biobased and circular industry
- Refinery terminals
- Independent tank storage
- Coal and iron ore
- Biomass

Hydrogen and electrification
- Gas
- Power + utilities
- Electrolysers
- Hydrogen + CO_2
- Nuclear power plants

Other land use
- Other land use

Occupancy option
- Deepsea
- Biobased and circular industry
- Gas
- Electrolysers

Reserved / available occupancy
- Reservation
- Available

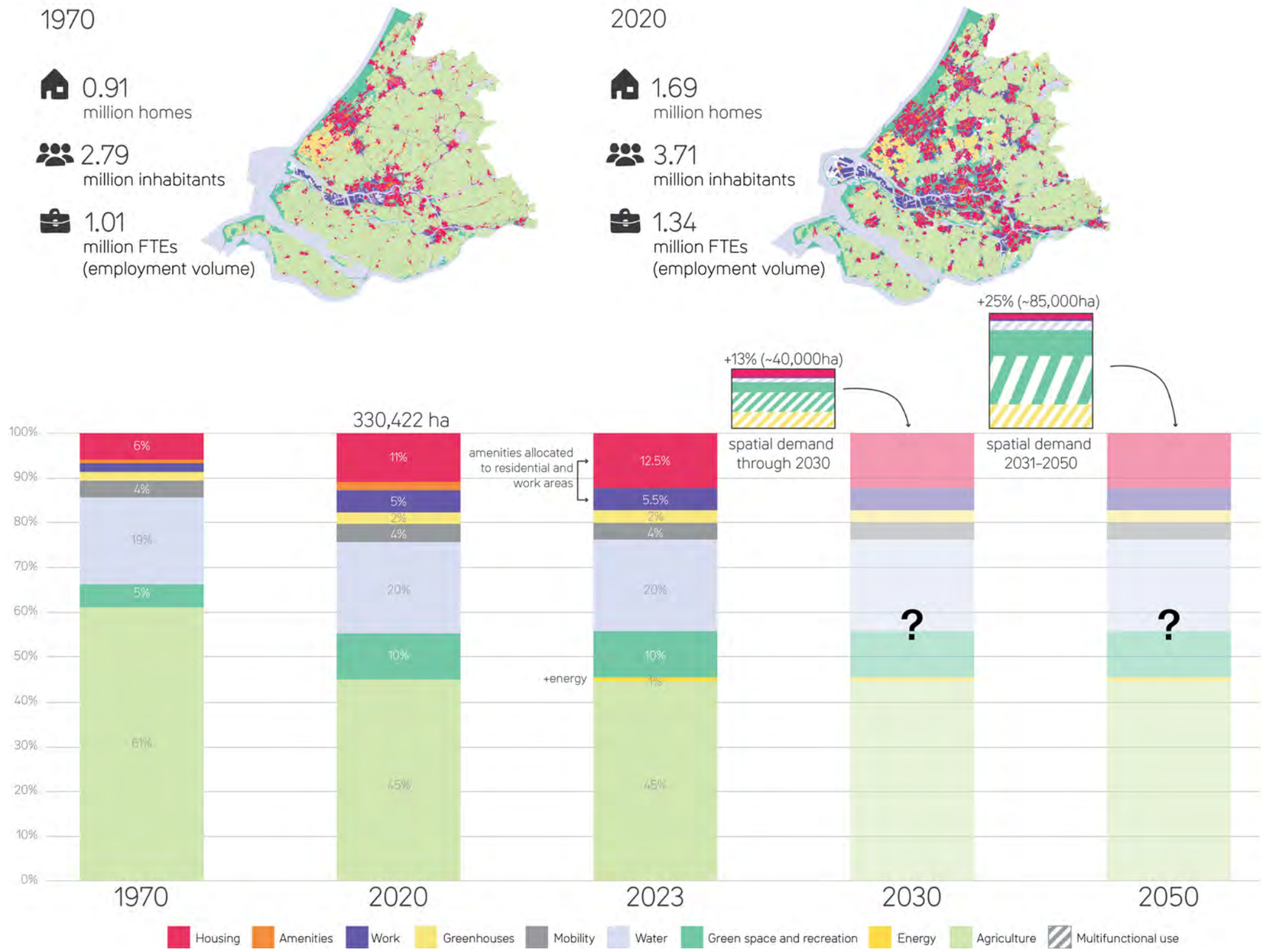
Critical Dependencies and Vulnerabilities

The region forms an integrated system in which vulnerabilities can compound quickly. The port is home to energy infrastructure, petrochemical clusters, hydrogen development and strategic logistics networks – assets that require continuous operation. The surrounding cities face their own challenges: housing shortages, competition for space, social inequality, and exposure to climate risks. The hinterland depends on freshwater supplies and uninterrupted transport chains for its agriculture and industry.

These layers reinforce one another. A disruption to flood safety can have cascading effects on economic networks, affect employment, put pressure on public budgets, and undermine social cohesion. Conversely, well-designed water strategies can stabilize long-term development, protect critical industries, and create space for spatial and social transformation.

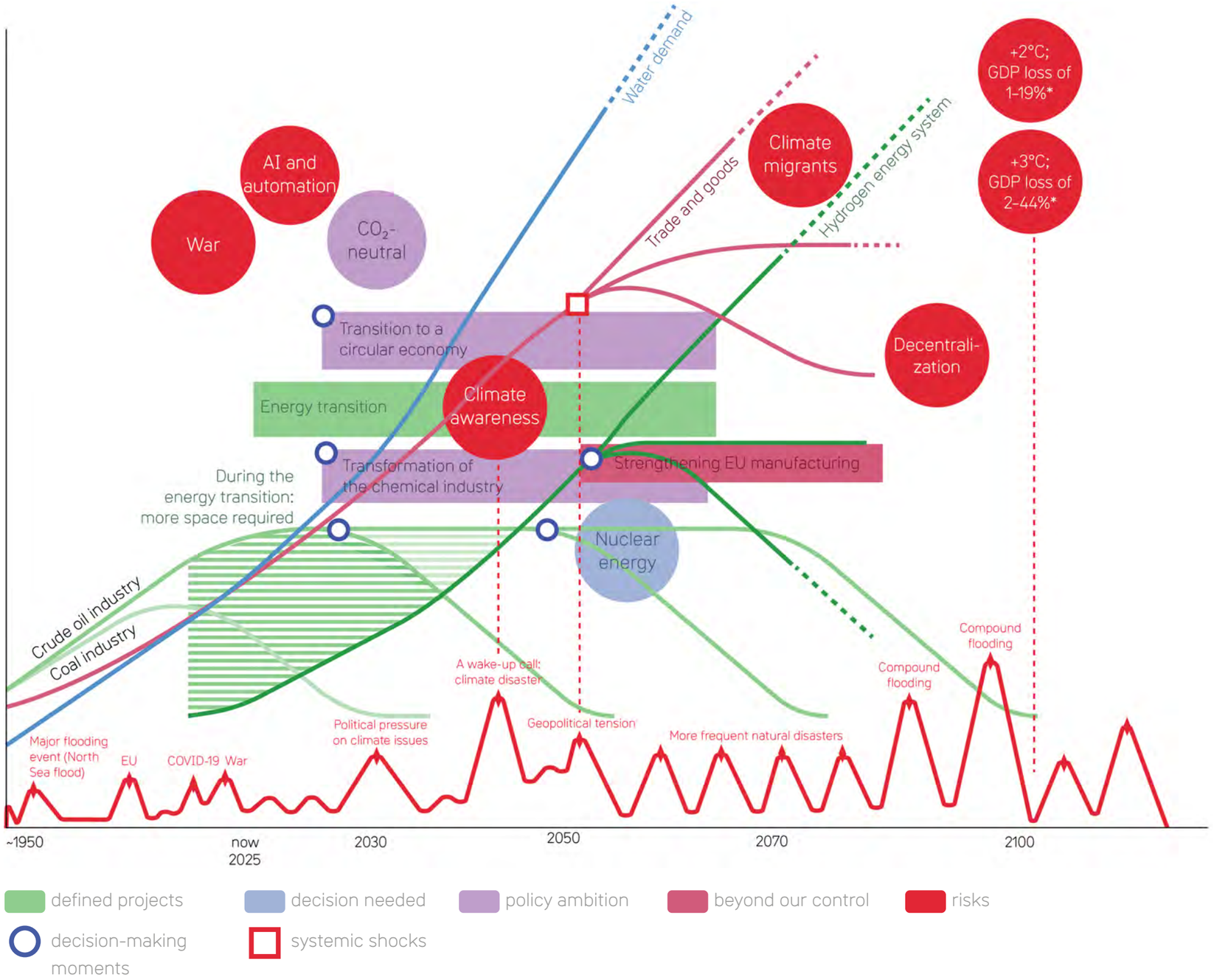
These regional dependencies are part of much larger global networks. The structure of maritime flows and port hierarchies determines how shocks spread and how vulnerable the Rotterdam region is to developments far beyond the region itself. The evolution of global maritime networks shows how port cities operate within changing networks of interdependence. Routes have become concentrated, hubs have emerged and disappeared, and geopolitical and economic dynamics have repeatedly reshaped global trade. Rotterdam functions as a critical node in this structure: its stability depends on political decisions made elsewhere, climatic conditions and disruptions far beyond the region. This systemic exposure means that local constraints on accessibility, flood safety, or freshwater availability can quickly propagate through supply chains and the wider economy.

Beyond the port, the region faces pressure from other competing spatial claims: agriculture and food production, service and knowledge economy, nature, housing, recreation, water, and more. Current projections assume that the total



Managing spatial pressure: land-use transformation from 1970 to 2020 (BRIGHT et al., 2022; adapted by PosadMaxwan).

land area will remain unchanged. But given sea-level rise, extreme rainfall, and the buffer capacity this requires, as well as the risk of inland flooding, the question is how this spatial pressure can be managed. After all, flood safety and freshwater availability require increasing amounts of space and investment.



Inevitable complexity and uncertainty in the future (PosadMaxwan)

Inevitable Complexity and Uncertainty in the Future

The current period is characterized by complexity and instability, making long-term stability an unrealistic assumption. Global systems – energy markets, technological development, and geopolitical relations – are increasingly interconnected. As a result, disruptions in one domain quickly affect others, directly affecting cities, ports, and societies.

Economic, ecological, and political developments no longer unfold separately but interact, reinforcing or mitigating one another in ways that are difficult to predict. The focus therefore shifts from control to resilience: the ability of regions, institutions, and communities to absorb shocks and continue performing essential functions. Long-term transitions – such as the shift to a low-carbon economy, automation, and circular production – are also taking place simultaneously with short-term crises, including armed conflicts, migration movements, and political instability.

In this context, physical and local interventions take on added significance. Flood safety measures are not only technical solutions but can also contribute to spatial quality and urban design, precisely through site-specific approaches. Strategy and design thus become an integrated whole: the robustness of the region is determined not by its ability to predict the future, but by its ability to continue functioning in the face of shocks.

*Network for Greening the Financial System (2024, p. 14). Note: NGFS harmonises different damage functions; figures represent GDP/output losses relative to a baseline without climate change and are subject to uncertainty.

4. 1 Assessment Framework Based on Scenario Thinking

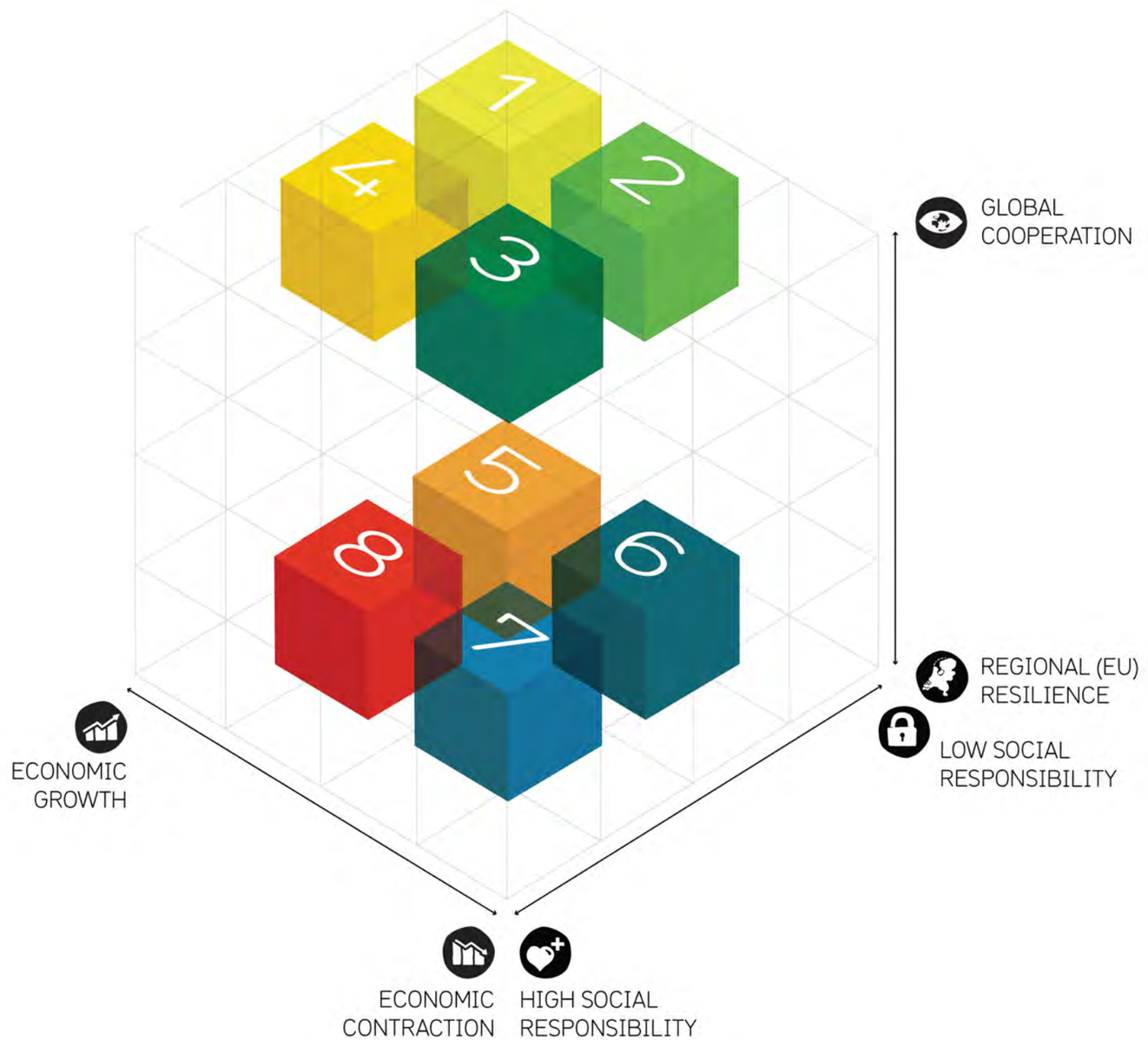
Three Axes, Eight Possible Future Scenarios

Future developments cannot be captured in a single projection. Global cooperation or regional resilience, economic growth or contraction, and varying degrees of societal responsibility all lead to fundamentally different pathways for society, the economy, and the built environment. These forces interact in unpredictable ways, and no single one of them can be regarded as a fixed basis for long-term planning.

The scenario model presented here makes this uncertainty explicit. It is structured around three axes, each representing an important dimension that shapes future conditions: the scale of governmental cooperation, the direction of economic development, and the degree of societal responsibility. Together, these axes generate eight different 'cubes': eight different future scenarios arising from their possible combinations. None of these scenarios is inherently more likely; each represents a plausible context within which spatial and economic decisions will have to function.

- The scale of governmental cooperation ranges from global cooperation to regional (EU) resilience – from countries acting collectively to a stronger focus on self-reliance.
- The direction of economic development ranges from growth to contraction – from continued expansion of prosperity to a future dominated by redistribution and moderation.
- Societal responsibility ranges from high to low – from choices guided by collective ethics, equity and sustainability to a more individualized and short-term outlook.

Each cube represents a possible future scenario shaped by the combination of these dimensions. There is no fixed or correct direction; the model serves as the basis for an assessment framework that gives decision-makers and policymakers insight into the bandwidth available – financially, politically, and socially – to achieve certain objectives, depending on the combination of dimensions that may arise. See Appendix B for a more detailed explanation of the different future scenarios.



Three axes generate eight future scenarios (PosadMaxwan)

Structure of the Assessment Framework

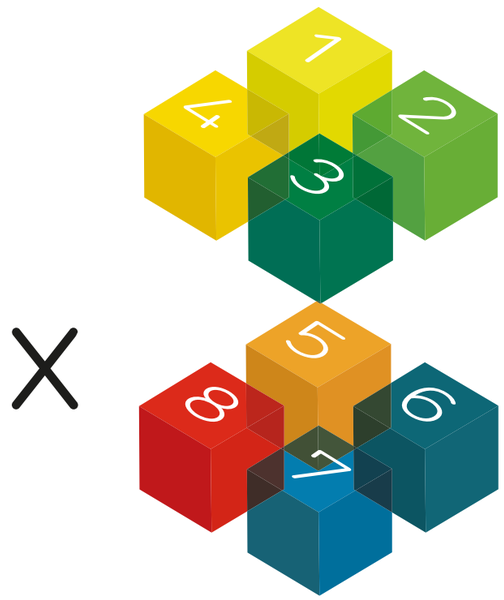
The HVK report (2025) assesses flood safety strategies in five impact categories: flood consequences, shipping, freshwater availability, tidal ecosystems, and buildings outside the flood defense system. These categories are used as a starting point, and the framework is expanded to include socioeconomic domains and topics from the working sessions. This results in seven themes: port & logistics, population & city, energy transition & circular economy, landscape & nature, agriculture & horticulture, freshwater demand, and investment in flood safety. The implications of the Polder and Estuarine Strategies for these themes are then summarized through three interrelated lenses: spatial, economic, and social.

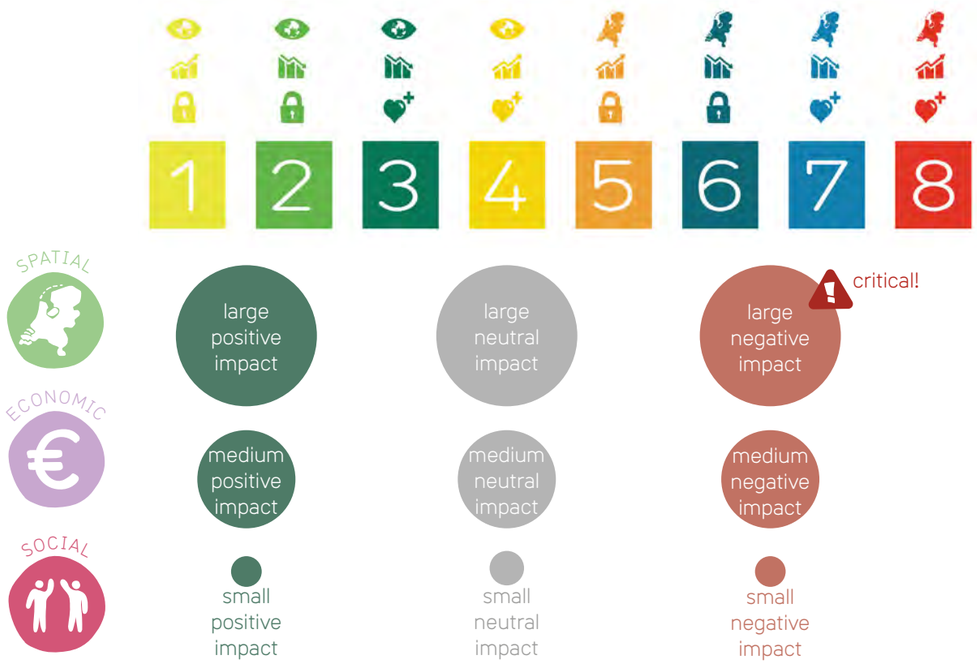
- The spatial perspective focuses on how the physical environment – such as land use, geography, infrastructure, nature, and ecology – can develop. It considers how space is allocated and how water management is spatially integrated.
- The economic perspective considers the economic factors that affect water systems, such as investments in flood safety, infrastructure, and technology, as well as how water is priced and managed within the economy.
- The social perspective reflects the social context, including public opinion, social values, equity, and acceptance of policies or technologies related to water management.

Opportunities and risks are summarized and, where relevant, visualized in maps. These visualizations do not represent an end state but serve as an assessment tool for making the consequences, tensions, and scope for decision-making explicit. This assessment is conducted for each of the eight future scenarios, so that the implications are not tied to a single 'expected' future. These scenarios serve as boundary conditions for spatial choices in the face of increasing water-related challenges; what is feasible and widely supported in one scenario may be constrained by funding, public support, or institutional capacity in another. For each scenario and theme, we indicate the direction of impact (positive, neutral, or negative) and the magnitude of impact (small, medium, or large), supplemented by an assessment of feasibility.

In practice, a future-proof approach will likely consist of a combination of elements from the strategies. We therefore assess not only the strategies as a whole but also their main building blocks: Which elements are robust across multiple scenarios, and which require compensation, alternative financing or a different spatial design? Appendix B contains the complete assessment matrix by theme and future scenario, including an explanation of the scores.

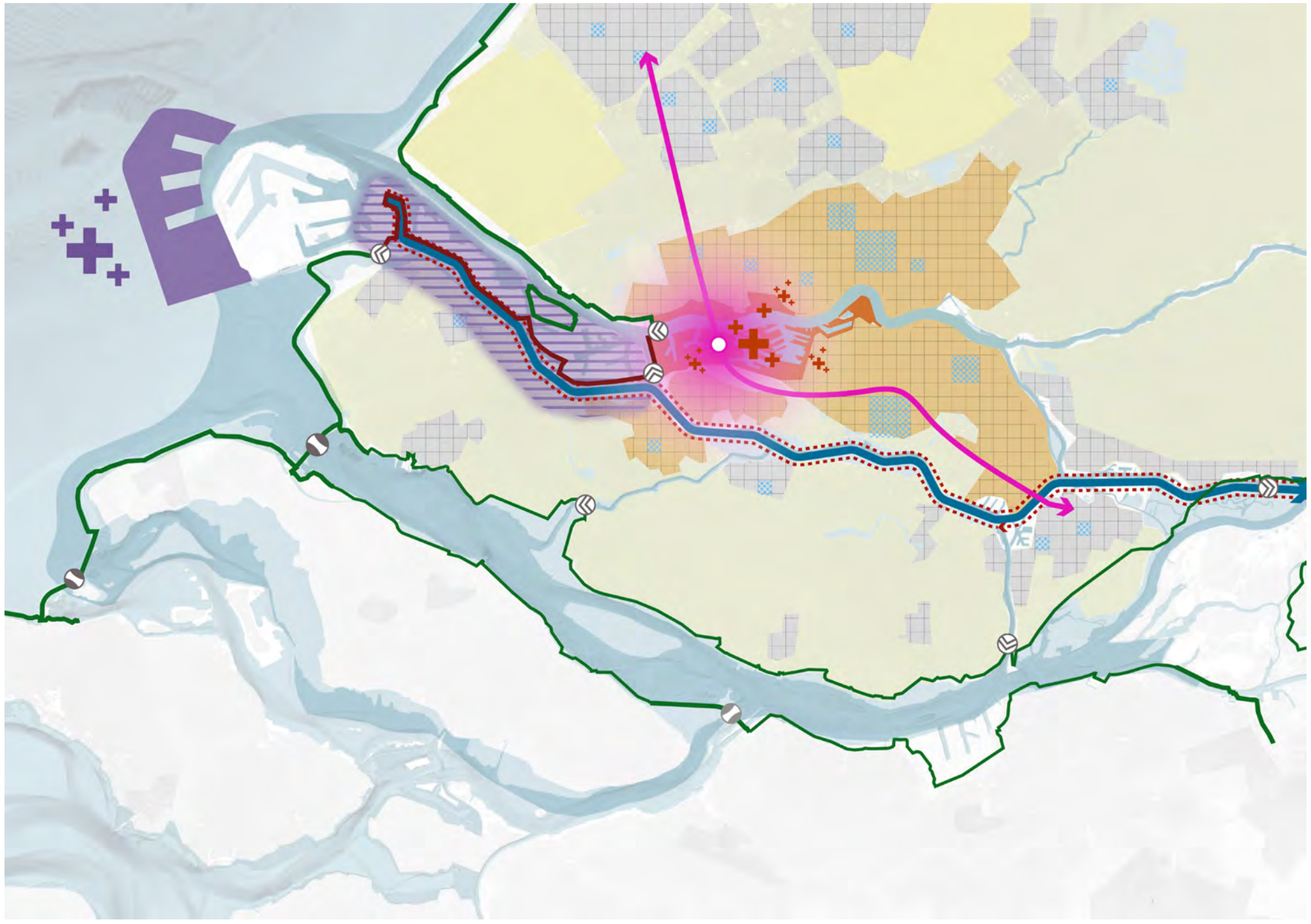
		LENGTH TO BE REINFORCED KM	COSTS (BILLION EUROS) WITH GREEN DIKES	COSTS (BILLION EUROS) WITH STRUCTURAL + GREEN SOLUTION	COSTS FOR ARTWORKS, PUMPING STATION, TRANSMISSION	OUTSIDE-DIKE BUILDINGS (X 1,000) OUT / 1,000 PJ	TIDAL NATURE	FRESHWATER AVAILABILITY HWS	NAVIGABILITY	FLOOD CONSEQUENCES
1	Stretching the current preferred strategy	484 (1,015)	33 (+29)	13 (+11)	9	25				
2A	Seaward - pumping	433 (963)	18 (+27)*	8 (+10)*	58	1				
2B	Seaward - sluicing	457 (987)	26 (+29)*	11 (+11)*	40	15				
3	Natural	499 (1,028)	39 (+31)	16 (+11)	6.6	27				
4	Rhine estuary	488 (1,018)	34 (+31)	13 (+11)	12	19				
5	Delta polder	452 (981)	17 (+29)	8 (+11)	18	11				
6A	Retreat Hoeksche Waard	418 (949)	33 (+29)	13 (+11)	33-34	15				
6B	Retreat Alblasserwaard	418 (949)	30 (+29)	13 (+11)	66-116	15				





Schematic representation of the assessment framework structure (PosadMaxwan; table on the left from HKV, 2025)

4. 2 Opportunities and Risks of the Polder Strategy



Spatial implications of the Polder Strategy (PosadMaxwan)

Spatial Implications

Reconfiguration of the area where seagoing and inland shipping routes intersect:

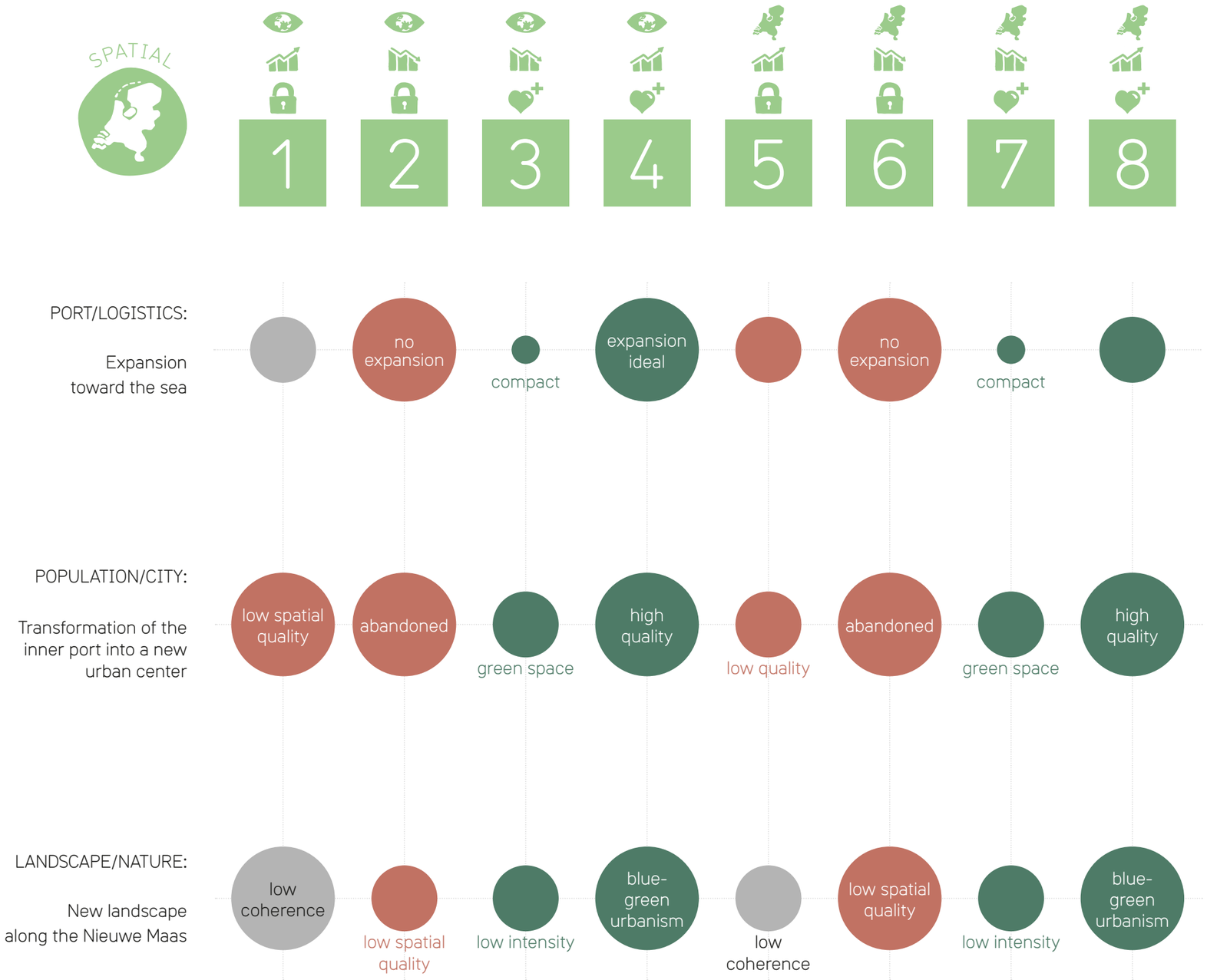
- Expansion of the port toward the North Sea (Maasvlakte 3 and 4).
- Potential areas for the development of new port infrastructure to enable the separation of seagoing and inland shipping and associated industry. Transshipment centers are needed to transfer cargo between vessels or to road and other modes of transport.
- Rerouting of the main shipping route toward the Oude Maas, requiring the Oude Maas to be widened to accommodate increased shipping traffic.

Transformation of inner port areas into new urban centers:

- Inner port areas such as the Eemhaven and Petroleumhavens could be transformed into new urban centers with a mix of functions.
- The development of new urban functions could better connect the north and south banks of the Nieuwe Maas, strengthening Rotterdam's metropolitan structure.

Urban areas must be prepared for extreme weather conditions:

- Urban areas within the Delta dike ring must be prepared for prolonged flooding caused by extreme rainfall, particularly when the capacity of the pumping system is exceeded.



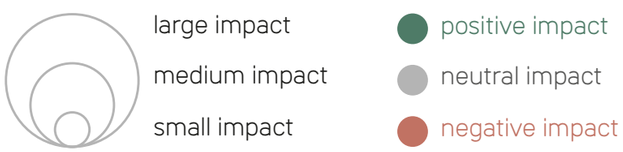
Spatial Implications × Scenarios

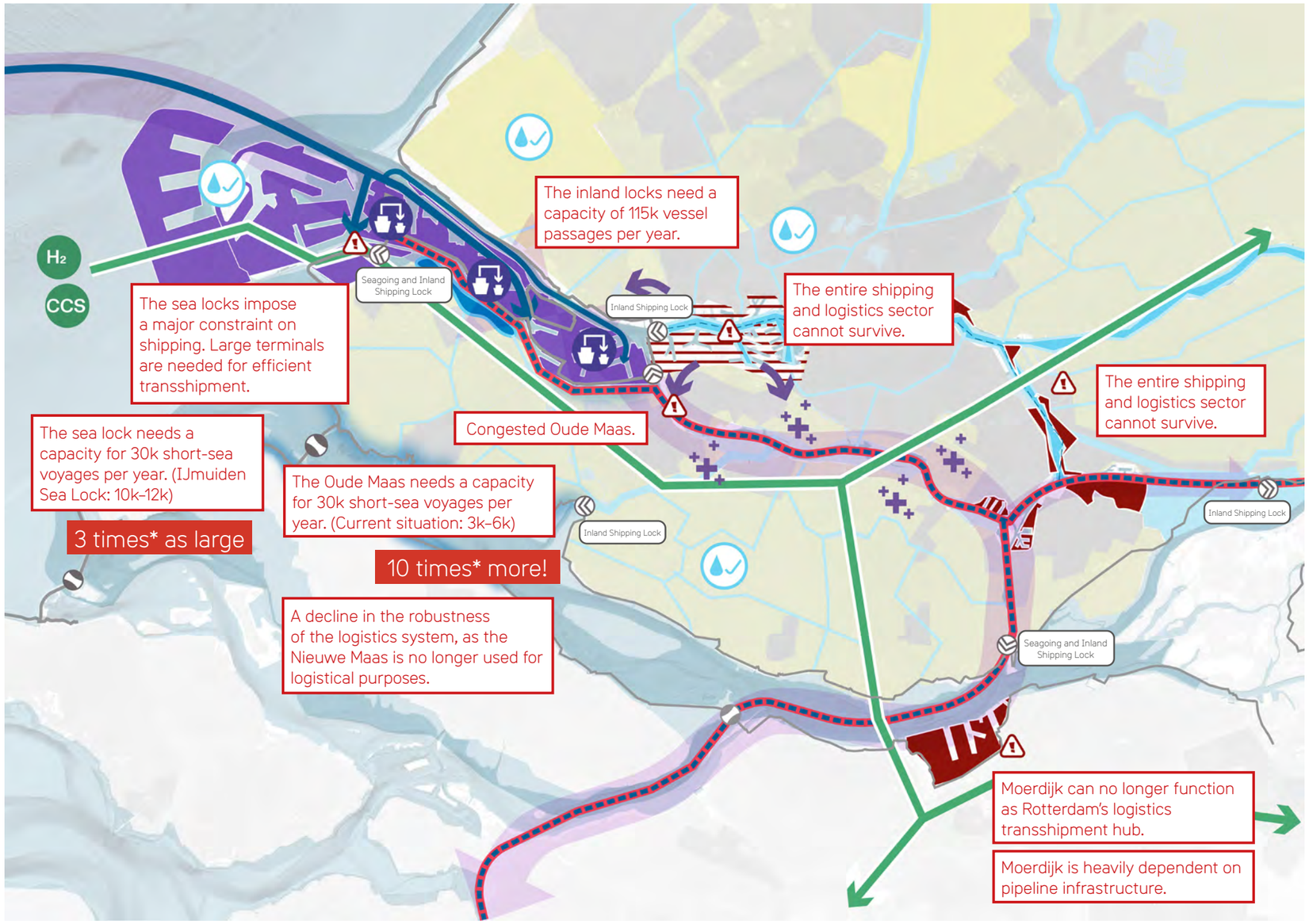
- Locks as spatial levers (opportunities and risks). They determine whether the Polder Strategy becomes a driver of synergy ((scenario 4, 8)) or a bottleneck and source of conflict (1, 2, 6).

- Growth requires integration; contraction requires compactness. In growth scenarios, expansion toward the sea can work if nautical capacity is designed as an integrated system (waiting areas, safe crossings, or separate navigation channels, smart routing).
  In contraction scenarios, the logic shifts toward compact, efficient, high-quality, low-impact logistics, consolidation, and reuse of existing resources (circularity and energy flows).

- Inner port areas as a test of good governance. The strategy can free up space for a new urban center, but without societal responsibility and investment, this leads to profit-driven development (low spatial quality) or prolonged vacancy and fragmentation. With a high degree of societal responsibility, phased transformation can instead produce a climate-resilient, multifunctional urban center (blue-green infrastructure, healthy mobility, and affordability).

- The Nieuwe Maas becomes a backbone, but only with continuity and good management. Market-driven growth and contraction can both quickly lead to fragmentation, through either privatization or neglect. The real benefit lies in a continuous blue-green system (navigation routes, riverbank quality, ecological connections, and wetlands), supported by long-term management and funding for maintenance.





Economic implications of the Polder Strategy (PosadMaxwan)

Economic Implications

The inner port areas along the Nieuwe Maas require a new economic profile:

- The shipping and logistics sectors along the Nieuwe Maas will be severely constrained.
- Maasvlakte/Europoort and Moerdijk will be less well connected logistically because of restrictions on shipping routes, which will also affect connections with Antwerp. Future activities will depend heavily on pipeline infrastructure for transport.
- The shipping industry will be severely constrained by reduced efficiency and restrictions on the types of products that can be transported as a result of complex shipping routes and shallow water depths.

Significant constraints on the shipping and logistics system:

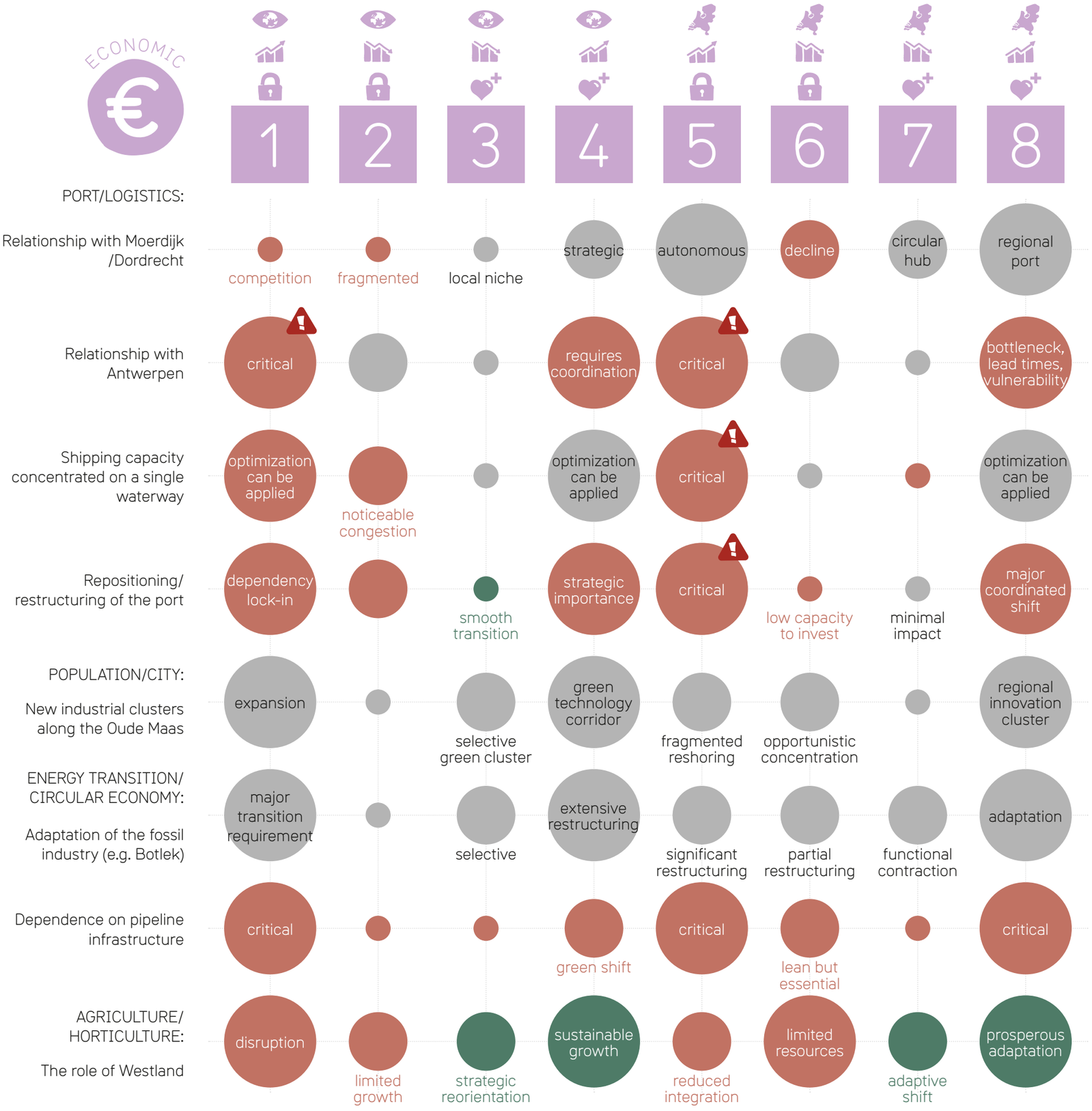
- New transshipment terminals are needed in ports that connect seagoing and inland shipping (Europoort, Botlek). This implies a reconfiguration of the port and possible expansion on the inland side to provide space for vessels to wait and berth.
- Under the Polder Strategy, the Oude Maas becomes congested and poses greater risks in the event of accidents, as there are no alternative routes for inland shipping.

Adequate freshwater supply in the area:

- There is a risk of salinization, but the freshwater supply is sufficient for industrial, agricultural and urban activities.

* Based on a presentation by the Port of Rotterdam Authority (2025; third working session, see Appendix A). Slide included in Appendix C for reference.

- Method: Demand for sea-lock passages was scaled based on the IJmuiden Sea Lock benchmark.
- Result: The estimated number of sea-lock passages at Rotterdam is approximately 30,000 to 72,000 per year (3 to 6 times the 10,000 to 12,000 passages per year at IJmuiden).
- Implication: If access via the Nieuwe Maas is restricted, a substantial share of seagoing and inbound traffic will shift to the alternative corridor and lock nodes, potentially increasing the number of local sea-lock passages from the current approximately 3,000 to 6,000 per year to tens of thousands per year (worst case: approximately 5 to 10 times as many).



Economic Implications × Scenarios

- Under the Polder Strategy, logistical reliability comes at a new price: the economy becomes dependent on fewer locks, corridors, and networks. Key vulnerabilities are (i) dependence on pipelines and energy corridors (including scenario 1, 5, 8) and (ii) shipping capacity concentrated on a single waterway.

- Under high growth, benefits arise only through coordinated repositioning of terminals, routing, and corridor management; otherwise, the shift itself becomes a shock and a source of congestion.
  Under contraction, the logic shifts toward 'no-regret' optimization: lower volumes, prioritizing maintenance, and focusing on viable activities (strategic sectors and local circular chains) rather than expansion

- Moerdijk and Dordrecht can take on key roles under green integration (4, 8) or become more competitive or redundant under autonomy (5), with higher system costs. Rotterdam–Antwerp remains a critical fault line: friction at locks can lead to duplicate facilities, detours, and modal shifts, reducing cluster efficiency.

- Repositioning becomes structural: new clustering shifts toward the Oude Maas, ranging from limited clustering in contraction scenarios to extensive clustering under green growth. The Botlek transition ranges from minimal adaptation (2) to broad transition (4, 8), with mixed but significant restructuring under EU competition (5). Westland ranges from disruption to strategic reorientation emphasizing green logistics, planning, and innovation (3, 4, 7, 8).



Social implications of the Polder Strategy (PosadMaxwan).

Social Implications

Environmental impacts on society resulting from the potential development of new industrial clusters along the Oude Maas:

Conflicts may arise between residents of cities and towns along the Oude Maas and potential future port expansion, as well as from increasing port activity in the area.

Job losses in port districts:

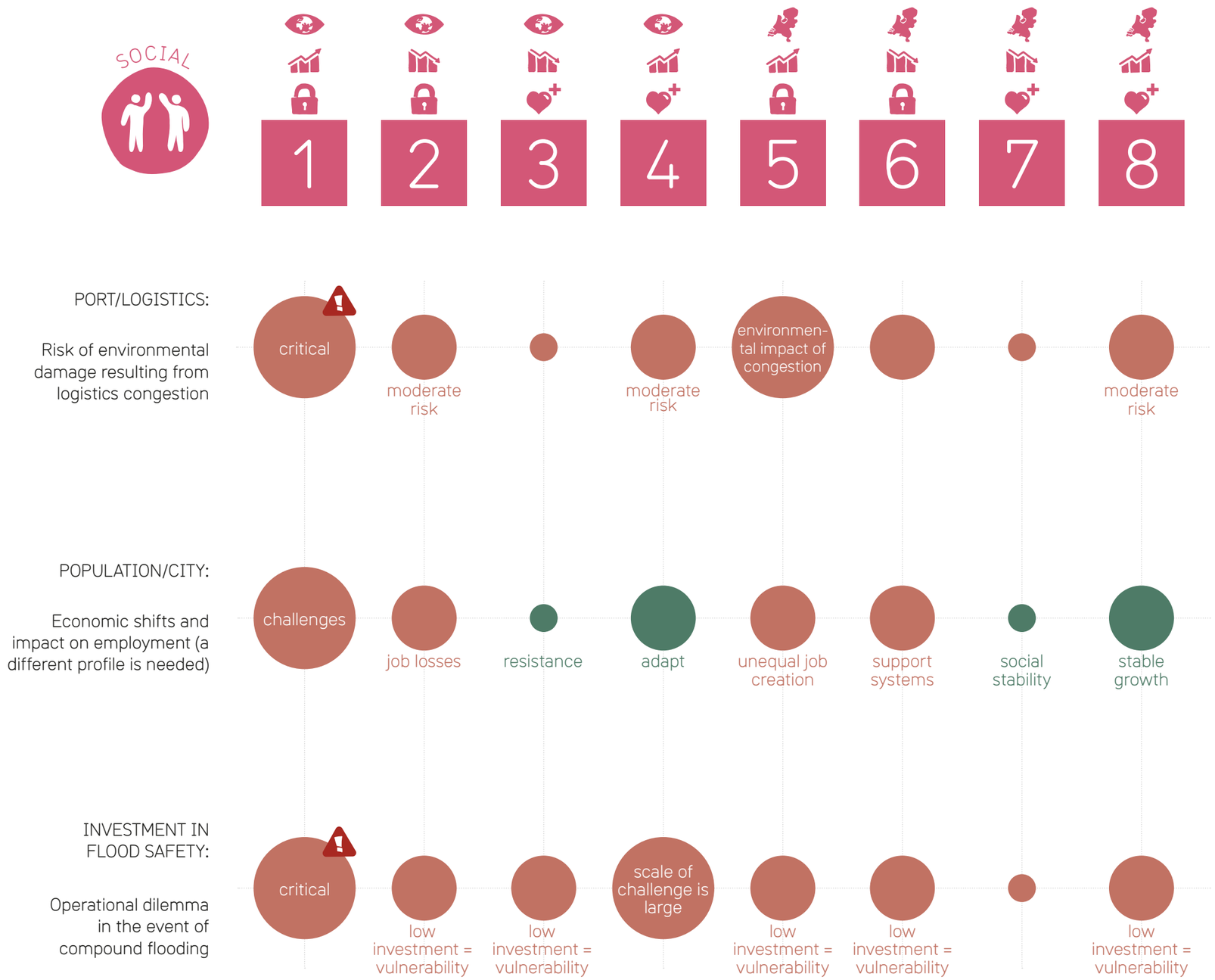
Districts closely tied to jobs that no longer fit the changing profile of the inner port areas will face significant job losses as existing industries are affected.

Potential loss of ecological value:

The quality of the freshwater ecosystem may be lower than that of existing tidal areas.

System dilemma in the event of compound flooding:

The water system faces a dilemma when areas within the flood defense system are at risk of flooding, requiring the locks to be opened, while a storm surge requires them to be closed. This could result in significant social and economic damage.

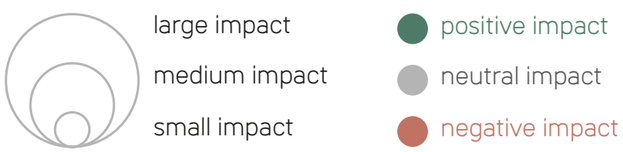


Social Implications × Scenarios

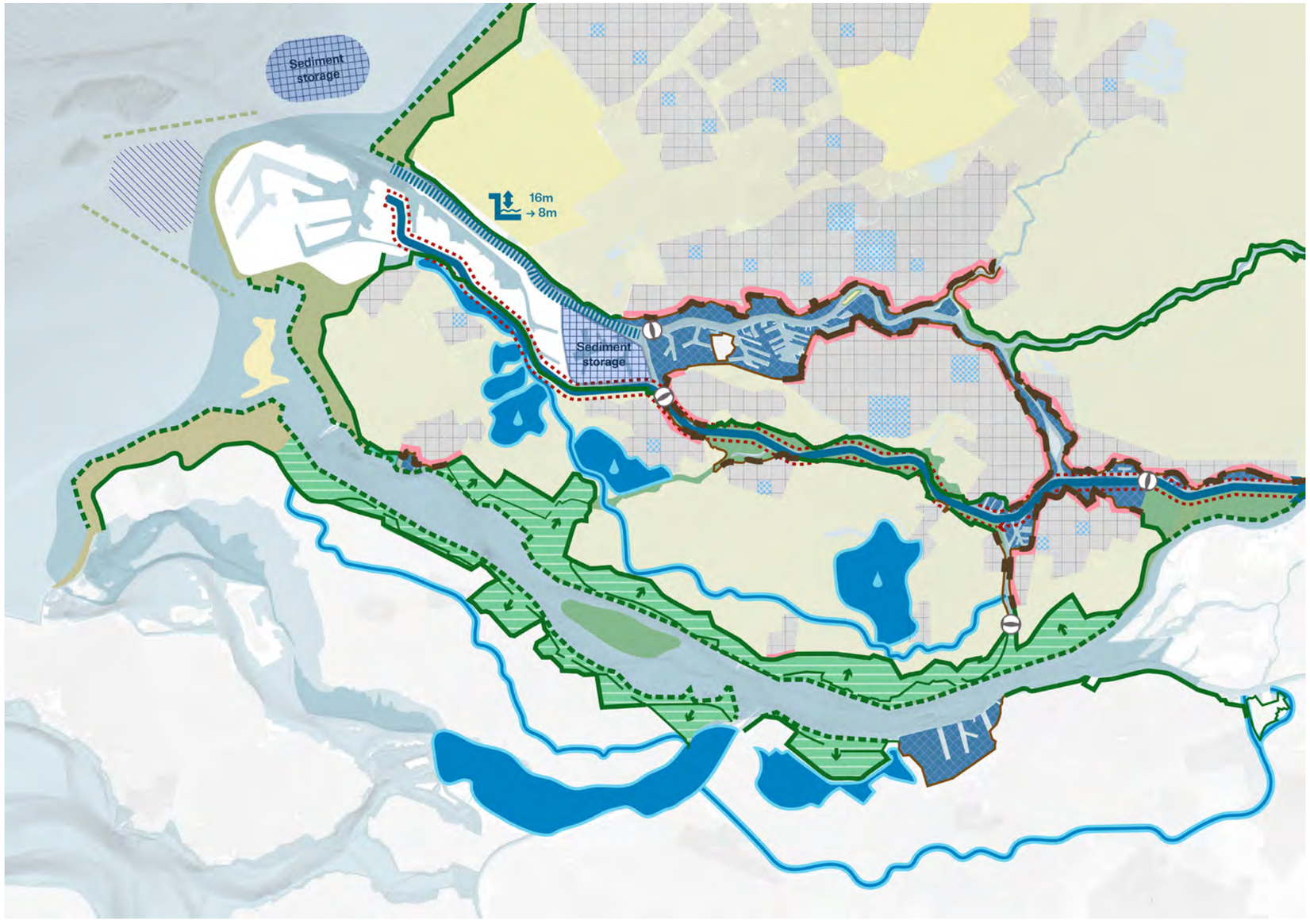
- Environmental impacts from logistics congestion increase with high volumes and limited route redundancy, particularly under global growth and EU protectionism. Growth scenarios increase pressure and the potential for conflict; societal responsibility determines the extent to which these impacts remain manageable. Under high growth, congestion, environmental pressures, and the risk of conflict around the Oude Maas increase. Contraction is not necessarily socially negative: with a high degree of societal responsibility, a crisis can lead to a managed transition – lower volumes reduce congestion risks, while social policies (training and income support) prevent a downward spiral.

- With a high degree of societal responsibility (4, 8), stricter standards, spatial buffers and investment can mitigate these impacts; with low societal responsibility (1, 5), local residents bear the burden through nuisance, an unequal distribution of benefits, and a lower quality of life.

- Flood safety is the social 'shock absorber', but the system dilemma remains relevant in all scenarios. The extent to which social consequences can be limited depends on investment, operational capacity, and the quality of governance. In scenarios with a high degree of societal responsibility, resources are more likely to be allocated to flood defenses, monitoring, emergency planning, and recovery support, reducing overall vulnerability.



4. 3 Opportunities and Risks of the Estuarine Strategy



Spatial implications of the Estuarine Strategy (PosadMaxwan)

Spatial Implications

Constraints on future port expansion:

Expansion of the Maasvlakte area is possible only to a limited extent and requires a morphological basis for establishing threshold values and compensatory measures to maintain sediment flows.

Transformation of urban areas:

Raising dikes in urban areas poses significant spatial challenges within the existing urban fabric.

Urban areas outside the flood defense system must be adapted at both the neighborhood and building levels to conditions in which they are less protected against high water.

Areas within the flood defense system must be prepared for prolonged flooding caused by extreme rainfall.

New landscape shaped by sediment processes:

A new landscape with a water buffer zone along the Haringvliet, created by setting back the dike inland to make room for a flood-defending landscape.

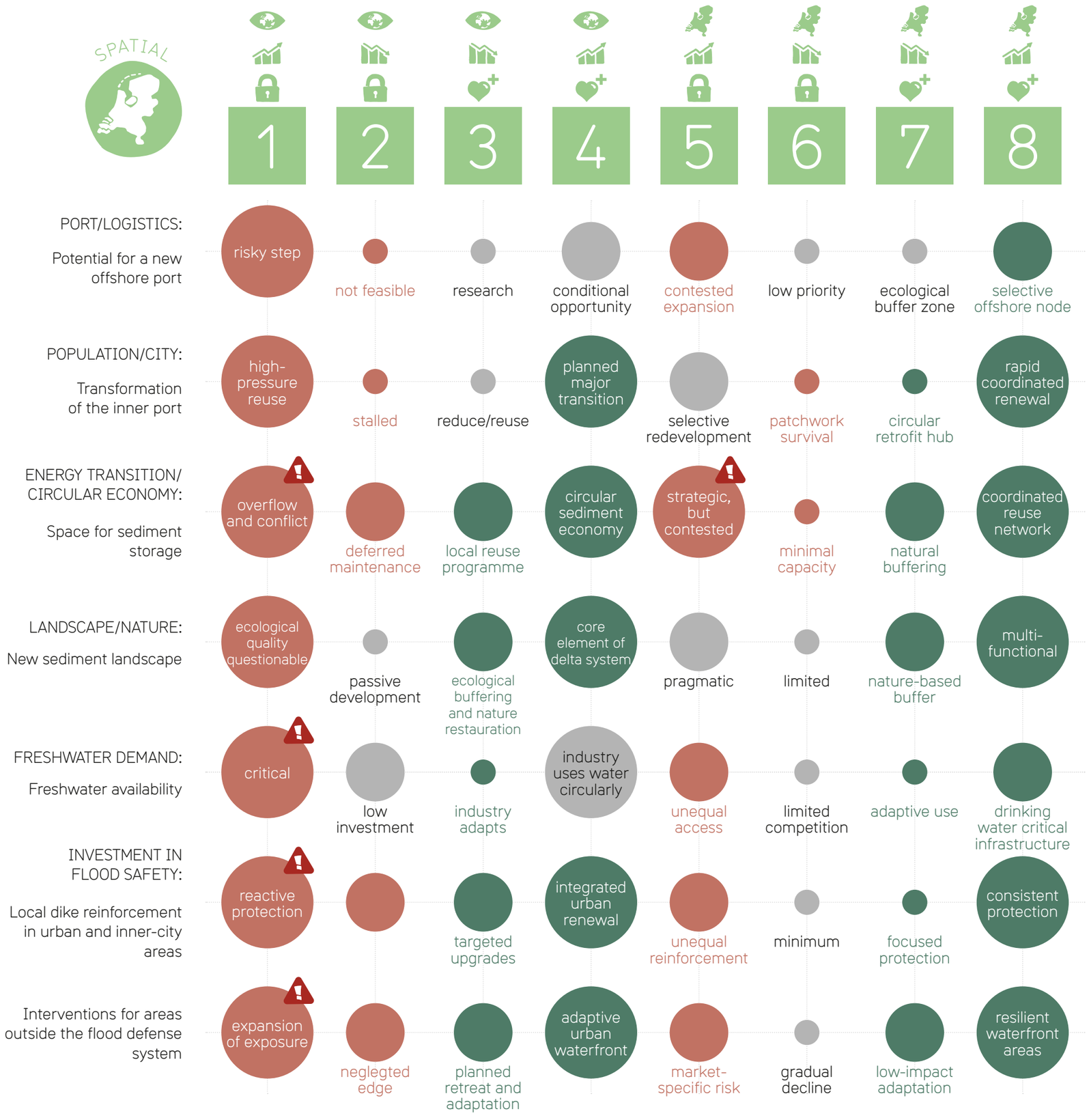
Potential areas for sediment storage. The Botlek is a suitable option because of its proximity to inland waterways, but businesses would have to relocate. Storage could also take place offshore.

New freshwater supply system:

A new freshwater supply system via the Hoeksche Waard to Voorne-Putten to support agriculture and industrial activities in the port. This includes widening old creeks, constructing a new waterway along the inner toe of the new dike landscape, constructing water reservoirs, and installing new underground pipelines.

Dike reinforcement with a landscape that keeps pace with sea-level rise:

Widening the Oude Maas for shipping, as the Nieuwe Maas will no longer be suitable for vessels requiring more than 8 meters of water depth.



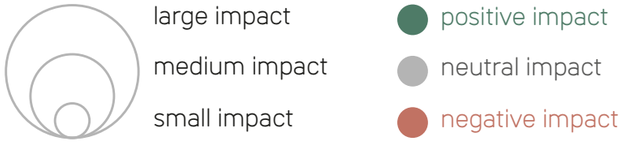
Spatial Implications × Scenarios

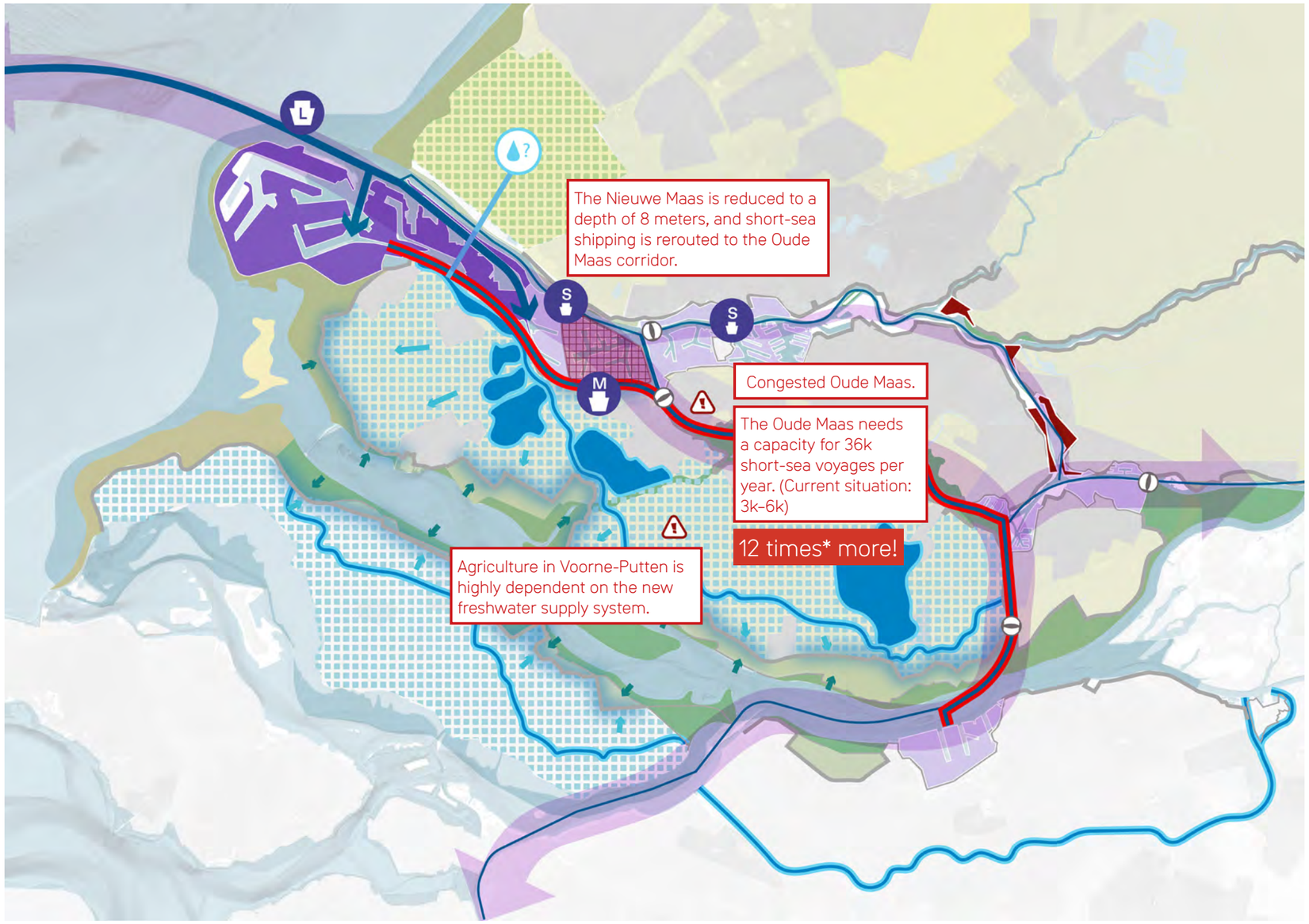
- Sediment determines whether the buffer landscape along the Haringvliet becomes a flood safety system that keeps pace with sea-level rise (scenario 3, 4, 7, 8) or a spatial conflict (1, 2, 5, 6). Without clear choices and a governance framework for sediment storage (onshore or offshore, supply chain and quality), the system remains vulnerable.

- Making room for water becomes a test of spatial quality in urban areas. Dike raising and dike zones work only if they are integrated into multifunctional urban space (blue-green infrastructure, mobility, and accessibility). Under low societal responsibility or contraction (1, 2, 5, 6), there is a risk of piecemeal solutions: hard edges and unresolved bottlenecks deferred to the future (quays, gates, cables and utility lines).

- Areas outside the flood defense system explicitly become adaptation domains. In all scenarios, there is a growing need to treat these areas as design areas with defined performance levels (frequency and duration of flooding, critical functions, evacuation, and ground-floor or building levels). Low investment (2, 6) can result in ‘selective retreat’ or neglect; with high societal responsibility (4, 7, 8), these areas can become an innovation zone for flood-resilient construction and port-city interfaces.

- Without continuous management, both growth and contraction lead to fragmentation: privatization under growth or neglect under contraction. The benefit of the Estuarine Strategy lies in a continuous blue-green system with structural funding and adaptive monitoring.





Economic implications of the Estuarine Strategy (PosadMaxwan).

Economic Implications

Rerouting of shipping routes and gradual transformation of the inner port areas:

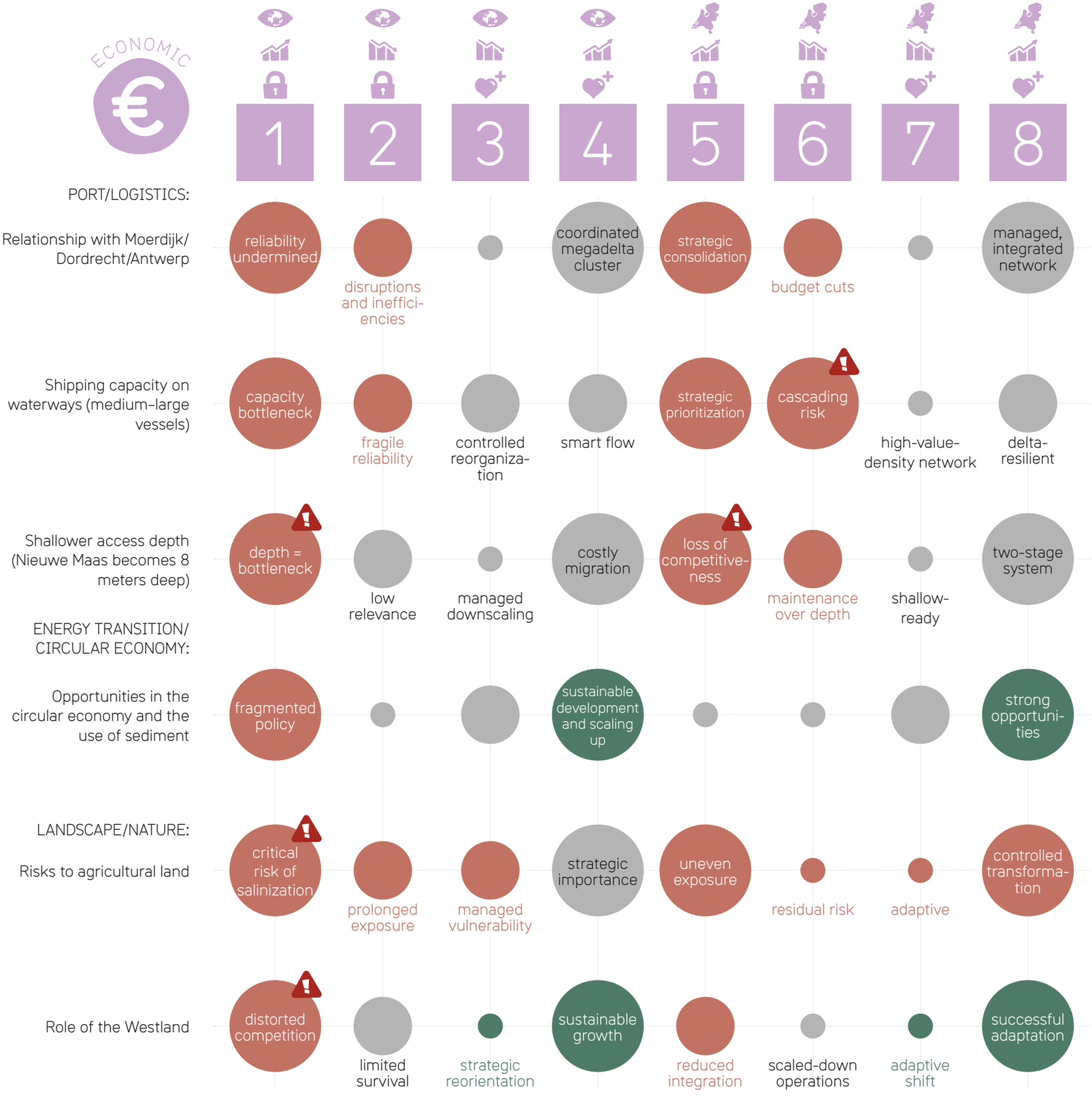
- Increased risk of congestion for medium-sized and large vessels due to the concentration of shipping routes on the Oude Maas rather than both the Nieuwe Maas and Oude Maas.
- The shipping industry will be constrained, with restrictions on the types of products that can be transported as a result of the shift to shipping routes with limited water depth.
- The inner port areas can undergo a gradual transition in line with the shift in shipping routes. This could lead to a gradual phasing out of businesses, while industrial sites could largely remain in their current locations.

Freshwater supply is a key determining factor:

- The agricultural sector in Westland requires fresh water from the new system.
- Voorne-Putten requires the freshwater system to prevent salinisation and support agricultural activities

* Based on a presentation by the Port of Rotterdam Authority (2025; third working session, see Appendix A). Slide included in Appendix C for reference.

- Method: Rather than using a sea lock as the basis for determining capacity requirements, these were estimated on the basis of (i) rerouting resulting from the new water strategy (Nieuwe Maas to approximately 8 meters deep) and (ii) the resulting concentration of seagoing and feeder traffic on the remaining deep-water corridor. In principle, storm surge barriers do not impose structural lock-capacity constraints, but closures can cause congestion.
- Result: Current seagoing traffic on the corridor concerned (blue circle) amounts to approximately 6,000 passages per year. If the Nieuwe Maas is restricted to a depth of 8 meters or less, it is assumed that a substantial share of short-sea and feeder traffic (requiring a depth of approximately 10 meters) will shift to this corridor, potentially increasing seagoing traffic to approximately 30,000 to 36,000 passages per year.
- Implication: This corresponds to an increase of approximately 5 to 6 times compared with 6,000 passages per year and, using the lower bound of earlier estimates (3,000 passages per year), as much as approximately 10 to 12 times. In addition, because storm surge barriers temporarily halt vessel traffic during storm-related closures, a higher baseline traffic intensity will result in disproportionately longer queues during closures.



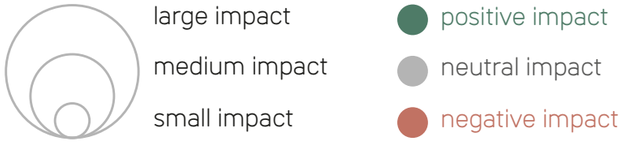
Economic Implications × Scenarios

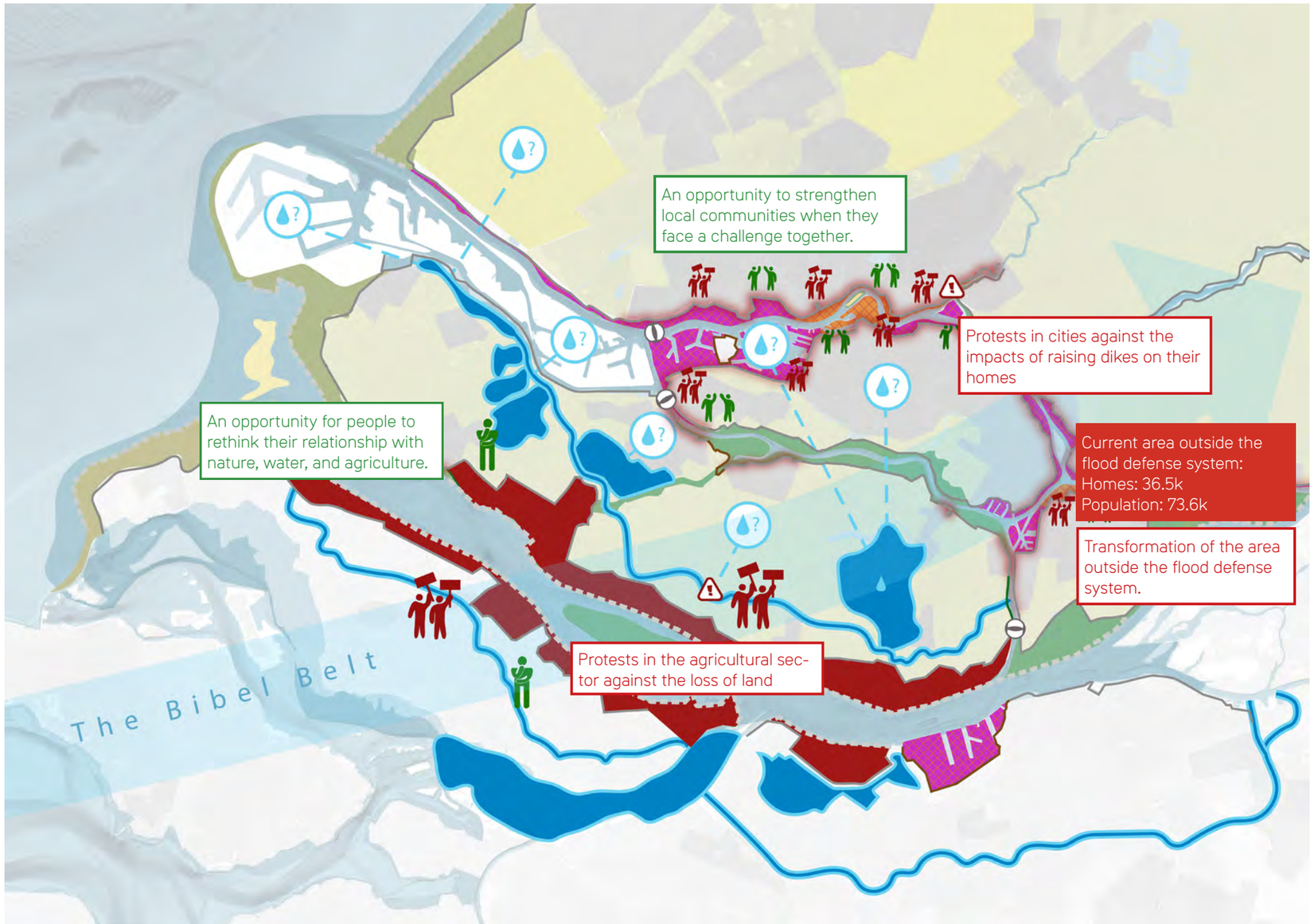
- The Oude Maas as the main corridor (for vessels requiring more than 8 meters of water depth, where possible): reliability determines economic performance. This works only if the corridor, nodes and maintenance are designed as an integrated system (waiting areas, safety, riverbank profiles, and dredging strategy). Otherwise, the costs and pressures shift elsewhere: to bottlenecks at bridges, storm surge barriers, and key nautical nodes, as well as to additional maintenance and pressure on available riverbank space.

- Growth requires supply-chain coordination; contraction requires no-regret choices. In growth scenarios, benefits arise only with active corridor management and repositioning (scenario 4, 8); otherwise, the transition becomes an economic shock (1, 5). Under contraction, maintenance takes precedence over expansion (maintenance rather than capacity increases, 6), along with selective consolidation of functions (2, 3, 7).

- A Nieuwe Maas with a depth of 8 meters creates an access constraint that affects competitiveness. Where deep-water access remains critical, 8 meters becomes a bottleneck (1) or leads to a loss of competitiveness (5). In scenarios with high governance capacity, this can be mitigated, but at a cost (costly mitigation, 4); a robust solution is a two-stage system (8): offshore/maritime logistics combined with clean feeder services and inland shipping farther inland.

- Freshwater is an economic prerequisite for Westland and port functions. Without a robust supply, competition is distorted (1) or integration is reduced (5). With regional coordination, Westland can transition to sustainable growth (4) or adapt successfully (8), with more efficient water and energy management.





Social implications of the Estuarine Strategy (PosadMaxwan)

Social Implications

A social risk, but also an opportunity:

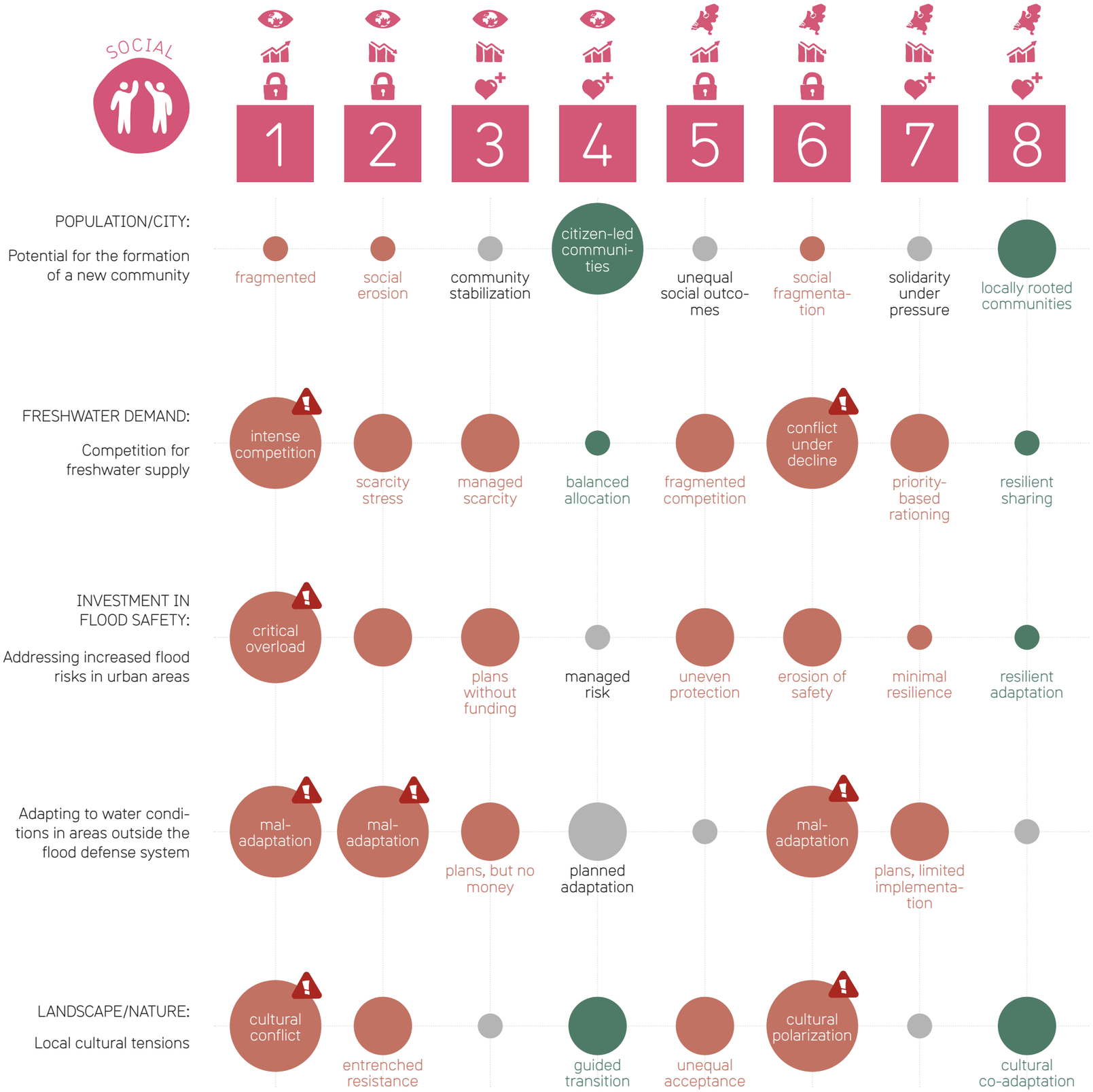
- Residents are affected when a dike has to be raised or reinforced. Tensions may arise when people's property or other interests are directly affected.
- Agricultural land is repurposed as a water buffer area, which may lead to tensions and a shift in local culture.
- Local communities are informed about and involved in the water strategy. Making decisions together that lead to meaningful outcomes can strengthen social ties.

Adapting to water in areas outside the flood defense system:

- Industrial and commercial areas outside the flood defense system require local strategies to remain operational during flooding. This requires planning and coordination between businesses and public authorities.
- Urban areas outside the flood defense system require local strategies to remain operational during flooding. This requires changes to existing buildings and coordination among owners, users, implementing organizations, and the public sector.

Competition for freshwater under extreme conditions:

- Competition among different sectors for freshwater supplies.



Social Implications × Scenarios

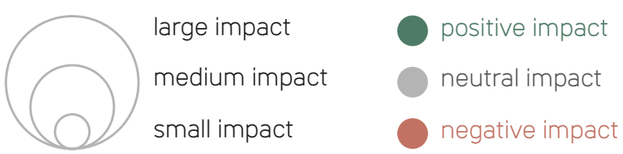
- Dike raising and restructuring directly affect homes and property and can provoke protest and distrust. With high societal responsibility, this can shift toward citizen-led community building (scenario 4) and locally rooted communities (8); with low societal responsibility or contraction, fragmentation and social erosion dominate (1, 2, 5, 6).

- Freshwater availability becomes a distribution issue that can generate social tensions. Under conditions of stress, competition between sectors and groups increases: from intense or fragmented competition (1, 5) to conflict under contraction (6). In integrated scenarios, this can be managed through balanced allocation (4) or resilient sharing (8); scenario 7 is more likely to involve priority-based rationing.

- Addressing flood safety risks: without sufficient investment capacity, plans remain unfunded (3) and flood safety erodes (6), with unequal protection (5) and critical overload (1). With strong governance, risks can be managed (4) or resilient adaptation becomes possible (8).

- Areas outside the flood defense system require collective agreements; otherwise, adaptation becomes unequal and conflict-ridden. With low societal responsibility, maladaptation (1, 2, 6) and cultural polarization or conflict (1, 6) emerge. Participation and long-term planning enable planned adaptation (4) and cultural co-adaptation (8); scenario 7 falls between the two, with plans being made but implementation remaining limited.

- Societal responsibility is essential, but investment capacity and financing are the second prerequisite.



4. 4 Summary of Reflections

Polder Strategy

We see a major economic lock-in resulting from the closed water strategy. The closed system requires substantial initial and ongoing investment in locks, pumping capacity, dikes, and pipelines. Once built, these investments severely constrain future choices and necessitate continued operation, even when conditions change. Uncertainty about the water regime will decrease. The strong dependence on centralized systems provides stability under normal conditions. However, it increases risk in the event of disruptions or system failures, such as the compound flooding dilemma. The risk is therefore low-frequency but high-impact.

In addition, this strategy requires rapid responses to changes in port infrastructure, including changes to shipping routes and adjustments to the port layout, to ensure the competitiveness of the Port of Rotterdam. Because shipping routes, vessel sizes, and logistics patterns are constrained, the port must continually adapt its layout, functions and partnerships to remain globally relevant. Strategic agility becomes an economic necessity, not an option. Regular consultation with key stakeholders (industry representatives, local government, and environmental organizations) is needed to make trade-offs and optimize the benefits of both open and closed water systems. However, the closed system depends on ongoing coordination by a limited group of actors (the port authority, national agencies, and major industry), while social actors and local communities are expected to remain primarily reactive rather than engage in co-production or build resilience.

Finally, we observe that the system enforces a clear functional separation between the city, port, and landscape. This clarity provides structural advantages for flood-risk management but reduces the adaptive overlap between these systems.

‘The strong dependence on centralized systems provides stability under normal conditions. However, it increases risk in the event of disruptions or system failures.’

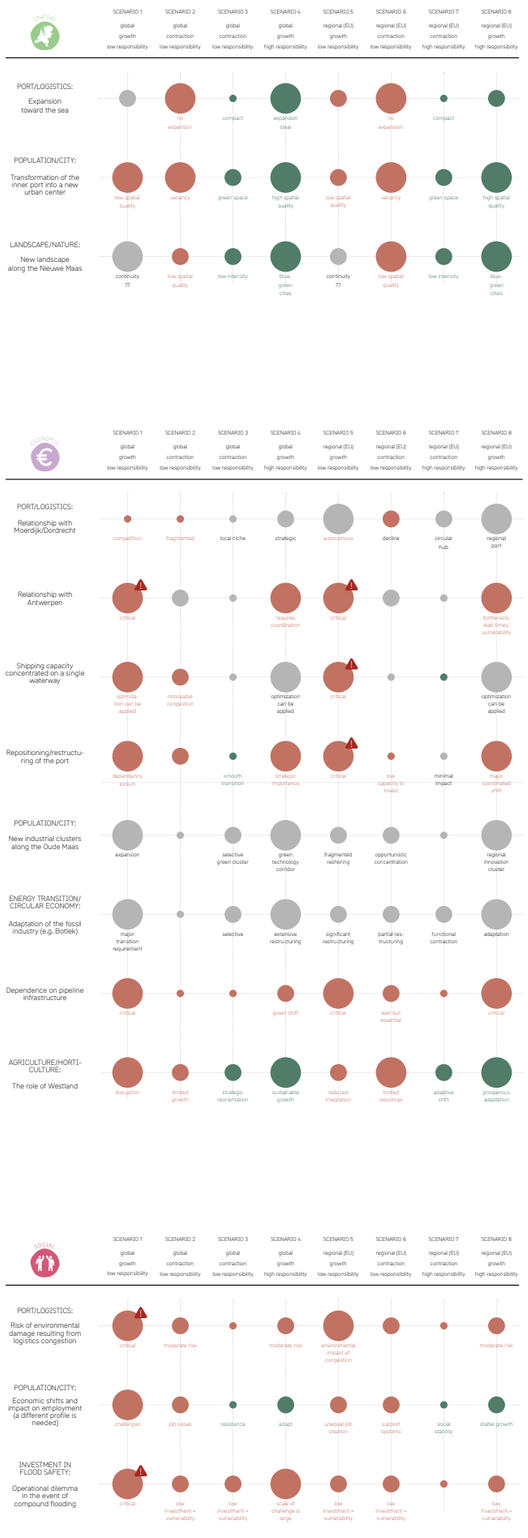
Estuarine Strategy

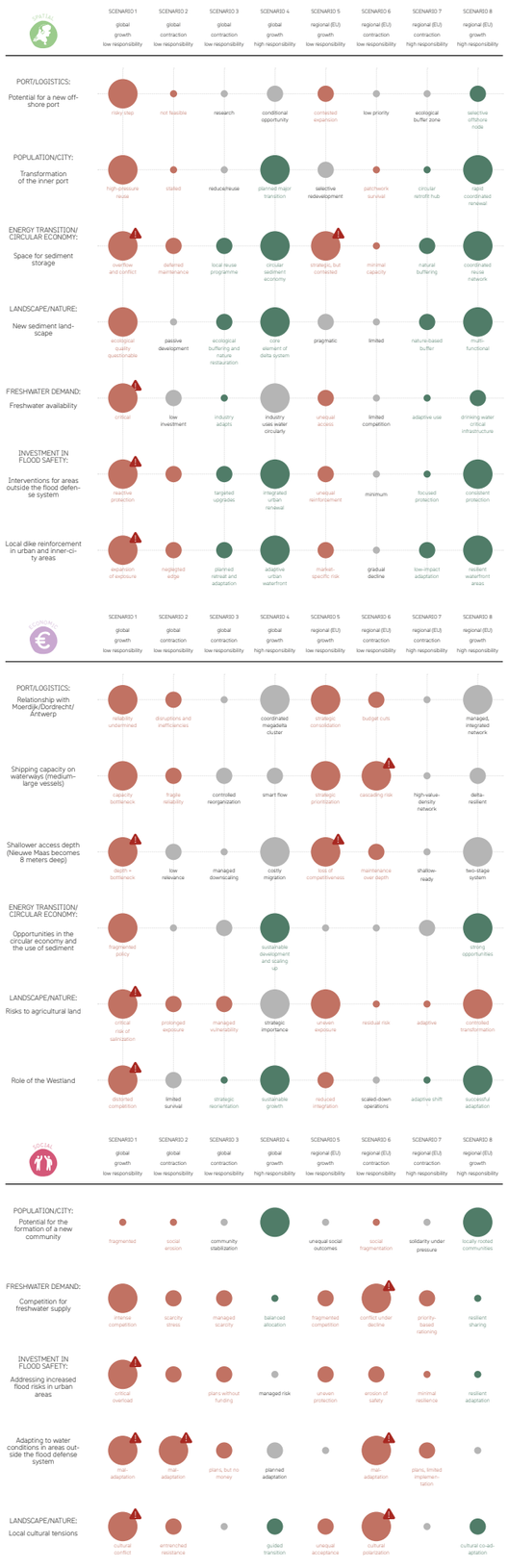
A fundamental premise of the Estuarine Strategy is that resilience is created primarily through social structures rather than through engineering structures. Risks are distributed spatially and socially through buffers, adaptive land use, and nature-based solutions. The performance of the flood safety system depends less on technical capacity and much more on the quality of governance, societal responsibility, and coordination across different levels. Where social cohesion and institutional capacity are strong, open systems generate resilient, robust landscapes. Where they are weak, an open system can exacerbate inequality, fragmentation, and conflicts over space and water. Governance must therefore be broad and include actors such as residents, farmers, industry representatives and regional authorities at multiple levels. This system can fail or gradually weaken if coordination deteriorates.

This strategy assumes a slow, long-term transition of the landscape, society, and economy that depends heavily on consistent policy and public support. The port, agriculture, and urban economy must all change with it – sometimes in character, sometimes in form, and sometimes in location. This presents challenges but also opportunities, such as the sediment economy. It also gives renewed focus to Dutch expertise in flood safety and how it can be integrated with ecological, economic, and urban development in innovative ways.

Spatial and economic measures follow once the social foundation has been established. Sediment dynamics, salinization, and changing water depths constrain current forms of large-scale industrial control but enable economic activities to evolve in ways that align with ecological processes rather than override them. Because risk is distributed across landscapes, buffers, and local interventions, this results in continuous negotiation over space, water, and priorities. Competition for space is also expected because of the scarcity of land.

‘Where social cohesion and institutional capacity are strong, open systems generate resilient, robust landscapes. Where they are weak, an open system can exacerbate inequality, fragmentation, and conflicts over space and water.’





Conclusion on spatial, economic and social implications (PosadMaxwan)

Different Future Scenarios at a Glance

Economic growth alone does not determine an area's resilience. Scenarios with growth but little societal responsibility repeatedly result in unequal protection, fragmented adaptation, and increasing conflicts, particularly in areas outside the flood defense system and where there is competition for freshwater. Uncoordinated growth increases exposure and exacerbates existing vulnerabilities.

Societal responsibility is the most important multiplier. Scenarios with high societal responsibility consistently reduce risk intensity, even under economic contraction. They enable collective investment, shared adaptation strategies, and community-oriented responses that perform better than purely technical solutions.

Regional governance matters more than the scale of cooperation. Regional (EU-oriented) scenarios with coordination perform better than global scenarios without coordination. This is particularly evident in competition for freshwater, adaptation of areas outside the flood defense system, and community building: proximity facilitates negotiation, coordination, and mutual learning.

Viewed together, the scenarios show that resilience stems from the quality of governance, not from economic volume or technical ambition. Systems fail where coordination breaks down, not where the water rises fastest.

‘Viewed together, the scenarios show that resilience stems from the quality of governance, not from economic volume or technical ambition.’



Photo: Jannes Linders, from the series Between City and Sea.

5 Adaptation Pathways and Governance Instruments PosadMaxwan

5. 1 Adaptation Pathways
5. 2 Reflection on Governance Instruments

5.1 Adaptation Pathways

The following pages present adaptation pathways aligned with the implementation of the two flood safety strategies developed in this study. Two versions are presented: the first focuses exclusively on water strategy interventions, such as raising and reinforcing dikes, replacing storm surge barriers, constructing locks, and redefining shorelines. In practice, however, adaptation unfolds as a complex, long-term process intertwined with social and economic developments.

The second version of the adaptation pathway builds on the first, while also showing this broader social and economic complexity.

Water Strategy Interventions and Tipping Points

Under the current flood safety framework, the service life of large-scale flood safety infrastructure is considered to extend to approximately 2070. The alternative strategies developed through this research by design extend beyond this horizon and explore long-term systemic changes and strategic choices.

The Estuarine Strategy depends heavily on slow, large-scale landscape processes. In practice, this means that once the Polder Strategy has been chosen, it is not realistic to switch to the Estuarine Strategy at a later stage. Conversely, it is technically possible to switch from an open strategy to a closed water strategy, as the latter relies to a greater extent on compact engineering interventions that can be implemented in a relatively short period. Such a switch – first open, then closed – would, however, constitute a sharp and abrupt transition requiring national coordination and substantial investment in the flood safety infrastructure required for both strategies. This tipping point is reached when the open strategy leads, or threatens to lead, to frequent flooding of large urban areas. If cities are insufficiently prepared, the social and economic damage will outweigh the benefits of maintaining the open connection to the sea.

Reflection on Adaptation Pathways

Adaptation pathways are often presented solely from the perspective of flood safety. This study broadens that perspective by also considering the social preconditions and economic tipping points arising from the water strategies. In this version of the map, the adaptation pathways are shown as blue lines. The pink areas represent social preconditions and requirements, while the orange areas represent economic and port-related challenges.

As concluded earlier, the Polder Strategy has a major impact on port activities and leads to significant constraints on the functioning of infrastructure. The associated economic transformation must be understood as a complex, multi-actor, long-term process. Economic changes – particularly in port functions, logistics, and industry – cannot be implemented quickly or unilaterally. They are often governed by long-term contracts and require sustained coordination among governments, market actors, and society as a whole over a period of decades.

By contrast, the Estuarine Strategy requires a much more extensive social transition and adaptation, as well as broader societal acceptance. This strategy requires numerous local interventions that directly affect both private property and economic activities, in agricultural areas as well as in high-density urban environments. It also entails a large-scale transformation of the built environment, requiring the active support and cooperation of individual property owners. Raising awareness of flood safety and strengthening a sense of responsibility take considerable time and must begin well before physical interventions are implemented. A crucial component of this strategy is the construction of a new freshwater system for Voorne-Putten and the port. If this system fails, both port-related economic activity and agriculture on Voorne-Putten will come under severe pressure.

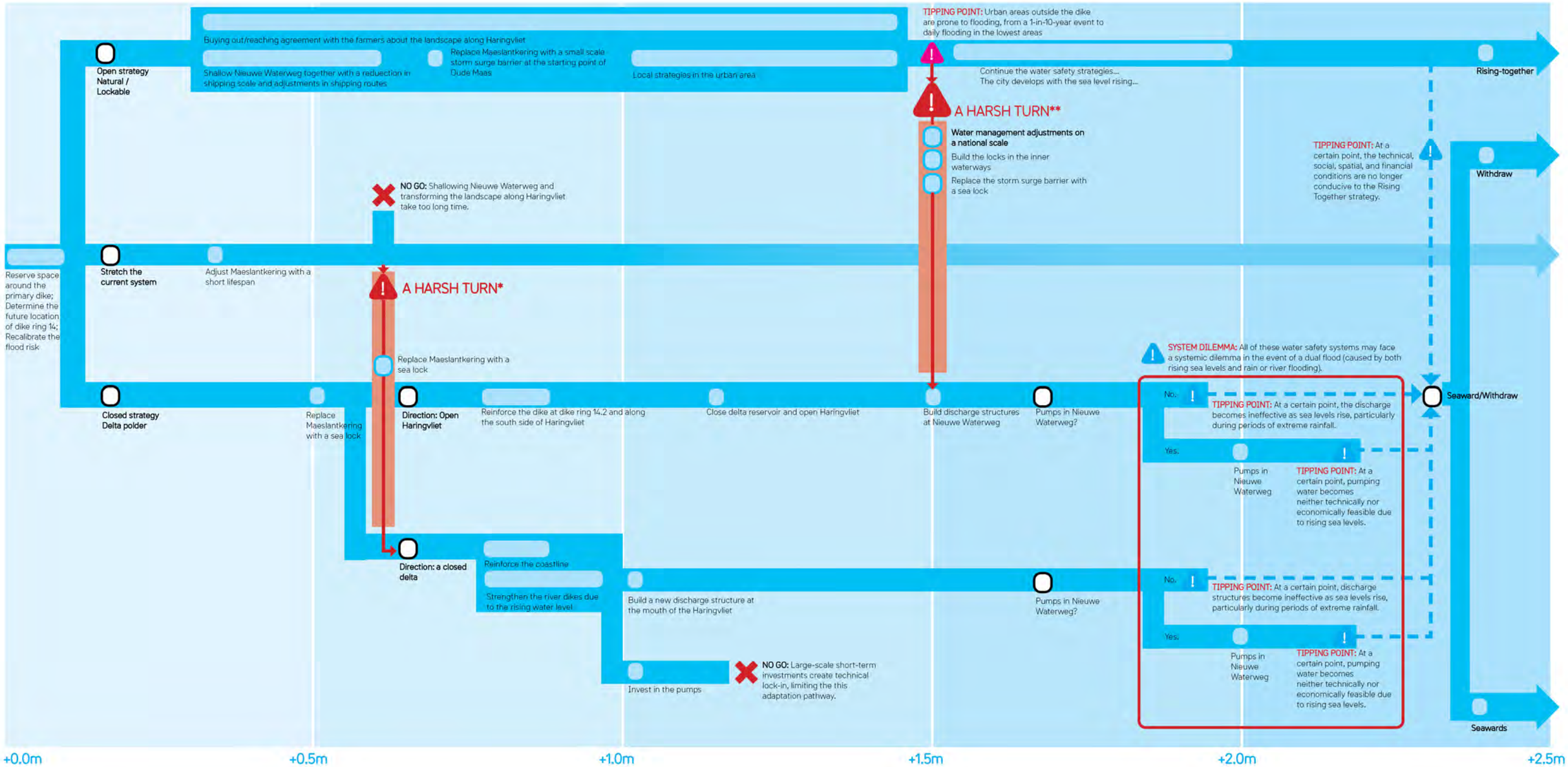
The diagram shows that the water strategies develop at different levels of intensity and over different time horizons. A closed system such as the Polder Strategy concentrates major infrastructure challenges within a relatively short period, while the open-system strategy explored here develops gradually, with the challenges distributed over a longer period and across society as a whole.

The (Un)avoidability of Abrupt Transitions

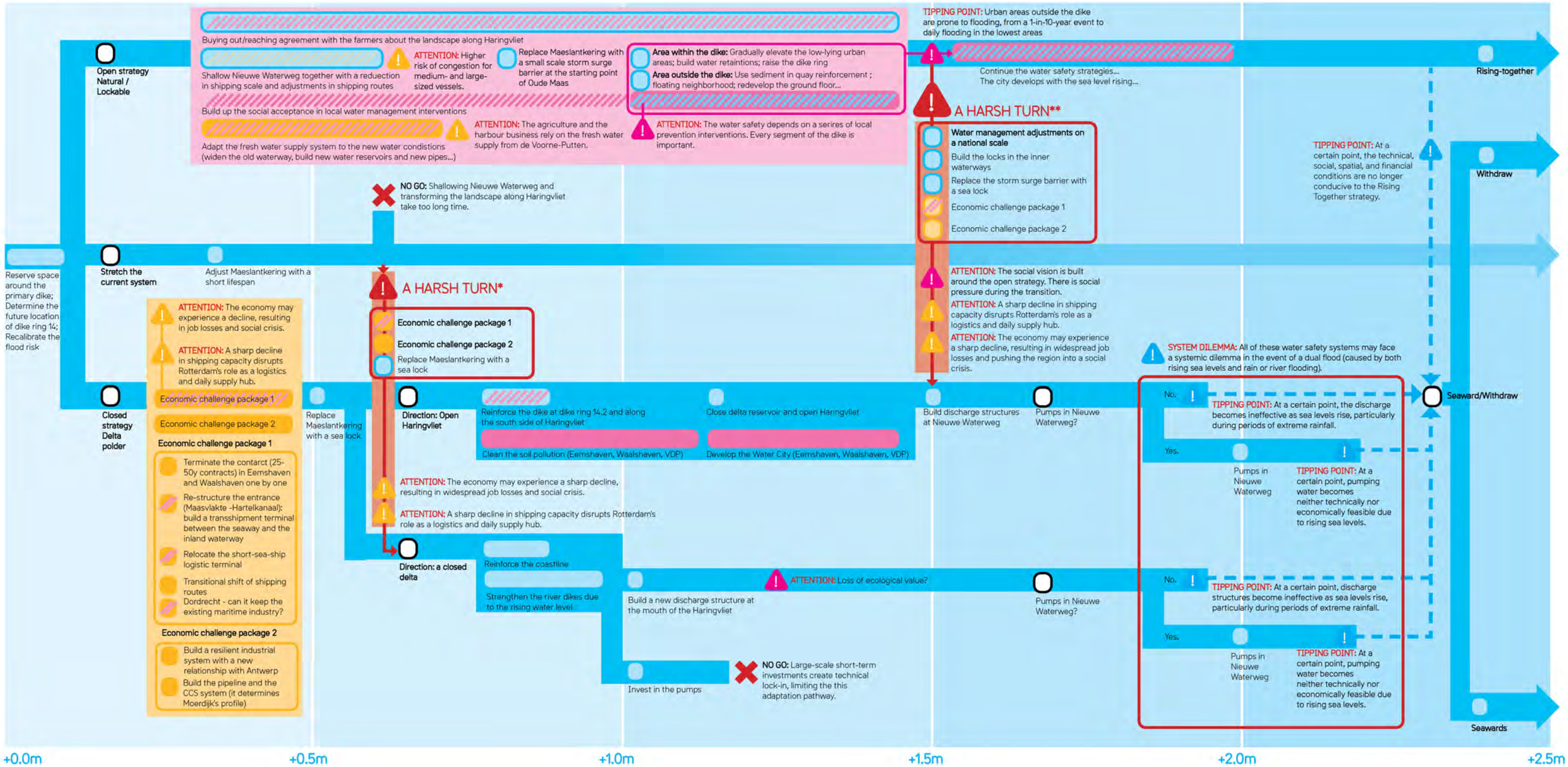
A sharp and disruptive transition will always remain a last resort when the water system – as a result of unavoidable climate crises – is forced to switch from an open to a closed configuration. Such situations can exacerbate crises precisely because society and infrastructure are insufficiently prepared, while large-scale construction and system interventions are already underway. In this scenario, economic transition packages will require substantial sacrifices because flood safety no longer leaves room for gradual adaptation.

Given that the discussion and decision-making surrounding Maasvlakte 2 took almost two decades – from the early 1990s until 2008 – while actual construction took only about five years, the importance of early, broad, and inclusive decision-making becomes clear. Only by conducting the debate in a timely manner can the region prepare for multiple possible futures.

It must also be recognized that an abrupt change of course can have profound societal consequences. If people have been encouraged over a long period – through social and educational programs – to believe in an open strategy and have already made personal efforts or concessions on that basis, a sudden reversal can lead to a loss of trust in government. Restoring that trust is in itself a major challenge.



Adaptation pathway map for the flood safety strategies explored (PosadMaxwan, based on H+N+S Landscape Architects)



Adaptation pathway map for the flood safety strategies explored, including socioeconomic challenges (PosadMaxwan, based on H+N+S Landscape Architects)



Wijnhaven, Dordrecht. Photo: Municipality of Dordrecht

5. 2 Reflection on Governance Instruments

If the Netherlands is to keep its head above water over the next 100 years – literally and economically – it is important that the societal dimension is not overlooked and that development remains balanced: equitable, healthy, and inclusive. Otherwise, there is an increased risk of further societal polarization. This is an enormous challenge in a world that has become increasingly uncertain, unpredictable, and unfamiliar.

Adapting to the consequences of climate change requires enormous investment, as well as continuity in policy and implementation, the right economic incentives, and an enormous societal effort. Water governance is no longer a sectoral matter. At the same time, sustained Dutch diplomatic efforts are needed to slow climate change as much as possible. The question underlying the choices before us is this: Do we give ourselves as much time as possible to carry out the adaptation task, including opportunities to experiment and learn, or do we extend the service life of the current system to such an extent that we force ourselves to make difficult choices quickly in the future?

With regard to future prosperity, it is essential to focus on innovation and the application of knowledge in order to generate prosperity and employment in the Netherlands. This, too, requires the involvement of society as a whole: government, education, the market, and citizens. The following bottlenecks have been identified (Wennink Report, 2025):

- Regulation characterized by action that is too late and too reactive.
- The quality of education and the ability to attract talent.
- Physical infrastructure that creates barriers to the sustainability transition, such as grid congestion.
- An administrative culture in which departmental silos prevent obstacles from being addressed in an integrated manner – there is a considerable lack of coordination, and processes are slow.

The world around us is changing, and we must change with it – preferably proactively, with choices available to us, rather than reactively and out of necessity. Rijnmond-Drechtsteden is where governance fails if challenges are not addressed in an integrated manner: the port function of national and international importance, the Maeslantkering, river discharge, extreme rainfall, salinization, land subsidence, urbanization, and critical infrastructure – all in one bathtub. Flood safety and climate adaptation, as well as efforts to secure future prosperity, require very long-term continuity in funding and in political and societal decision-making, as well as the capacity to act. Organizing and embedding this continuity so that it transcends day-to-day political concerns presents major challenges. In addition, the two flood safety strategies developed in this study represent two very different water-system logics. Governance must be capable of accommodating both and switching between them in good time.

The resulting complexity of governing these factors calls for a different governance approach from what is generally adopted in the Netherlands. In governance terms, the Rijnmond-Drechtsteden region needs to be transformed from a 'node' into a 'governance region.' The following are some recommendations:

- A single regional coordinator with a clear remit and mandate: Delta Rijnmond-Drechtsteden Coordination, bringing the national government/Rijkswaterstaat, water boards, province(s), municipalities, the Safety Region, the Port of Rotterdam Authority, and operators of critical networks together around a single adaptation pathway map and investment agenda.
- Treat the Maeslantkering as a 'system risk,' rather than as an asset-management issue. With accelerated sea-level rise, closure frequency could increase to dozens of times a year (Deltares reports approximately 30 closures per year with 1.5 meters of sea-level rise), affecting both the port and river discharge, and therefore inland flood risk.
- Explicitly include the interests of the port cluster in the adaptation pathway map: not 'port economy versus safety,' but rather: What port capacity do we want under which sea-level scenarios, at what societal cost, and with what alternatives in terms of spatial planning, logistics, and the energy system? The port's vision for the future must fit within the national strategy and vice versa – and the two must be brought together through dialogue, with clear, comprehensive, and periodic assessments of costs and benefits to society.
- Link spatial choices in the area to 'system challenges': every decision on growth or transformation must demonstrably align with water storage, evacuation, the freshwater strategy, and the energy grid.

No-regret actions that can be initiated now in the DPRD:

- A 'sponge standard' for the entire urbanized delta: make rainwater capture and buffering standard practice in streets, squares, and business parks, as this is already urgent with 1 meter of sea-level rise and with current extreme rainfall.
- A single regional evacuation and shelter concept, including vertical evacuation where necessary, linked to spatial permits.
- Sediment as a strategic resource: establish the 'beneficial use of dredged sediment' as a joint program with international knowledge exchange.
- Coordinated freshwater and saltwater management: a plan for flushing capacity, alternative drinking-water production, and the associated energy implications.
- A single shared database for the region, ensuring that all consultation forums use the same maps, triggers, and decisions.

An interesting opportunity in terms of governance, investment, and the societal narrative is to link efforts to secure future prosperity with flood safety and climate adaptation. The Netherlands already has a strong foundation for this, including its international reputation, which, if deliberately built upon, could provide a renewed engine for economic development, knowledge development and sharing, and innovation.

‘The water strategies develop at different levels of intensity and over different time horizons.’



Photo: Jannes Linders, from the series Between City and Sea

6 Conclusion and Start of a New Beginning
Lead Designers

6. 1 General Conclusions
6. 2 Research Program
6. 3 Research Questions and Topics for Further Research by Design
6. 4 Organization

6 Conclusion and Start of a New Beginning

6.1 General Conclusions

It is not far-fetched to think of the west and north of our country as a gigantic water machine: a prosthesis that enables us to live, work, farm, and make our homes below sea level. This artificial situation has worked so well to date that most Dutch people are unaware of its existence and feel safe. Occasionally, this reality becomes tangible, prompting some grumbling about matters such as dike reinforcement when maintaining our prosthesis affects our everyday living environment. The warming of the planet and the resulting sea-level rise, changes in river discharge, and extreme meteorological events necessitate a major overhaul of our prosthesis.

Our research shows that both future strategies are feasible and can provide flood safety in the long term, but that they have fundamentally different values and 'price tags.' Because water and soil – in the form of sediment – are indeed guiding principles in our region, the two approaches also entail fundamentally different spatial planning perspectives. In brief:

Polder:
A perspective with a straightforward flood safety strategy that builds on our hydraulic engineering tradition and that – in the long term – entails the end of the open port.

- Port: A fairly extensive restructuring of the port. Port interests have to give way. The position of the maritime manufacturing industry in the Drechtsteden region is weakened.
- City: Urban development opportunities for more direct contact with freshwater; areas of Rotterdam and Dordrecht outside the flood defense system become safe.
- Nature: Ultimately, the exclusion of tidal influence creates a familiar type of aquatic habitat, but only after a long transition from brackish to freshwater conditions.

Estuarine:
A perspective with an (ultra-)long-term strategy that requires innovation in the hydraulic engineering repertoire and – spread over a long period – implies a strategic retreat, primarily at the expense of agricultural land. This buys time and space to achieve flood safety at lower cost.

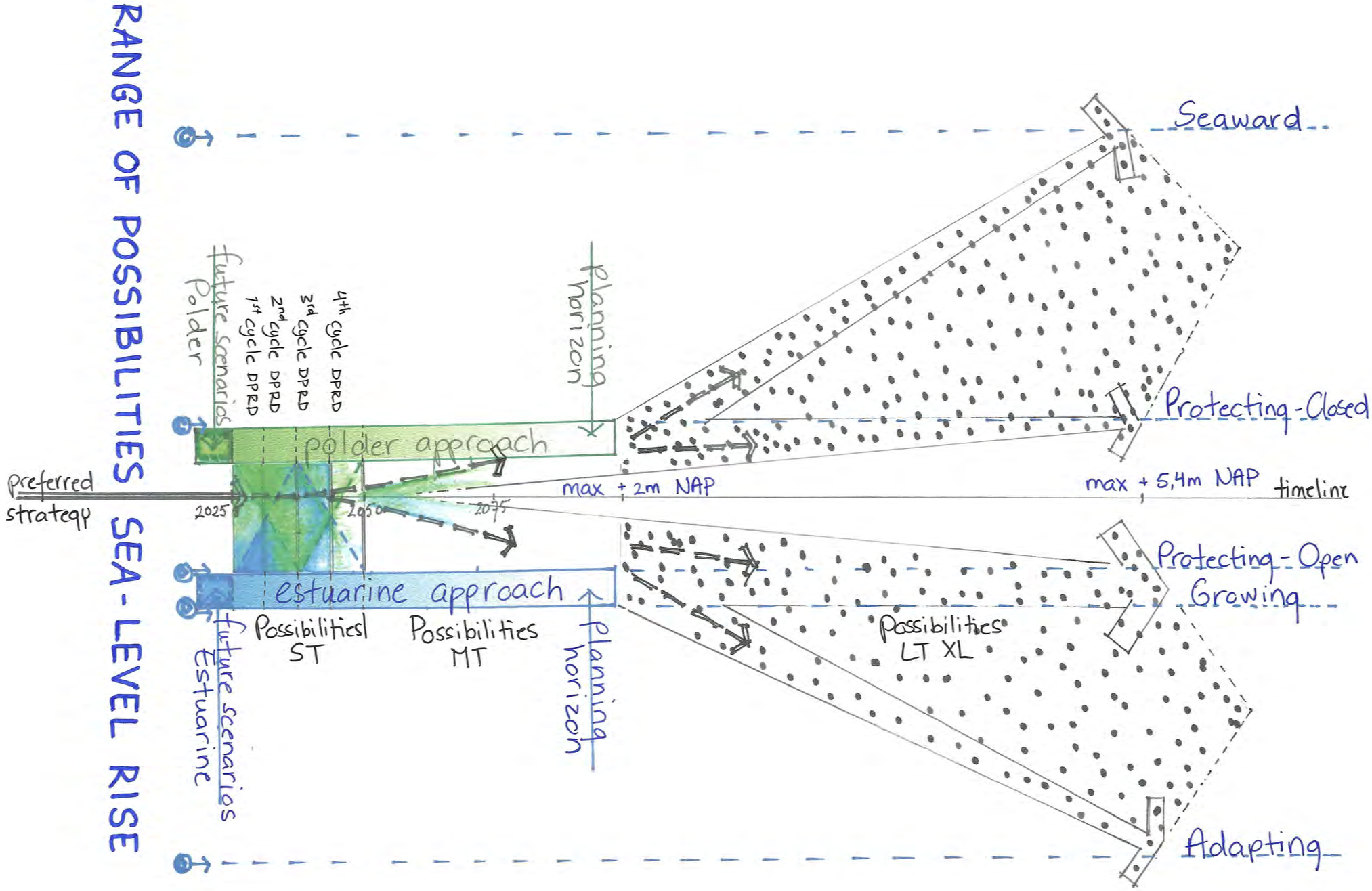
- Port: The open port connection remains, although the Nieuwe Waterweg gradually becomes shallower, requiring an equally gradual reorganization of the port. The port cluster, including the maritime manufacturing sector in the Drechtsteden region, remains connected.
- City: Locally tailored solutions create differentiated urban environments. Raising ground levels where necessary is far-reaching and requires careful timing. Area development for advanced practitioners.
- Nature: System restoration toward robust estuarine nature that does not need to be protected like a greenhouse plant but ultimately protects us. Ecological engineering is civil engineering for advanced practitioners.

If we look broadly at the results of the three research-by-design studies, each of which sought to explore these distant futures from its own perspective, it becomes clear that strategic decisions concerning flood safety, spatial planning, and port organization are closely interrelated. Decisions in each of these three domains cast long shadows into the future. But our research also shows that no irreversible decisions need to be made during this DPRD policy period that would result in lock-in to either of the two directions.

The diagram showing the regional exploration space for adaptation to sea-level rise (next page) distinguishes three time periods: the short term (ST), medium term (MT), and long term (LT). The brief for this research by design focuses primarily on developing long-term perspectives for this region, based on sea-level rise of 2 meters relative to current conditions. The diagram shows the two long-term perspectives to illustrate the planning horizon of the 'Polder' and 'Estuarine' approaches. These two perspectives represent the transition pathways between the extremely long term on the right side of the diagram and the short and medium term on the left.

For the short term, a research program appears necessary, aimed at further developing both approaches and exploring possible smart combinations of specific elements. The short term can in turn be divided into four (or five) cycles corresponding to the update rounds of the Delta Program Rijnmond-Drechtsteden. The first round could focus on further developing the approaches, while later rounds could place greater emphasis on optimizing combinations and preparing for the actual decision points. These are expected to arise in the medium term, when the Maeslantkering approaches the end of its service life and decisions will also have to be made about the future of areas outside the flood defense system and the approach to dikes.

In the previous chapters, each of the three design firms formulated its conclusions and recommendations. This chapter draws a number of general conclusions. The following sections examine in greater detail suggestions for a future research program, the research questions and topics for further research by design that would form part of it, and suggestions for organizing such a program.



Schematic representation of the exploration space for adaptation to sea-level rise in the Rijnmond-Drechtsteden region: the vertical axis shows a spectrum of possible approaches, while the horizontal axis represents time in meters of sea-level rise. The diagram shows the Preferred Strategy and bifurcations in the short, medium, and long term, within which the Polder and Estuarine approaches are positioned (Lead designers; image: Lodewijk van Nieuwenhuijze)

6. 2 Research Program

This is a tough section for people who are annoyed by reports in which researchers invariably recommend further research. There is no getting around it. In fact, we ourselves recommend setting up an entire research program. The fact that no definitive choices need to be made yet does not mean that we can sit back; quite the opposite. In our view, the coming DPRD cycle – and possibly even several cycles – should be used to establish and implement a long-term research program tailored to the region. As we see it now, the regional partners in the Regional Coordination Group (Gebiedsoverleg) should take on that role. Tasks such as commissioning, management, progress monitoring, applying the research results, and developing proposals for an investment agenda can be carried out by the Program Team.

As argued in the introduction, research by design and the iterative process of calculating and drawing provide a way of addressing complex, ill-defined problems. As former Special Envoy for International Water Affairs Henk Ovink remarked in response to an earlier version of this report: 'Spatial scenarios require continually shifting back and forth between scales and between causes, systems, and interventions, with their different dependencies and relationships with actors and networks.'

There are, in fact, no clear-cut solutions to this type of problem. The logic of induction or deduction does not lead us out of the fog. In abduction, the problem is 'abducted' into a free space – that is, a niche where it can be studied freely, without too much interference or need for consultation – where a 'provisionally good enough' answer is formulated. Good enough to make initial decisions and/or formulate follow-up questions and identify knowledge gaps. Evaluation of the effects of those actions, or new insights gained from that research, then provides input for a new round, leading to a new – again provisional – hypothesis. If necessary, this process is repeated several more times. This mode of research enables us to define the challenge and the problem more clearly. You never get it right on the first attempt. A kind of intelligent stumbling forward may be the most that can be achieved with such staggeringly complex issues.

Working in Dialogue with the System – Three Versions

Cumbersome? Not really. If we zoom out a little and take a broad view, we can see that our water management system, with its protocols for assessment, evaluation, and guidance, also works through such iterations, albeit within a more predetermined program structure. Zooming out even further, the way we manage our delta may offer an even better analogy. It can be described as a long history of iterations between research – intervention – evaluation – research – intervention – and so on. Henk Saeijs, director of the Deltadienst and a pioneer at the interface between civil engineering and ecology, called this iterative process 'working in dialogue with the system.'

We would like to add 'working in dialogue with the social system,' because in both approaches the democratic credo is: Do it together, or don't do it at all. We would like to quote Delta Commissioner Co Verdaas, who said at the 2025 Delta Congress: 'If we want to do it, we can – but only if we work together. Government, science, and society must work as a team and understand one another well in order to accomplish great things together.' Public support is needed. This means that societal legitimacy must be safeguarded. Without equity and inclusion, we will move toward polarization and instability, and the project will fail.

There is a third complex ecosystem with which we must likewise work in dialogue. This is the system of companies in the vast port complex. This system is so complex, layered, and interconnected that it is referred to as an industrial ecology: through a myriad of material and logistical connections, it can be regarded as a single whole. In the words of former CEO of the Port of Rotterdam Authority Allard Castelein in an interview with VNO-NCW magazine: 'The ecosystem makes the port. There is so much professionalism and quality there; it is incredibly powerful and something we must continue to cherish.'
In short, we recommend structurally linking follow-up research on flood safety to research into the socio-spatial future of this metropolitan region, as well as the spatial organization of the port complex, including the transition challenges associated with moving toward a post-fossil and more circular economy. We propose continuing to work with the simplified framework of two – or three, if extending the Preferred Strategy is regarded as a third – families of water management strategies, and broadening the research from there.

'We recommend structurally linking follow-up research on flood safety to research into the socio-spatial future of the metropolitan region and the spatial organization of the port complex.'

6. 3 Research Questions and Topics for Further Research by Design

We identify the following knowledge gaps, research questions, and topics for further research by design from the three IABR studies and the discussions during the various IABR working sessions. This is neither an exhaustive nor a definitive list – the reviews of this report and subsequent discussions will undoubtedly generate further suggestions for the follow-up program.

General

- Clearly signposted adaptation pathways for the region:

  Perhaps the most important, but also the most complex, puzzle is how to improve our understanding of the region's adaptation pathways. How long can choices be postponed? Which decisions need to be made when? If the national adaptation pathways can be compared to a kind of metro map that clearly shows when particular turns in a chosen water strategy need to be taken – or remain possible – then what the DPRD should add can be compared to the underlying bus network. Some stops will coincide with metro stations, but the bus network is much more finely branched. It has numerous stops of its own, bifurcation points, termini, and so on. This is complex because mitigation measures, such as the energy transition of the economy and the port, interact with the long-term adaptation measures that – as outlined – can follow two different courses. Sometimes they will reinforce one another, and sometimes they will seriously interfere with one another.

- The complexity is further increased by the need to consider:

  - The functional service life of the Maeslantkering.
  - Incorporating 'decision times,' 'lead times,' and 'implementation times' for the various interventions (sometimes measured in decades).
  - Synchronizing adaptation and mitigation measures wherever possible.
  - This is like working on an engine while it is running: interventions must take place while minimizing disruption to business and logistics processes which requires finding and scheduling temporary relocation space.

- To this we link the following questions, among others:

  - Which no-regret measures can be taken earlier?
  - What are the connections between short-term projects and long-term strategies? Maintaining these connections is important for engaging stakeholders who focus primarily on the short term.
  - When should spatial planning reservations be made and/or strategic land positions be acquired?

- Specifying and timing investment needs:

  Although the HKV report (2025) already provides an initial indication of the investments required for each water strategy, the long-term research makes it possible to produce more precise estimates and to specify investment needs over time and by investor, whether public or private.

  - HKV estimates approximately €25 billion in flood-safety-related investments for the period 2025–2100. To put this in perspective, this is 10 to 12 times the budget of the Room for the River program (€2.3 billion over the period 2006–2018) and 4 to 5 times the budget of the Eastern Scheldt works (€6 billion in current prices, between 1976 and 1987). The estimated €25 billion does not yet include spatial adaptations, the aforementioned transformation of the port complex, or investments in the city and rural areas.
  - These amounts are spread over a period of 75 years, but there will undoubtedly be investment peaks that can already be plotted in broad terms on a timeline.

'If the national adaptation pathways can be compared to a kind of metro map that clearly shows when particular decisions in a chosen water strategy become necessary – or remain possible – then what the DPRD should add can be compared to the underlying bus network.'

IABR Atelier Delta Rijnmond-Drechtsteden 2100

‘We also recommend studying in the “opposite direction” by investigating socio-spatial models corresponding to a world that is 2.5–3.5 degrees Celsius warmer and – through backcasting – developing adaptation pathways for them. What will that society look like by then, and what needs will it have?’

- Combinations and hybrids:

  The two approaches, Polder and Estuarine, are mutually exclusive in some respects but, as noted, are not hermetically sealed models. Various combinations are also possible. We recommend initiating research by design into hybrid models, their place in the adaptation pathways, and their spatial implications once a number of the knowledge questions formulated below have been clarified. The range of corresponding closure structures and control works can also be tested for effectiveness.

- Collision tests:

  We also recommend studying in the ‘opposite direction’ by investigating socio-spatial models corresponding to a world that is 2.5 to 3.5 degrees Celsius warmer and – through backcasting – developing adaptation pathways for them. What will that society look like by then, and what needs will it have?

  This changing society, with such high temperatures and geopolitical transitions, will inevitably affect how we live here, how the economy operates, and what this means for the scenarios we choose to meet our flood safety challenge. The sensitivity analyses produced by PosadMaxwan can serve as a starting point for such ‘collision tests’ between the region and a changing world.

- Learning by doing:

  Closer to home, in developed areas outside the flood defense system, such as in Rotterdam and Dordrecht, problems already arise with just a few decimeters of sea-level rise. A perspective for action will also have to be provided for these areas. It makes sense to regard the measures to be taken as social and physical experiments and to ensure that the results are monitored so that they contribute to ongoing knowledge development.

- Governance: navigating complexity

  The far-reaching transformations will not take place until the long term. But because they will manifest themselves in every fiber of our society, preparing society for this change must begin early.

  - Social science research into transition processes tailored to our region.
  - What forms of governance are appropriate here? In other words, how radically do our existing institutions and decision-making processes need to be transformed from ‘Booklet A’ to ‘Booklet B’ (van der Steen et al., 2025; see Appendix A, Session 5, p. 123)? The system of periodic DPRD revisions already appears to come reasonably close to ‘Booklet B.’
  - What form of political articulation would be appropriate for acting under uncertainty?
  - How do we uphold our democratic achievements on the bumpy road ahead, and how can they be put to use in the public dialogue?

Further Development of the Polder Planning Concept

(further research by design)

- <u>The transition from areas outside the flood defense system to a world inside the flood defense system:</u>

  The transition to life inside the protective dike ring of the newly created 'Polder' is far-reaching but brimming with urban design potential – living and making our homes in more direct contact with water and waterside environments that dramatically expand the ways in which water can be used. These more Amsterdam-like environments should be developed further in the context of the Rotterdam region.

- <u>Transition of the flood defense zones:</u>

  The same applies to the flood defense zones, which would no longer need to retain their status as delta dikes and would instead become boezem (dispersed reservoir) embankments, potentially creating a new type of residential environment.

- <u>Comprehensive port plan:</u>

  The Polder approach has far-reaching consequences for the port. The open connection to the sea would be closed by constructing a lock, introducing a clear separation between the seaward and river sides. As input for the work on the adaptation pathways (see above), or as a follow-up to that study, a plan for the reconfiguration of the port is required:

  - The location of the locks (sea lock or inland navigation lock) and the various alternatives.
  - Preparing for the relocation of industries that depend on deep navigable water.
  - Where will the large-scale transshipment site(s) be located?
  - How much temporary relocation space is needed, where, and when?
  - Would this planning concept necessitate a third Maasvlakte? And if so, could the Delta21 energy-storage lake support this development and be integrated with it?
  - Could such a shortage of space be addressed through intensification of the port complex along the Oude Maas?
  - A more precise elaboration of the subtasks involved in this complex transformation over time is required, with a view to synchronizing them with the depreciation cycles of industrial assets. In developing this timeline, attention should be paid to the problem of working on an engine while it is running: How can the port continue to function during construction of the locks (important for the construction sequence), and how can the river continue to flow, given the major backwater effect, particularly during construction but also later during operation?
  - Further research into possible changes in shipping routes, traffic volumes, and so on.
  - An economic impact assessment of the consequences for competitiveness, the business climate, and investment opportunities throughout the port complex.
  - All of this should result in one or more preferred alternatives regarding the type, function, location, and costs of the lock complex.
  - Identify synergies with the transitions in the port (CO2, heat, H2, and circularity).

- Input for the adaptation pathways study: position all decisions – and their interactions – associated with the Polder approach more precisely on the timeline.

Knowledge Questions for the Polder Approach

- Further develop and estimate the costs of the required pumping and sluicing capacity and the integration of the associated infrastructure. The same applies to water storage and water-level management.
- Further investigate closure technologies: each structure differs in terms of vessel passage, sediment passage, fish passage, freshwater/saltwater separation, and failure probability.
- If a third Maasvlakte proves necessary, what would its effect be on the direction of sediment flows and on coastal morphology? In other words, how could this choice affect the prospect of 'keeping pace with sea-level rise' in the rest of the delta?
- How can desired changes in discharge distribution among the Rhine branches be achieved? What would be the effects of a changed discharge distribution between the Nederrijn/Lek and the Waal?
- Assess the transition period from brackish to freshwater conditions, outline the intermediate stages, and identify their temporary effects on livability.
- What will the unavoidable 'salt leakage' be under different implementation variants of the lock complex? How can it be controlled?
- Forecast the ecological consequences of closing off the open estuary, the resulting loss of the freshwater–saltwater gradient, and the direct and indirect consequences of restricting fish migration, both nationally and internationally.
- Investigate the hydraulic engineering aspects of various ways of creating a softer transition between dikes and nature.
- Assess the economic and spatial-logistical consequences of the interventions for the region.

Further Development of the Estuarine Planning Concept

(further research by design)

- Further development of the concept of 'flood-defending landscapes':

  - Build on existing foreshores.
  - Further explore the development potential of these new landscapes for multiple uses, including recreation, housing, and agriculture, such as saline crops.

- Further develop the flood safety strategy and calculate its costs, also in relation to periodic dike reinforcements, safety aspects, and mortality.

- Further investigate the possibilities for providing flood safety for areas of Rotterdam outside the flood defense system by means of 'keeping pace with sea-level rise.' This lies on the critical path for this approach.

- Further explore through design the actual possibilities of locally tailored solutions, Hamburg-style flood protection solutions, raising ground levels, and flood-adaptive construction in urban areas.

- What architectural and urban design concepts are possible in combination with 'keeping pace with sea-level rise' in areas outside the flood defense system in the DPRD region?

- Organize a design competition for a 'storm surge barrier permeable to silt and sand' (in collaboration with the national Delta Program):

  Developing such a barrier would constitute a major innovation in civil engineering worldwide. It would also bring the Estuarine approach closer to realization. Such a competition would have PR value for the region and could also serve as a distinctive social catalyst.

- Comprehensive port plan:
  Gradually phasing out the maintenance of the Nieuwe Waterweg at its current depth is less far-reaching than constructing a lock, as in the Polder Strategy, but it also has profound consequences for the spatial organization of the port. This approach likewise requires a port plan setting out the necessary reconfiguration over time.

- Does the Delta21 initiative fit with the Estuarine Strategy and the possible opening of the Haringvliet?

- Input for the adaptation pathways study: position the decisions – and their interactions – associated with the Estuarine approach more precisely on the timeline.

Knowledge Questions for the Estuarine Approach

- Set up pilots to investigate the functioning and effectiveness of the strategy of keeping pace with sea-level rise. These pilots may have to take place outside the region. Build on and financially support existing research in, for example, the Westerschelde. Three locations have already been considered suitable in principle for this type of measurement.

  - What sedimentation rates can be expected in this region?
  - What proportion could consist of river sediment?
  - At what rate could the process of keeping pace with sea-level rise take place along the Haringvliet?
  - Where, how frequently, and in what quantities would a nourishment strategy involving additional sand and silt need to be applied?

- What lessons can be learned from experiments with similar objectives, such as the Kleirijperij in the Eems-Dollard area and the Hedwigepolder?
- What are the costs of the flood-defending landscapes ('double dikes') if it were decided to open the Haringvliet?
- To what extent would the process of shallowing reduce high-water levels, and how far would this reduce the urgency of raising dikes and areas outside the flood defense system in the DPRD region?
- How can desired changes in discharge distribution among the Rhine branches be achieved?
- The motto is 'soft where possible, hard where necessary.' Where and in what ways will flood safety have to be achieved using 'hard' measures in any case?
- Further investigate closure technologies: each structure differs in terms of vessel passage, sediment passage, fish passage, freshwater/saltwater separation, and failure probability.
- To what extent would shallowing push back the salt wedge in the Nieuwe Waterweg–Scheur–Nieuwe Maas?
- How cost-effective is the supply system based on adapting existing creeks and waterways?
- What is the ecological potential of the Estuarine approach?
- To what extent can the European targets for these habitat types be met?
- Conduct a policy study on incorporating the thinking behind the Estuarine approach into the Natura 2000 system, or determine how a more process-based approach to natural processes would require changes to European Natura 2000 legislation.
- Estimate the economic and spatial-logistical consequences of the interventions for the region.
- Inschatting maken van economische en ruimtelijk-logistieke consequenties voor de regio van de ingrepen.

6. 4 Organization

The research program outlined above should be adopted by the regional governance partnership for the Rijnmond-Drechtsteden region and, in its implementation, could rely on its administrative counterpart, the Program Team. A more integrated approach can be achieved by making spatial planning a permanent part of the programming process. In addition to technical, ecological, and spatial questions, the program will include social science questions, including questions of public administration.

‘In addition to technical, ecological, and spatial questions, the program will include social science questions, including questions of public administration.’

The program is tailored to the region and actively coordinated with national research initiatives and other knowledge-exchange programs, including international programs. Good coordination prevents duplication of effort. A dedicated member of the Project Team could be assigned this coordinating role and take the lead in preparing for the expansion of the research staff.

As outlined above, the DPRD program includes various forms of research:

- Desk research to address knowledge questions
- Practical trials, to be outsourced
- Longer-term pilots
- Multidisciplinary research by design
- Programmatic research
  - Needs assessments
  - Forecasts
- Historical-geographical research

‘Because the available budgets are often organized by sector and vary considerably, we recommend integrating them.’

The DPRD research program is dynamic and ongoing. It is directly linked to policy preparation and decision-making for the DPRD cycles and has its own budget. Around three FTEs are currently allocated to research. We recommend basing research funding on a fixed per-mille share – formally established by the governing bodies – of the total required investment costs. For each of the three approaches – the Preferred Strategy and the Polder and Estuarine Strategies – these costs can be estimated in the tens of billions. The resulting research budget should amount to several million. A mature program of this kind should be managed by a multidisciplinary research staff supporting a program directorate. Because the available budgets are often organized by sector and vary considerably, we recommend integrating them.

‘Perhaps the most important, but also the most complex, puzzle is how to improve our understanding of the region’s adaptation pathways.’



Photo: Jannes Linders, from the series Between City and Sea

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Images

Cover
• Subsurface Map of the Netherlands: H+N+S & Peter Veldt in H+N+S+ landschapsarchitecten (2022).

Introduction
• HKV long-term flood safety strategies (p.11 en 19): Waterstudio Ties Rijcken in HKV (2025, pp. 6–10).

• Range of possibilities for adapting to sea-level rise in the Rijnmond-Drechtsteden region (p. 12): Lodewijk van Nieuwenhuijze.

Chapter 2 by De Urbanisten

Other images in chapter 2:

• Scenario B2 with Delta Polder and High-Water Corridor (p. 19): Kennisprogramma Zeespiegelstijging (2024, p. 34).

• Impact of land subsidence on dike reinforcements with 2 meters of sea-level rise by 2200 (p. 21): HKV (2025, p. 20).

• Flooding of areas outside the flood defense system in Rotterdam – Climate Scenario 2100 W+ (p. 22): De Urbanisten in Rotterdam Climate Initiative et al. (2013, p. 40).

• Flooding of areas outside the flood defense system in Rotterdam (p. 22): Deltares in Rotterdam Climate Initiative et al. (2013, p. 72).

• Perspective on the Port of Rotterdam in 2100 (p. 26): LOLA Landscape Architects in De Urbanisten et al. (2022, p. 23).

• Freshwater supply bottlenecks map (p. 27): Deltaprogramma Rijnmond-Drechtsteden (2013, p. 12).

• Rotterdam connects with the Nieuwe Maas (p. 31): De Urbanisten in De Urbanisten & Deltares (2023, p. 26).

• The urban ports offer many possibilities for water-oriented housing typologies (p. 33): De Urbanisten in De Urbanisten & Deltares (2023, p. 26).

• The controlled water level behind the locks allows for much more direct contact with the water and its banks (p. 34). De Urbanisten in De Urbanisten & Deltares (2023, p. 23).

• Behind the locks of Rijnmond-Drechtsteden, port and industrial areas can be transformed step by step (p. 35): De Urbanisten in De Urbanisten & Deltares (2023, p. 25).

• Holland Hydrogen I hydrogen plant (p. 36): Havenbedrijf Rotterdam, 2022.

• Offshore Center Maasvlakte (p. 36): Havenbedrijf Rotterdam, 2017.

• AWE 1-GW green hydrogen plant (p. 36): Havenbedrijf Rotterdam, 2023.

• Deep polders such as Krimpenerwaard [...] (p. 38): De Urbanisten in De Urbanisten & Deltares (2023, p. 20).

• p. 40: BoschSlabbers Landschapsarchitecten (2012).

• Visualizations of flood-defending riverbank zones in Rotterdam under various weather conditions (p. 62): H+N+S in H+N+S Landschapsarchitecten et al. (2023).

Chapter 3 by H+N+S+ Landschapsarchitecten

Chapter 4 by PosadMaxwan

Other images in chapter 4:

• p. 76: Ducruet et al. (2025).

• Current land use in the Port of Rotterdam by sector (p. 77): NOVEX Rotterdamse haven et al. (2025, p.22), bewerking door PosadMaxwan.

• Estimates of land use in four future scenarios (p.77): FABRICations (2025a), bewerking door PosadMaxwan.
Omgaan met ruimtedruk - historische transformatie tussen 1970-2020 (p. 78): BRIGHT, et al. (2022), bewerking door PosadMaxwan.

Chapter 5 by PosadMaxwan

Chapter 6
• Range of possibilities for adapting to sea-level rise in the Rijnmond-Drechtsteden region (p. 108): Lodewijk van Nieuwenhuijze.

Appendix A
• Organization of the research-by-design process (p. 121): Dirk Sijmons.

• The genesis of ports and port cities in six stages (p. 123): Kuipers (2025).

• The forces shaping the transition and spatial demands of the Rotterdam port-industrial complex (p. 123): FABRICations (2025b).

• Book A/ Book B (p. 123): van der Steen et al. (2025, p. 48).

• Bridging the divide between development and management (p. 125): ten Kate (2025).

Appendix C
Shipping – passages per year (Port of Rotterdam Authority N.V., 2025).

Photography

• The Delta Rijnmond-Drechtsteden 2100 Team (p. 7): Sabine van der Vooren, 2025.

• Working session 4, 'City and Hinterland,' (p. 10): Sabine van der Vooren, 2025.

• 'Between City and Sea' (p. 15, 44, 73, 97, 105, 116): Jannes Linders.

• De Slikken van Voorne, Oostvoorne (p. 36): Jelmer Teunissen, 2023.

• p. 37 (right): Ikreis. (2020). *Polder den Hoek ten oosten van Lekkerkerk* [Photo]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Polder_den_Hoek.jpg

• p. 39 (left): van de Velde, P. (2017). *Zicht op een deel van het pad langs de Oostdijk (De Biesbosch, Dordrecht)* [Photo]. Wikimedia Commons. https://commons.wikimedia.org/w/index.php?curid=74013268

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• Tidal nature on Brienenoord Island, Rotterdam (p. 46): Marijne Kreulen, n.d.

• Tidal nature on Brienenoord Island, Rotterdam (p. 47): Linde Keip n.d.

• Landscape that keeps pace with sea-level rise at Landtong Rozenburg (p. 50): Tineke Dijkstra, 2021.

• Salt marsh in Vlieland (p. 55): Pim Kupers, n.d.

• Clay Ripening Facility pilot in the Ems-Dollard Estuary, Delfzijl (p. 57): Ecoshape, 2018.

• Simulation of natural sedimentation in the Nieuwe Waterweg in 'De Metronoom' (p. 71): Kleinhans et al., 2026.

• Wijnhaven, Dordrecht (p. 102): Gemeente Dordrecht.

• Presentation by DPRD during the kick-off (p. 122): Sabine van der Vooren.

• Presentation by Defacto during the kick-off (p. 122): Sabine van der Vooren.

• Presentation by PosadMaxwan during the kick-off (p. 122): Sabine van der Vooren.

• Project 'Where the River is' (Maud van den Beuken; p. 122): Lena de Rouw.

• Bart Kuipers gives the lecture 'The Port Complex as an Economic System.' (p. 123): Jelmer Teunissen.

• Maaike Dalhuisen (Port of Rotterdam Authority) gives the lecture 'The Port and Its Future.' (p. 123): Jelmer Teunissen.

• Work session 4: City and Hinterland at the WaterSchool (p. 124): Sabine van der Vooren.

• Work session 5: Governance (p. 125): Sabine van der Vooren.

Credits

International Architecture Biennale Rotterdam (IABR)
Atelier Delta Rijnmond-Drechtsteden 2100

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• Marc Eisma (Water Policy Advisor, Port of Rotterdam Authority N.V.)
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• Robin Hill (Researcher, Nederlandse School voor Openbaar Bestuur)
• Bart Kuipers (Port Economist, Erasmus UPT, Erasmus University Rotterdam)
• Marije ten Kate (Spatial Planner, Urban Development, Municipality of Rotterdam)
• Bart Maas (Expert Flood Risk Management, Deltares)
• Rianne Makkink (WaterSchool, Founder Studio Makkink & Bey)
• Moze Naél (Spoken Word Artist)
• Dirk Sijmons (Founder H+N+S, Landscape Architect and Author)
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Disclaimer
This research is a valuable building block and one of the steps toward further developing alternatives and transition pathways for long-term flood safety. It is intended to provide inspiration and knowledge for the development of follow-up research.

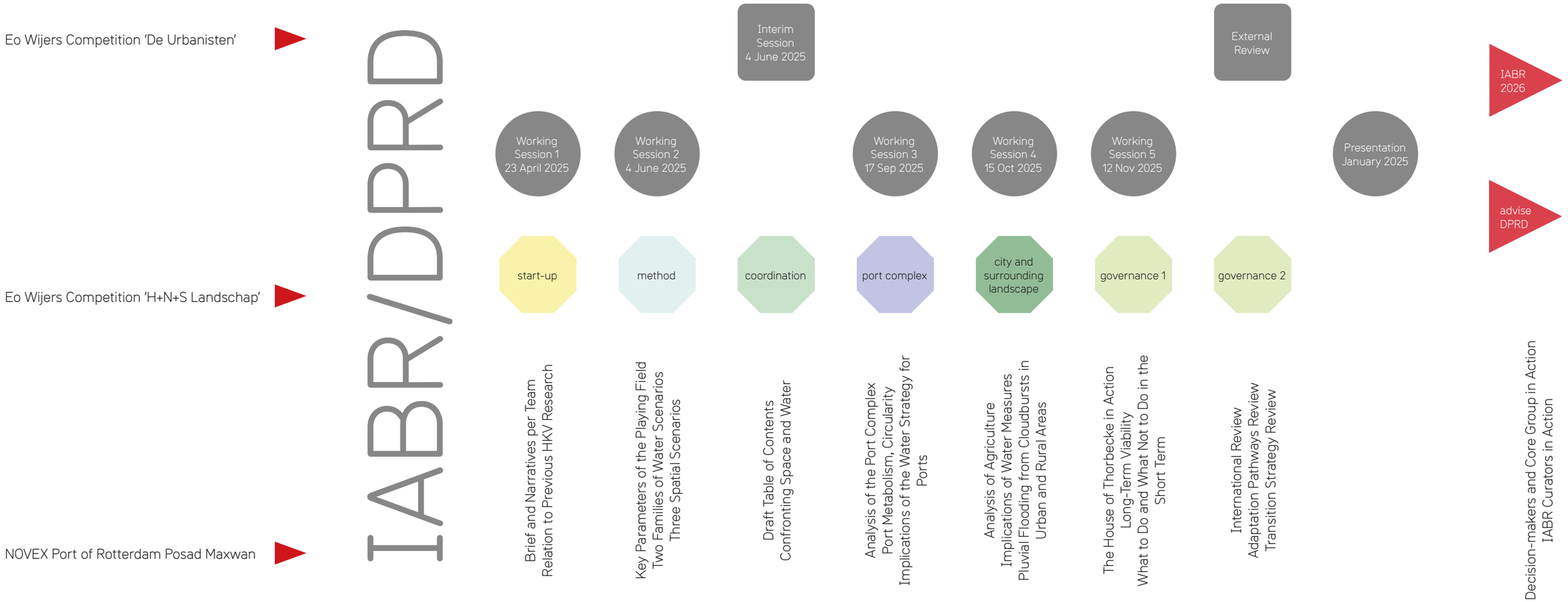
The views and opinions expressed in this research are those of the author(s) and, although there is broad support for the research, do not necessarily reflect those of all commissioning parties in every respect.

Bijlage A, B, C

Appendix A

The Research-by-Design Process

The IABR Atelier Delta Rijnmond-Drechtsteden 2100 was set up as a research-by-design process in which complexity is not reduced but made productive by connecting design, knowledge, and experience. A series of thematically structured working sessions between March 2025 and January 2026 brought together and developed a range of perspectives: from the historical layering and increasing scale of the Rotterdam port complex, made tangible through a screening of Kano naar Zee, to the interconnected future of city and surrounding landscape, where Dirk Sijmons's three 'escape routes' for the agricultural system guided the discussion on sustainable agriculture and landscape development, and to the governance session, which explored how long-term scenarios for flood safety and sea-level rise can be translated into governance decisions in the short term. Design served not as a final vision but as a research instrument for making possible futures imaginable, questioning assumptions, and making consequences visible. Knowledge emerged through interaction among design teams, experts, policymakers, and lead designers and took shape as shared authorship within an open research environment, supported by an online workspace where all input, designs, and reflections came together and were connected across the sessions. In this way, the Atelier developed into an iterative process of exploration, testing, and recalibration that does not produce blueprints but shared approaches to guide decisions in the present with an eye to the long term.



Process design of the research-by-design process (IABR, Ateliermeesters; beeld: Dirk Sijmons).



Presentation by DPRD during the kick-off. Photo: Sabine van der Vooren.



Presentation by Defacto during the kick-off. Photo: Sabine van der Vooren.



Presentation by PosadMaxwan during the kick-off. Photo: Sabine van der Vooren.



With her project Where the River Is, Maud van den Beuken makes port sediment tangible, confronting us with the staggering quantities that are, and must be, dredged. Photo: Lena de Rouw

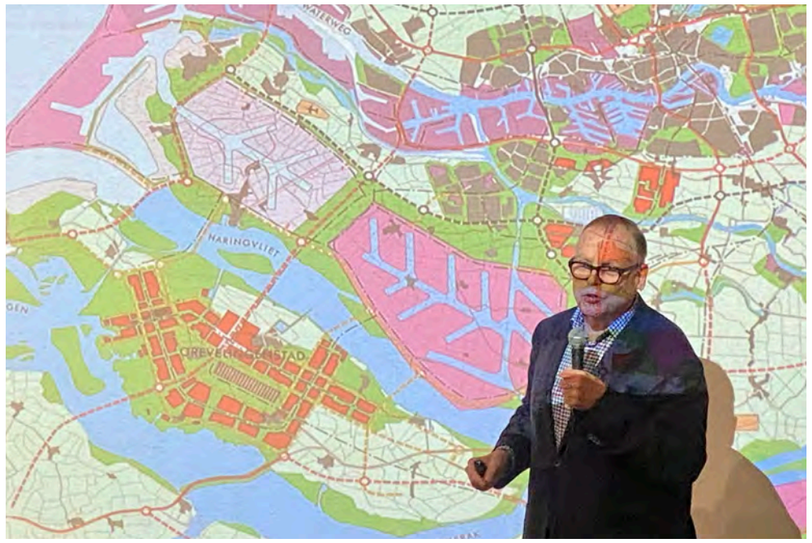
The Process – Dirk Sijmons

The IABR not only shaped the structure of the process but also wove broader and cultural themes throughout it, challenging designers and policymakers to broaden their perspectives. To this end, each of the five working sessions planned to review the design teams' interim results was organized around a theme, with external experts invited to give a lecture.

Sessions 1 & 2: Kick-off and Method

The first session, held on 23 April at the 'IABR headquarters' in the Keilepand, was devoted entirely to the methodology of research by design and to refining the assignment. On 4 June at OASE on Lloydkade, the firms presented their first intuitions and results.

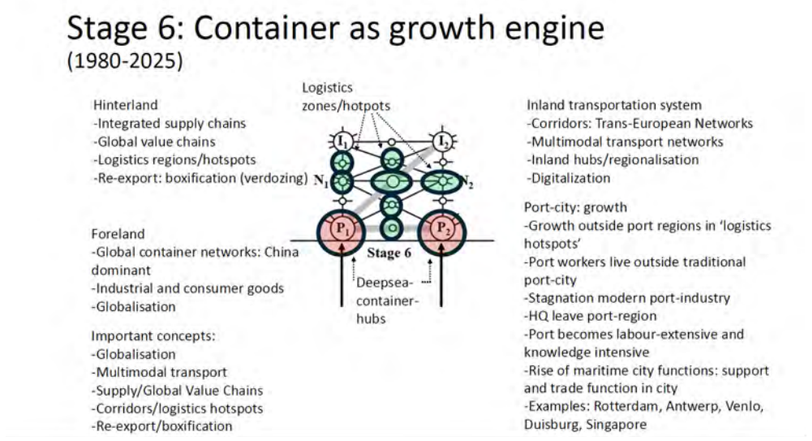
Artist Maud van der Beuken gave a lecture on her project Where the River Is, which at the time was being presented on the quay at Schiehaven by TENT Rotterdam (in collaboration with Rotterdam Architecture Month). Her intervention – six enormous containers filled with port sediment, a film screening, and an installation (Sediment Station) where visitors could prepare carrying bags for a procession along the river, in which the public rather than the river carries the sediment – made tangible the millions of tons of sediment that must be dredged each year to keep Rotterdam's port basins accessible to deep-draft vessels.



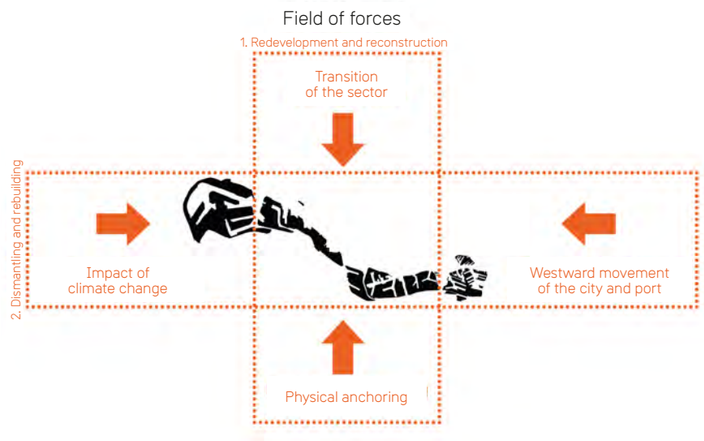
Bart Kuipers gives the lecture 'The Port Complex as an Economic System.' Photo: Jelmer Teunissen



Maaike Dalhuisen (Port of Rotterdam Authority) gives the lecture 'The Port and Its Future.' Photo: Jelmer Teunissen



Bart Kuipers: The genesis of ports and port cities in six stages, from the early history of a port complex in the Middle Ages to the modern container port. Image: Kuipers (2025)



Rens Wijnakker: The forces shaping the transition and spatial demands of the Rotterdam port-industrial complex. Image: FABRICations (2025b)

Session 3: The Port of Rotterdam

On 17 September, a series of presentations focused on the future of the port. A solid foundation had been laid the previous evening, 16 September, with a screening of André van der Hout's monumental documentary Kano naar Zee on the history of the Port of Rotterdam.

Bart Kuipers, a researcher in port economics at Erasmus University, opened the series with a wide-ranging account of the step-by-step development of complex port systems. The port typology he presented, for example, helped prompt us to add maps showing a broader geographical context to the report, showing the far-reaching influence of the economic gravitational field of the Rotterdam port complex and its interconnectedness with river-based economies upstream.

Rens Wijnacker's (FABRICations) presentation on the demand for space in the Rotterdam port-industrial complex in transition provided valuable input for understanding the processes of change in the metabolism of the port complex as the various transitions and the circular economy gradually take shape.

Maaike Dalhuisen (Port of Rotterdam Authority) outlined four scenarios that formed the basis of the new Port Vision Rotterdam (2025), which sets out the goals for circularity and the energy transition of the port-industrial complex. These provided input for PosadMaxwan's broader scenario work. The four possible futures are adaptations of the PBL scenarios tailored to the port economy. Given the port's current performance, the climate targets of the 2025 Port Vision are highly ambitious: a 55 percent reduction in CO_2 emissions by 2030 compared with 1990 and carbon neutrality by 2050.

Marc Eisma (Port of Rotterdam Authority) concluded the series with a lecture on climate change and the port, in which he explained the port's adaptation strategy, and the research underpinning it, in relation to flood safety.









Work session 4: City and Hinterland at the WaterSchool. Photos: Sabine van der Vooren

Session 4: City and Surrounding Landscapes

The region is more than Rotterdam and its port. The fourth working session was therefore devoted to the rural landscape. At Studio Makkink & Bey's WaterSchool, representatives of smaller municipalities in the Rijnmond-Drechtsteden region and experts from the water authorities provided us with input. Three thematic lectures formed the backdrop to our discussions. Werenfried Spits (KNMI) placed the national and regional debate in the context of a world that has warmed by 2.5 degrees Celsius and showed that such warming would produce a world that, in many respects, no longer quite resembles the one we live in today.

In addition to sea-level rise and changing river discharge patterns, we also need to take the meteorological consequences of climate change into account. First, periods of drought: low river discharge not only profoundly affects freshwater availability (for agriculture, drinking water, and industrial water!) but also makes the port inaccessible to inland shipping for several days a year. Clusters of extreme rainfall, such as those that occurred several years ago in Limburg and neighboring Germany, should also receive attention in the studies. We asked Bart Maas of Deltares to provide insight into risk management for clusters of extreme rainfall.





Work session 5: Governance. Photos: Sabine van der Vooren.

	Book A	Book B
Principles	Sea-level rise as a knowable and controllable phenomenon	Sea-level rise as an unknowable and uncontrollable phenomenon
Governance Principles	A. Look before you leap	I. Leap before you look
	B. If you are stuck, simplify	II. If you are stuck, make it more complex
	C. Working on the basis of our capacity to predict	III. Working on the basis of our capacity to predict
	D. One destination, multiple pathways	IV. Multiple destinations, multiple pathways
	E. Frame 'we fight against the water'	V. Frame 'we live with the water'

From Robin Hill's introduction: governance of the climate challenge cannot proceed 'by the book': 'What got us here, won't get us there.' Image: van der Steen et al. (2025)

From Marije ten Kate's introduction: bridging the divide between development and management by giving vital systems a structural place in planning processes through a permanent networked expert forum. Image: ten Kate (2025)

Session 5: Governance

The final working session, on 12 November, was devoted entirely to governance – perhaps the most difficult issue of all. How do you deal, from a governance perspective, with problems that will not materialize until the distant future but already require us to prepare for them now and make difficult decisions?

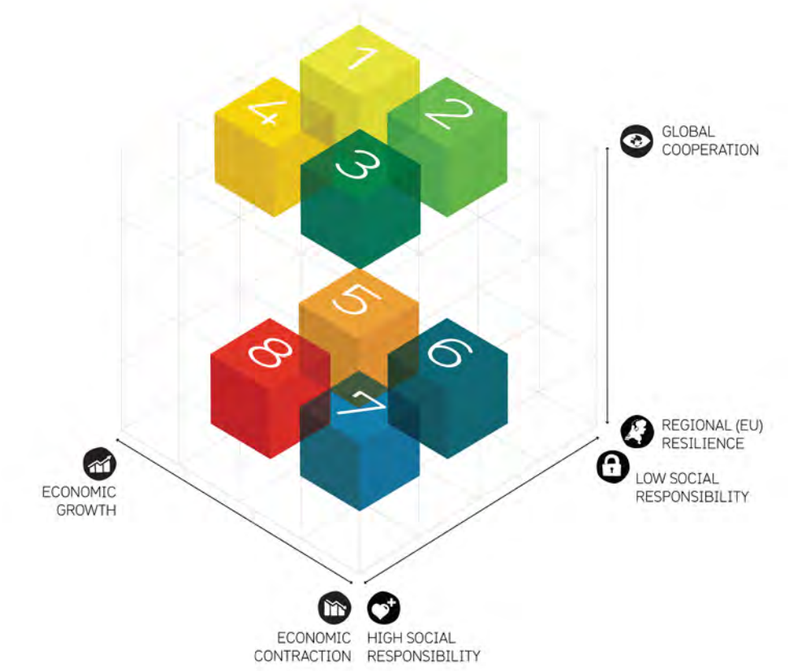
Robin Hill of the Netherlands School of Public Administration had something to say about this – or rather, two 'books' to open. Can we actually manage these kinds of problems with our current governance tools? His presentation, Volgens het Boekje (By the Book), showed not only that this requires a different mindset but also what a long-term strategy for sea-level rise might look like. In his view, this is a complex-chaotic problem that requires dynamic interaction and is 'predictably surprising': we know that surprises are coming but do not know what they will be ('the unknown unknown').

The governance response to this confusing situation cannot be 'by the book.' Hill argued that we will have to switch from 'Book A' to 'Book B,' with new principles of governance. The familiar 'look before you leap' may have to give way to 'leap before you look,' while the engineering maxim of 'working on the basis of our capacity to predict' may have to give way to the more intuitive 'working on the basis of our capacity to imagine.'

Marije ten Kate, a planning specialist at Rotterdam's Department of Urban Development, argued convincingly in her presentation that we need to stop artificially separating development from management. The two flow seamlessly into one another in a system of multilevel governance, as envisioned by the City of Rotterdam.

Appendix B

Future Scenarios (PosadMaxwan)



Three axes generate eight future scenarios (PosadMaxwan)

1 – Turbo-Global

· ECONOMIC GROWTH
· LOW SOCIAL RESPONSIBILITY
· GLOBAL COOPERATION

Global / EU / national outlook:

Global cooperation is primarily economic in nature and focused on maximizing growth and efficiency. Environmental and social costs are shifted to less prosperous regions, leading to increasing global inequality and accelerating climate impacts. Wealthy countries retain the capacity to protect themselves, but systemic instability increases as pressure on resources, climate migration, and ecological decline intensifies. The model generates prosperity in the short term but becomes increasingly vulnerable over time.

Implications for the Rijnmond-Drechtsteden region:

The Port of Rotterdam expands aggressively, both seaward and inland, driven by global trade and automation. Economic benefits are concentrated around the port, while the broader societal benefits remain limited. Environmental pressures increase as a result of salinization, rising water levels, and supply-chain vulnerabilities. The labor market becomes polarized: highly skilled workers leave in search of better living conditions, while low-skilled workers become increasingly replaceable. Spatial pressure increases as industry and logistics continue to grow, limiting opportunities for housing and green space. The regional economy becomes increasingly dependent on the port and less diversified.

2 - Stalled Globalisation

· ECONOMIC CONTRACTION
· LOW SOCIAL RESPONSIBILITY
· GLOBAL COOPERATION

Global / EU / national outlook:

Resource depletion, climate shocks, and debt burdens lead to a synchronized slowdown. Global trade continues out of necessity, but volumes shrink and margins evaporate. Governments focus on crisis management and abandon ESG commitments to support domestic industries. Advanced economies lose purchasing power; emerging economies slide back into poverty. Populism flourishes as citizens resist the idea of 'permanently having less'. Multilateral forums remain intact but are functionally toothless – coordinating rationing rather than progress.

Implications for the Rijnmond-Drechtsteden region:

Freight volumes fall below 350 million tons by 2040. Trade in liquid fossil fuels collapses first and is replaced by low-value scrap and feedstocks for waste-to-fuel production. Expansion projects are suspended, and deferred maintenance makes quays outside the flood defense system increasingly vulnerable to flooding. Farmers successfully lobby to convert peripheral port areas into freshwater reservoirs, leading to conflicts over land use. Refinery layoffs exceed the limited retraining budgets, while declining municipal revenues delay dike improvements. The region's CO_2 footprint decreases only marginally because the capital required for a genuine energy transition is lacking.

3 - Deliberate Contraction Compact

· ECONOMIC CONTRACTION
· HIGH SOCIAL RESPONSIBILITY
· GLOBAL COOPERATION

Global / EU / national outlook:

A critical mass of countries recognizes planetary limits and signs a legally binding pact for 'prosperity within limits'. They impose caps on material consumption, levy high carbon taxes, and use the proceeds to fund universal basic services and the global distribution of clean technology. Wealthy economies accept lower per capita consumption; developing countries leapfrog to low-impact infrastructure, supported by open-source technology transfer. Global GDP contracts, but well-being indicators stabilize; education, health care, and ecological restoration become the main criteria for growth. Success depends on continued trust and verification – comparable to a new Bretton Woods conference for sustainability.

Implications for the Rijnmond-Drechtsteden region:

The EU's 'strategic autonomy' leads to the rerouting of supply chains through a protected megahub between Rotterdam and Antwerp. Short-distance and rail traffic within the customs union increases sharply, while transoceanic traffic levels off. Subsidized caverns store critical minerals; CCU facilities supply e-fuel blending plants, delaying genuine decarbonization. Additional border controls and cybersecurity measures slow port operations. Complaints about air quality lead to piecemeal measures, but funding remains available for raising the dikes along the Hartelkanaal.

4 - Green Global Renaissance

• ECONOMIC GROWTH
• HIGH SOCIAL RESPONSIBILITY
• GLOBAL COOPERATION

Global / EU / national outlook:

A breakthrough in multilateral climate diplomacy (a carbon price floor + a green finance agreement) triggers a 'clean industrial revolution'. Massive public-private investment scales up renewable energy, green hydrogen, negative-emissions technology, and circular production. Digital chain-of-custody platforms make ESG compliance fully transparent, encouraging a positive race to the top. Participation by the Global South is ensured through concessional financing and technology partnerships, making climate action the main driver of inclusive growth. By mid-century, warming is on track to remain below 1.8 degrees Celsius, while cross-border labor mobility increases to fill highly skilled green jobs.

Implications for the Rijnmond-Drechtsteden region:

By 2050, the port handles 40 percent more freight while emitting 80 percent less CO_2. Liquid bulk consists almost entirely of green ammonia, methanol, and e-kerosene; fossil flows disappear. Six gigawatts of offshore wind power supply an electrolysis valley on the Maasvlakte. Digital-twin planning halves lead times; inland vessels and trucks are emission-free. The full climate adaptation strategy – higher quays, floating logistics islands, and restored wetlands – keeps expected flood damage stable despite rising sea levels. Industrial waste heat supplies district heating networks, reducing household energy bills and improving quality of life in the region.

5 - Competing Clusters

• ECONOMIC GROWTH
• LOW SOCIAL RESPONSIBILITY
• EU RESILIENCE

Global / EU / national outlook:

Geopolitical rivalry divides global markets into fortified blocs. The EU doubles down on strategic autonomy by reshoring critical supply chains, introducing carbon and security tariffs, and subsidizing 'made in Europe' industries. Growth is respectable but largely financed through public debt and redirected R&D budgets. Social equality stagnates as the costs of adapting to worsening climate impacts consume fiscal capacity. Brussels maintains cohesion through protectionist benefits, but relations with non-EU neighbors deteriorate; migration barriers become stricter, and renewable-technology patents become bargaining chips.

Implications for the Rijnmond-Drechtsteden region:

The EU's 'strategic autonomy' leads to the rerouting of supply chains through a protected megahub between Rotterdam and Antwerp. Short-distance and rail traffic within the customs union increases sharply, while transoceanic traffic levels off. Subsidized caverns store critical minerals; CCU facilities supply e-fuel blending plants, delaying genuine decarbonization. Additional border controls and cybersecurity measures slow port operations. Complaints about air quality lead to piecemeal measures, but funding remains available for raising the dikes along the Hartelkanaal.

6 - Fortress Austerity

• ECONOMIC CONTRACTION
• LOW SOCIAL RESPONSIBILITY
• EU RESILIENCE

Global / EU / national outlook:

Successive energy, food, and security crises undermine the EU's economic foundations. Member states prioritize national survival, pay lip service to Brussels, and direct their dwindling resources toward domestic adaptation projects and border control. The internal market fragments; cross-border investment and research programs disappear. External superpowers dictate trade terms and exploit Europe's dependence on imported raw materials. Political polarization peaks as living standards decline, putting the continued existence of the Union at risk.

Implications for the Rijnmond-Drechtsteden region:

The EU budget crisis brings cohesion funding to an end; annual tonnage falls below 300 million tons. Trade in crude oil, coal, and ore collapses, creating capacity for imports of scrap and emergency food supplies. Aging locks and quays experience 15 percent downtime; insurers raise flood-risk premiums, forcing tenants to abandon their berths outside the flood defense system. Unemployment in the petrochemical sector exceeds 20 percent, and strikes regularly bring the remaining trade to a standstill. Declining tax revenues bring urban flood protection to a halt; older port areas are repurposed for emergency housing.

7 - Circular Fortress

• ECONOMIC CONTRACTION
• HIGH SOCIAL RESPONSIBILITY
• EU RESILIENCE

Global / EU / national outlook:

Shaken by a series of climate disasters and import disruptions, the EU embraces a radical agenda of 'sufficiency and circularity'. GDP stagnates, but material and energy intensity falls sharply as products are designed for longevity, repair, and closed-loop reuse. Strategic partnerships are limited to like-minded countries, while carbon-intensive imports face prohibitive tariffs. A robust social safety net and ambitious retraining programs maintain social cohesion despite lower overall production. Europe becomes a laboratory for post-growth prosperity but must spend heavily on defense and diplomacy to navigate an increasingly volatile world.

Implications for the Rijnmond-Drechtsteden region:

Bulk volumes decline, but value density increases. Specialized terminals handle plastics-to-chemicals loops, urban-mined metals, and nutrient concentrates. Surplus oil tanks become rainwater buffers and biofeed silos, in line with the Delta Programme Rijnmond-Drechtsteden. Inland vessels with swappable batteries and a micro-feeder network connect secondary Dutch and Belgian ports. Restored tidal marshes between breakwaters absorb storm surges and enhance biodiversity. A port-wide skills pact keeps unemployment below 6 percent despite the contraction.

8 - Regional Green

• ECONOMIC GROWTH
• HIGH SOCIAL RESPONSIBILITY
• EU RESILIENCE

Global / EU / national outlook:

The EU achieves far-reaching fiscal and political integration and launches a Green Investment Union worth trillions of euros. Leveraging its market power, the EU sets global standards for carbon-free products and establishes a lead in hydrogen, batteries, and biobased value chains. A robust redistribution policy aligns social welfare with industrial strategy, maintaining broad public support. Outside Europe, progress is uneven, but EU trade policy, climate diplomacy, and strategic aid gradually bring partners onto a similar path. The Union emerges as the world's most competitive and climate-resilient market, spreading its model by example (and selective market access) rather than coercion.

Implications for the Rijnmond-Drechtsteden region:

Rotterdam anchors the EU's North Sea supergrid, receiving 25 terawatt-hours of electricity per year and importing 10 million tons per year of green hydrogen derivatives. Biorefineries process seaweed and lignocellulose into aviation fuels; captured CO_2 is transported offshore. Container volumes remain stable but shift toward high-tech modules and prefabricated timber. Autonomous electric inland vessels reduce Rhine corridor costs by 40 percent. Port emissions are 85 percent below 2020 levels, well beyond the Fit for 55 target. Smart water dashboards balance Rhine inflows, industrial reuse, and groundwater recharge, preventing salt intrusion even in dry years. High-quality housing and amenities reverse decades of population decline.

Polder Strategy



	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
PORT/LOGISTICS: Expansion toward the sea		no expansion	compact	ideal expansion		no expansion	compact	
	Port expansion has mixed implications: strong global demand drives growth, but weak social and environmental safeguards make the outcomes highly dependent on external shocks and public opposition.	Economic contraction causes a sharp decline in port growth, making major seaward expansion unprofitable and reducing the port's competitiveness in contracting global trade.	A focus on sustainability and regional resilience promotes a compact, efficient port layout, with limited but high-quality expansion in line with low-impact logistics.	Strong global cooperation and investment in clean energy make seaward expansion ideal, creating a thriving, low-carbon port that serves as an anchor for global green trade flows.	EU-focused protectionism and continued dependence on fossil fuels create an inefficient, costly logistics system, weakening the case for major seaward expansion.	Prolonged economic contraction and tight public budgets block new investment, resulting in no growth and underused, aging infrastructure with poor long-term prospects.	The emphasis on circularity and self-sufficiency results in a compact port that prioritizes repair, reuse, and regional cycles over extensive seaward expansion.	The expansion of green energy and strong integration in the EU support moderate seaward growth, creating a sustainable port that plays a leading role in regional clean-energy trade.
POPULATION/CITY: Transformation of the inner port into a new urban center	low quality	abandoned	green space	high quality	low quality	abandoned	green space	high quality
	Strong global growth and migration put pressure on the redevelopment of the inner port for housing and amenities. A lack of social responsibility risks producing a densely populated, profit-driven urban edge with low spatial quality and few public amenities.	The global economic slowdown and declining trade leave large areas of the port vacant, but a lack of capital hampers redevelopment. Parts of Waalhaven and Eemhaven remain underused for long periods and become partly abandoned, with fragmented ad hoc uses rather than coherent urban centers.	Managed degrowth and strong social responsibility steer the inner port away from intensive urbanization. Port functions gradually disappear and make way for parks, sustainable housing, and community facilities: a green, quiet waterfront district rather than a densely populated metropolis.	Massive investment in clean industry and inclusive urban development accelerates large-scale transformation. Port areas become high-quality, multifunctional urban centers with climate-resilient public spaces, green mobility, and affordable housing: a model of sustainable redevelopment.	Massive investment in clean industry and inclusive urban development accelerates the transformation. Port areas become a high-quality, multifunctional urban center with climate-resilient public space, green mobility, and affordable housing: a model of sustainable port-city redevelopment.	Repeated crises undermine trade and public finances, resulting in large-scale vacancy in Waalhaven and Eemhaven. Without redevelopment funding, the area deteriorates into derelict plots with temporary uses and emergency facilities, with a major negative impact on the western urban edge.	A focus on regional self-sufficiency and circular production turns part of the inner port into a compact network of repair, recycling, and energy hubs surrounded by new blue-green spaces. The center remains modest but robust and rich in nature: less metropolis, more resilience.	Coordinated EU investment and regional planning enable the redevelopment of the inner port. Reduced logistics activity creates space for a compact, mixed-use, low-carbon urban center with good public space, social housing, and green space – with clear benefits for quality of life.
LANDSCAPE/NATURE: New landscape along the Nieuwe Maas	coherence ??	low quality	low intensity	blue-green cities	coherence ??	low quality	low intensity	blue-green cities
	Strong global growth and private investment accelerate redevelopment along the freshwater river. The landscape changes rapidly but remains fragmented: high-quality areas alongside privatized edges, hard quays, and commercial hotspots. Ecological continuity is weak, and public access varies considerably from place to place.	Economic contraction limits investment, leaving riverbanks fragmented and poorly maintained. Some sections improve, but many retain aging infrastructure and little ecological value. The freshwater landscape changes, while its quality declines through neglect and uneven management.	The river is regarded as a shared ecological and social resource. Modest but deliberate interventions create natural banks, small wetlands, and quiet recreational spaces. The result is a gentle, community-oriented landscape that prioritizes ecological health and quiet enjoyment over iconic development.	Coordinated investment and strong social responsibility turn the freshwater river into a continuous, climate-adaptive blue-green system. Nature-friendly quays, high-quality public space, ecological corridors, and active routes form a world-class river landscape and a model for resilient design.	The EU-focused industrial strategy creates a riverfront with contrasting functions: modernized innovation zones alongside infrastructural or monofunctional areas. Public access varies, and ecology remains subordinate to economic objectives. The landscape changes, but in a fragmented and uneven way.	Severe budget deficits and declining capacity cause widespread deterioration. Riverbanks become primarily functional, with aging quays, little maintenance, and sporadic use for emergencies. The freshwater system changes substantially but continues to produce poor spatial and ecological outcomes.	Regional self-sufficiency and circular practices produce a modest but ecologically responsible river landscape. Small-scale interventions – wetlands, local food plots, and simple recreational facilities – are well maintained by the community. The result is a low-intensity, resilient waterfront with a strong local character.	EU investment and regional planning enable a high-quality river landscape with integrated parks, ecological restoration, and accessible public space. The freshwater system becomes the ecological backbone of the region, bringing recreation, biodiversity, and climate adaptation together in a coherent, well-funded design.



large impact
medium impact
small impact

positive impact
neutral impact
negative impact

Polder Strategy

ECONOMIC

	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
PORT/LOGISTICS: Relationship with Moerdijk / Dordrecht	competition	uncoordinated	local niche	strategic	autonomous	decline	circular hub	regional port
	Strong global growth reinforces Rotterdam's dominance, leaving little room for balanced cooperation with Moerdijk or Dordrecht. Both satellite ports grow, but primarily in subordinate or competing niches rather than as part of an integrated network.	Economic contraction reduces freight flows and weakens the incentive for a coordinated regional port strategy. Moerdijk and Dordrecht retain their basic functions but lack the capital to reinvent themselves, resulting in slow and fragmented development.	With material flows declining and a strong focus on self-sufficiency, Moerdijk and Dordrecht support small-scale, environmentally responsible logistics and local production. Their role gradually changes, but overall port activity remains modest.	Rapid investment in clean industry allows Moerdijk and Dordrecht to specialize in green activities such as biochemistry, circular production, and inland hydrogen hubs. Cooperation with Rotterdam intensifies as the region develops into a coordinated, climate-positive port system.	EU protectionism forces ports to protect their own value chains. Moerdijk develops into an autonomous energy and chemical center and Dordrecht into a strategic urban-industrial hub. There is coordination with Rotterdam, but it is driven primarily by competition and security.	The economic downturn reduces activity in Rotterdam, making Moerdijk and Dordrecht more important as low-cost, lower-risk alternatives. Their functions expand modestly out of necessity, but without strategic planning or major innovation.	Regional self-sufficiency creates demand for decentralized circular industry. Dordrecht develops strong repair and maker clusters, while Moerdijk accommodates regional biobased and recycling flows. The network becomes more polycentric, albeit on a small scale.	EU-coordinated green investment makes Moerdijk and Dordrecht essential pillars of a regional port system. They specialize in inland hydrogen logistics, circular production, and climate-resilient distribution and work closely with Rotterdam.
Relationship with Antwerp	critical			requires coordination	critical			delivery-time bottleneck, vulnerability
	Growth requires integrated chains, but new locks reduce the reliability and flow of short-sea shipping between Rotterdam and Antwerp. As a result, cooperation shifts toward competition, and reduced connectivity becomes a critical weakness for the regional petrochemical system.	Declining trade volumes and dwindling investment cause the Rotterdam–Antwerp chemical corridor to decline gradually. The locks create additional friction in already weakened flows, further reducing cooperation, but the overall effect is tempered by lower demand and unused capacity on both sides.	A deliberate move away from high-volume petrochemical products reduces dependence on the connection between Rotterdam and Antwerp. As both ports focus on lighter, lower-impact value chains, the closed route becomes less important; the relationship weakens, but without major strategic consequences.	Green investment requires a single Rotterdam–Antwerp cluster with strong short-sea and inland shipping connections. Lock restrictions and variable transit times create friction and the risk of duplicate corridors and higher costs. The connection remains, but operating as a single green hub requires joint corridor management and slot coordination.	In a protectionist EU with competing blocks, short-sea connections are crucial to strategic autonomy. Restricted routes between Rotterdam and Antwerp disrupt cross-border chemical chains and increase tensions. Ports therefore develop their own value chains, resulting in high costs and loss of efficiency.	Recession and austerity reduce activity, making integration less worthwhile. The closed water system continues to create friction, but overcapacity reduces the impact. Cooperation becomes pragmatic (planning, safety, continuity), and the connection weakens primarily through stagnation rather than rivalry.	As regions prioritize local cycles over long petrochemical chains, material flows between Rotterdam and Antwerp decline. The blocked route is a disadvantage but not decisive; cooperation shifts toward knowledge exchange, while physical integration plays only a subordinate role.	The Green Investment Union requires robust short-sea networks. Lock and route bottlenecks between Rotterdam and Antwerp increase variability in delivery times and force detours or modal shifts, reducing interoperability and making the system more vulnerable. Coordination helps but remains less efficient than an open-route system.
Shipping capacity on a single waterway	optimization can be applied	noticeable congestion		optimization can be applied	critical			optimization can be applied
	Global growth generates very high freight volumes in the remaining corridor. The loss of the second route leads to severe congestion and bottlenecks. Without strong coordination, the waterway becomes a major vulnerability for the logistics system.	Global contraction reduces overall volumes, but weak cooperation leaves little scope for adaptation. The reduced network still produces noticeable congestion, but it does not reach critical levels.	Deliberate contraction and sustainability policies sharply reduce freight volumes. International cooperation and social responsibility enable effective demand management and coordinated planning. The remaining corridors and locks can accommodate these flows, limiting congestion to peak periods.	The growth of green industries increases shipping volumes and puts pressure on the corridor and locks. Global coordination improves planning, but lock capacity remains a constraint. Without additional locks and strict traffic management, queues and delays increase; with these measures, congestion remains manageable.	Regional protectionism and strategic autonomy increase short-distance and inland shipping, while coordination between ports and corridors remains weak. More traffic therefore passes through the same corridor and a limited number of locks, resulting in chronic overloading and long queues. Reduced redundancy makes the network vulnerable, causes structural delays, and harms the regional economy.	Regional economic contraction reduces industrial activity and transport demand, limiting pressure on the corridor. Budget cuts and low social responsibility constrain investment in maintenance, staffing, and traffic management, resulting in downtime and inefficiencies at locks. Congestion here is caused primarily by disruptions and low reliability rather than volume.	Circularity and self-sufficiency reduce long-distance freight volumes and shift flows toward smaller, local, and predictable movements. High social responsibility allows rules such as slot allocation and prioritization to be applied consistently, keeping demand for lock capacity manageable. Capacity loss therefore has little effect and congestion remains low.	Regional green growth and increased short-distance and domestic transport put considerable pressure on the only remaining corridor. Coordination and digital planning help, but the structural capacity constraint still creates a substantial risk of congestion.

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Polder Strategy

ECONOMIC

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Repositioning / restructuring of the port	locked-in dependency	slow transition	smooth transition	strategic importance	critical	low investment capacity	minimal impact	major coordinated shift
	Global growth drives up short-sea shipping, making terminal relocation a major undertaking. The network currently revolves around Eemhaven; a shift to the southern corridor requires major investment, temporary inefficiencies, and the restructuring of logistics chains.	Trade volumes decline, reducing the urgency, but financial constraints and weak cooperation make the relocation slow. Limited capital and poor coordination result in a long transition period marked by inefficiencies.	Demand for short-sea shipping declines due to lower material flows and greater regional self-sufficiency. As a result, relocating the terminal becomes easier and less expensive, and the new location can be smoothly integrated into a smaller, cleaner logistics network.	Short-sea shipping increases thanks to clean fuels and integrated green supply chains. The relocation becomes a strategic priority for maintaining high operational efficiency. Strong governance helps, but the transition still has a considerable impact because of the high level of activity.	Protectionist dynamics lead to a dramatic increase in intra-EU coastal shipping. Ports do not coordinate, yet they all depend on high throughput. Relocation causes major disruptions, creating bottlenecks and competition for scarce space and capacity along the southern corridor.	The economic downturn leads to a sharp decline in short-sea shipping. Relocating the terminal is necessary but has limited operational consequences. The system becomes leaner, with lower expectations and smaller volumes.	Short-sea activity is limited and concentrated primarily on regional circular supply chains. Relocating the terminal is a modest adjustment and may even offer an opportunity to redesign logistics in a more regenerative way.	Regional industrial growth increases short-sea shipping's demand for clean fuels, prefabricated products, and circular flows. The relocation is substantial but manageable through coordinated planning, although the shift places considerable transitional pressure on the southern corridor.
POPULATION/CITY: New industrial clusters along the Oude Maas	expansion	limited development	selective green cluster	green technology corridor	fragmented reshoring	opportunistic concentration	small circular hubs	regional innovation cluster
	High levels of global trade and industrial activity create strong demand for locations with direct access to water. The new waterway corridor attracts substantial relocations and expansion, resulting in extensive new clusters along the Oude Maas.	The global decline in trade and reduced investment capacity result in limited new development. Along the Oude Maas, small, scattered industrial sites emerge rather than clearly defined clusters.	Lower material throughput reduces overall demand for new industrial space, but certain activities are still relocated. The result is medium-sized, deliberately selected clusters, often linked to long-term, stable functions.	Strong industrial growth and the planned restructuring of logistics create a substantial concentration of activities along the new waterway. Large, coordinated clusters emerge, reflecting the corridor's role in future-oriented production and distribution.	EU-focused growth and the reshoring of production increase regional demand for industrial sites. Along the Oude Maas, new activities emerge as several medium-sized clusters shaped primarily by sectoral and market dynamics.	Overall economic activity contracts, but certain strategic sectors consolidate in the EU. The Oude Maas becomes one of the areas where these activities cluster, forming a limited number of major clusters.	Reduced material flows and a focus on regional self-reliance create relatively little demand for new sites. Industrial activity along the corridor concentrates in a few small but stable clusters that serve essential regional functions.	Regional economic growth and coordinated planning support a substantial concentration of activities along the new waterway. Large clusters emerge, with functions aligned with the broader regional industrial and logistics system.
ENERGY TRANSITION / CIRCULAR ECONOMY Adaptation of the fossil industry (e.g., Botlek)	major transition challenge		selective	extensive restructuring	substantial repositioning	partial restructuring	functional contraction	adaptation
	Strong global growth increases pressure on Botlek to modernize for cleaner production and remain competitive. The adaptation is substantial, driven by international standards and market expectations, but fossil-related functions continue alongside new technologies.	Economic contraction and reduced investment capacity slow the transition. Infrastructure ages, and adaptations occur only where absolutely necessary to maintain operations. Overall transformation remains modest.	Lower material throughput reduces the scale of heavy industry. Botlek refines its functional profile and converts part of its fossil assets to circular or environmentally friendly applications. The pace is steady but not expansionary.	Strong global cooperation and rapid decarbonization accelerate the shift away from fossil assets. Botlek undergoes a broad, coordinated transition toward hydrogen, biobased industry, and circular raw-material systems.	The EU's competitive strategy stimulates targeted investment. Some fossil capacities are consolidated or phased out, while new production chains emerge simultaneously. The adaptation is substantial but uneven and shaped by sectoral market dynamics.	Economic contraction reduces industrial activity, but certain strategic capacities are retained for security reasons. Adaptations are implemented where necessary to increase resilience, resulting in a medium-scale but functionally important transformation.	The emphasis on self-sufficiency and low material consumption reduces demand for fossil activities. Botlek selectively shifts toward circular processes, with a smaller industrial footprint and steady but moderate adaptation.	Regional planning and green investment programs stimulate Botlek's broad transformation. Fossil functions are replaced or integrated into circular and renewable systems, creating a reconfigured industrial landscape with a high intensity of adaptation.

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ECONOMIC

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Dependence on pipelines	critical			green transition	critical	thin, but essential		critical
	High global growth keeps fossil and raw-material flows large. Because waterborne transport is limited, energy and petrochemical chains depend heavily on pipelines. Investment increases capacity, but redundancy remains limited: failure of several main pipelines could cause major regional economic damage.	Trade and demand decline, but existing fossil infrastructure remains in use. Limited capital means pipelines are maintained rather than fundamentally redesigned. Dependence remains significant, with moderate vulnerability resulting from aging assets and few alternatives.	Lower material throughput and strong efficiency policies reduce demand for fossil fuels. Energy systems shift toward local renewable energy sources and electrification. Pipelines remain in place, but the system is less focused on them, resulting in relatively low reliance.	The large-scale rollout of hydrogen and CO_2 networks results in an extensive pipeline system. Flows are substantial, but management, coordination, and digital monitoring are robust. The system is pipeline-intensive but designed with buffers and alternative routes.	EU strategic autonomy prioritizes secure flows of energy and raw materials in the Union. Replacement flows for hydrogen and fossil fuels run through a limited number of corridors between key clusters. Large volumes, protectionism, and limited coordination between ports increase dependence on a small number of pipelines.	Economic contraction and budgetary pressure constrain new investment. Some pipelines are decommissioned, while others remain crucial for a smaller number of strategic industries. Dependence is moderate: volumes decline, but alternatives remain scarce wherever pipelines continue to operate.	Circular economy, self-sufficiency, and regional independence reduce the long-distance transport of energy and materials. Local district heating networks, storage, and short supply chains dominate. Pipelines continue to play a role, but dependence on large interregional systems is minimal.	Coordinated EU green policy creates a continuous regional network of hydrogen and CO_2 pipelines, with large flows and cross-border connections. Dependence remains high but is partly mitigated through planning and redundancy.
AGRICULTURE / HORTICULTURE The role of Westland	disruption	limited growth	strategic reorientation	sustainable growth	reduced integration	limited resources	adaptive shift	prosperous adaptation
	Global growth increases demand for logistics services while waterways are lost. As a result, the agricultural sector in Westland faces logistical bottlenecks, affecting the efficiency of production and distribution. Limited attention to sustainability leads to disruption.	While global contraction reduces trade and shipping flows, the lack of investment in sustainability causes the Westland sector to stagnate somewhat, with limited innovation and adaptation.	The shift toward sustainability in a contracting global economy offers Westland opportunities to adapt to circular models and innovative production despite the economic downturn.	With a focus on green policy and global cooperation, Westland benefits from a thriving, sustainable market that promotes growth through environmentally friendly logistics and innovative practices.	Regional growth offers some opportunities, but limited social responsibility leads to fragmented growth, leaving Westland less well integrated into sustainable practices and logistics networks.	Regional contraction combined with minimal sustainability efforts places considerable pressure on Westland, as reduced industrial activity constrains growth and resource efficiency.	While regional contraction slows the economy, a high degree of social responsibility supports the adaptation of agricultural practices in Westland, emphasizing sustainable models and local production systems.	Regional growth combined with strong social responsibility results in a thriving, sustainable agricultural sector in Westland, supported by environmentally friendly logistics, local partnerships, and innovation.

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SOCIAL

	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
PORT/LOGISTICS: Risk of environmental damage resulting from logistical congestion	critical				environmental impact congestion			
	Global growth increases trade and shipping traffic, placing pressure on waterways and particularly on short-sea shipping. Seaward expansion helps deep-sea shipping, but the risks of environmental damage from hazardous cargo and landside congestion remain high.	Although shipping activity is lower, the global slowdown in trade still affects regional routes. Traffic would be less intense but still substantial, leading to potential, though not severe, environmental risks resulting from moderate congestion in short-sea shipping.	Although global contraction occurs, a high degree of social responsibility can lead to more sustainable shipping practices and greater environmental awareness. Short-distance traffic declines, but the focus on emissions reduction keeps the risk of environmental damage more manageable.	Growth continues in this scenario, but the emphasis shifts toward sustainable and responsible logistics. Although global shipping may move offshore, inland and short-sea shipping still face congestion risks. Environmental impacts remain substantial but are mitigated by green policy.	Regional growth creates greater dependence on inland and short-sea shipping, leading to considerable congestion and potential environmental risks. As global connections become less of a priority, the environmental impact of shipping congestion increases.	Contraction leads to less shipping traffic, but regional ports may still come under pressure as they handle a larger share of domestic trade. Short-sea shipping may still experience congestion, although environmental impacts remain limited because of lower overall shipping volumes.	Although regional contraction reduces demand for maritime transport, a high degree of social responsibility would lead to investment in cleaner, more sustainable transport methods. Environmental risks are lower than in other scenarios, although congestion may still occur on short-distance routes.	Regional growth with a high degree of social responsibility prioritizes sustainability and may lead to more efficient, greener short-sea shipping networks. Increased shipping volumes could nevertheless still create congestion risks, resulting in a moderate environmental impact.
POPULATION/CITY: Economic shifts and their impact on employment status (different profile)	challenges	job losses	resilience	adaptation	unequal job creation	support systems	social stability	stable growth
	Global growth generates many jobs, while strong social responsibility ensures fair working conditions and job security. Some sectors nevertheless remain sensitive to changing global demand, which may create temporary instability for certain workers.	During periods of economic contraction, job losses are substantial, and the lack of social support aggravates the situation. As the economy contracts, social systems fail to cushion the consequences for workers, resulting in high unemployment and economic instability.	Despite global contraction, strong safety nets and retraining provide support for affected workers. As a result, unemployment remains more manageable, social unrest declines, and the city can adapt.	Global growth generates many jobs, while strong social responsibility ensures fair working conditions and job security. Although some sectors struggle to adapt, the commitment to workers' rights helps limit negative effects and creates a more equitable labor market.	Regional growth stimulates employment, but the lack of social responsibility means many of these jobs are insecure, low-paid, and without social safety nets. This increases inequality and labor-market insecurity, negatively affecting the city's social fabric.	Regional contraction leads to job losses, and the lack of social responsibility worsens the situation because little assistance is provided to those affected. As a result, the city experiences higher unemployment and increasing social tensions, with few opportunities for economic recovery.	Despite economic contraction and job losses, strong safety nets cushion the effects of unemployment through retraining, benefits, and social stability. Workers can therefore transition more easily between jobs.	Regional growth creates jobs, and strong social responsibility ensures good wages, job security, and worker protection. Although sectoral adjustment continues to present challenges, social stability is maintained, with less inequality and a better quality of life.
INVESTMENTS IN FLOOD SAFETY Operational dilemma in compound flooding	critical	low investment = vulnerability	low investment = vulnerability	scale of challenge: high	low investment = vulnerability	low investment = vulnerability		low investment = vulnerability
	Global growth increases pressure on flood safety systems. A low degree of social responsibility results in limited investment in flood defenses, leaving the system highly vulnerable to simultaneous flooding from rivers and the sea, with serious risks to the environment and society.	Global contraction reduces activity, but the lack of social responsibility means that no investment is made in flood prevention. The system remains vulnerable to compound flooding, but the consequences are less severe than in a growth scenario.	Contraction reduces pressure on systems, while a high degree of social responsibility leads to investment in resilience. The system is better able to manage flood risks, although challenges may still arise when river and coastal flooding occur simultaneously.	Global growth increases pressure on the water system, but strong social responsibility leads to substantial investment in resilience. Although the system is well prepared, the scale of the challenge remains large because of high population density and industrial activity.	Regional growth puts pressure on water systems, but a low degree of social responsibility limits investment in resilience. Although the impact is substantial, it is smaller than in global growth scenarios, with localized flood risks.	Contraction reduces demand, but a low degree of social responsibility prevents effective investment in flood defenses. The system faces challenges in adapting to flooding, particularly when river and coastal flooding occur simultaneously.	Regional contraction reduces pressure, while a high degree of social responsibility ensures robust flood defenses. The system can manage flood risks, with moderate challenges in adapting to complex events.	Regional growth places additional pressure on water systems, but a high degree of social responsibility leads to investment in resilience. The system is prepared for flood risks, although managing compound events remains a moderate challenge.

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Estuarine Strategy



	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
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PORT/LOGISTICS: Potential for a new offshore port	risky push	not feasible	research	conditional opportunity	contested expansion	low priority	ecological buffer zone	selective off-shore node
	Strong global growth creates high demand for offshore capacity, but a low degree of social responsibility leads to aggressive engineering in unstable sediment zones. Continuous dredging, ecological conflicts, and high maintenance costs make this option risky and politically vulnerable.	Reduced trade volumes and limited public investment make offshore port development unrealistic. Sediment constraints further discourage long-term investment, resulting in postponement or cancellation.	Low economic pressure reduces the urgency, while high social responsibility shifts the focus toward understanding sedimentation systems rather than building. An offshore port remains a long-term option rather than an active project.	Demand is high, but development is constrained by sediment flows. Solutions focus on adaptive design, floating or flexible infrastructure, and integration with sediment management. Feasible only with strong governance capacity and long-term coordination.	Regional growth increases pressure to expand capacity, but limited coordination and environmental awareness lead to conflicts over sediment disturbance. Offshore development competes with coastal resilience objectives and encounters opposition.	Contraction will lead to less shipping traffic, but regional ports may still come under pressure as they handle a larger share of domestic trade. Short-sea shipping may still experience congestion, although the environmental impact will be limited because of lower overall shipping volumes.	Although regional decline reduces demand for maritime transport, a high degree of social responsibility would lead to investment in cleaner, more sustainable transport methods. The environmental risk is lower than in other scenarios, although congestion may still occur on short-distance routes.	Regional growth with a high degree of social responsibility would prioritize sustainability and could lead to more efficient, greener short-sea shipping networks. However, increased shipping volumes could still cause congestion risks, resulting in a moderate environmental impact.
POPULATION/CITY: Transformation of the inner port	high-pressure reuse	locked in	downsize / reuse	planned major transition	selective redevelopment	patchwork survival	circular re-trofit hub	rapid coordinated renewal
	Strong growth creates intense demand for space. The inner port is rapidly repurposed, often driven by market pressure rather than long-term spatial quality or social balance.	Economic contraction and limited coordination prevent major changes from taking place. The inner port remains largely unchanged, with only minimal or temporary uses.	Lower demand reduces pressure for redevelopment. A high degree of social responsibility supports adaptive reuse, temporary programs, and incremental transformation on a modest scale.	Strong growth combined with a high degree of social responsibility enables a coordinated, long-term transformation. The inner port develops into a well-integrated urban district with new functions.	Regional growth leads to redevelopment at specific high-quality locations. Transformation is uneven, with limited integration between projects and surrounding urban areas.	Economic contraction and weak coordination lead to fragmented reuse. Small, disconnected interventions predominate, aimed at maintaining basic functionality rather than strategic change.	Reduced growth shifts the focus toward reuse and circular strategies. The inner port becomes a testing ground for adaptive, environmentally responsible transformation and new urban production functions.	Regional growth and strong social responsibility support rapid, coordinated transformation. The inner port is repositioned as a resilient, multifunctional urban hub in the broader region.
ENERGY TRANSITION / CIRCULAR ECONOMY Sediment storage space	overflow & conflict	deferred maintenance	local reuse program	circular sediment economy	strategic, but contested	minimal capacity	natural buffering	coordinated reuse network
	High activity generates large volumes of sediment and competition for space. Storage takes place, but primarily as a short-term solution; conflicts with industry and logistics and environmental pressures increase.	Lower economic activity reduces the capacity for planning. Sediment storage becomes an unmanaged burden; low-cost disposal sites and makeshift storage predominate.	Even with limited financial resources, targeted management is possible: reuse for dikes, soil improvement, and nature buffers. Smaller in scale, but relatively effective.	The best way to turn sediment into an asset: coordinated storage centers, processing, and reuse for dike reinforcement and landscape formation. High investment + strong governance.	Regional growth increases the need for storage, but a lack of trust and coordination leads to conflicts over site selection (Botlek versus the living environment versus ecology). It works but is inefficient and politically messy.	Lower demand, but also low investment. Sediment storage is maintained only at a basic level; opportunities for long-term resilience are missed.	Sediment storage is integrated into the landscape strategy: wetlands, floodplains, local dike reinforcement. Less industrial processing, more "sediment as ecology."	Strong regional planning creates a network: storage sites + reuse pipelines (dikes, building-material trials, ecosystem restoration). A major opportunity to turn this into a stable economic activity.



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LANDSCAPE / NATURE New sediment landscape	questionable ecological quality	passive development	ecological buffering and nature restoration	core element delta system	pragmatic	limited	nature-based buffer	multi-functional
	High economic and logistics pressure drives rapid land reclamation, but sediment landscapes are shaped primarily for protection and capacity, with limited ecological or social integration.	Reduced investment and weak coordination limit the active development of the sediment landscape; changes remain largely passive and incremental.	Lower growth pressure allows sediment to be used primarily for ecological buffering and landscape restoration rather than economic expansion.	Strong governance allows sediment landscapes to combine flood safety, ecology, and spatial quality, making them a core element of the delta system.	The use of sediment focuses on pragmatic flood protection and land stabilization, with little attention to ecological value or the long-term landscape.	Economic contraction limits large-scale sediment projects; dike relocations and sedimentation take place only where strictly necessary.	Sediment landscapes are strategically used as low-cost, nature-based buffers that support resilience and gradual land adaptation.	Coordinated regional planning transforms sediment landscapes into multifunctional zones that combine flood safety, ecology, recreation, and circular land use.
FRESHWATER DEMAND Freshwater availability	critical	low investment	industry adapts	industry uses water circularly	unequal access	limited competition	adaptive use	drinking water critical infrastructure
	Demand for freshwater surges (industry + population). Governance is weak, buffers are exceeded in dry years, and salinity peaks break through. Competition prevails over coordination.	Lower demand helps, but a lack of investment undermines buffer maintenance. The system survives because of reduced pressure, not because of good design.	Lower volumes + strong governance ensure that freshwater is prioritized, buffered, and shared. Industry adapts rather than competes.	The system works only if: reused water is given explicit priority rules, industry is required to implement reuse, cascading and seasonal allocation, and buffers are politically protected.	Access to freshwater becomes unequal: some sectors have a guaranteed supply, while others face shortages. Recurring disputes and ad hoc emergency measures can be expected during dry periods.	Demand is lower, so competition for freshwater remains limited. The main problem is underinvestment and poor maintenance, causing risks to accumulate quietly and manifest themselves during dry years rather than as a continuous conflict.	This is a 'slow water' scenario: buffers function well, salinity is managed spatially, and freshwater is conserved through adaptive use rather than growth pressure.	Freshwater is regarded as critical infrastructure. Industrial clusters adapt to availability, rather than the other way around. There is competition, but it is moderated through planning and pricing.
INVESTMENTS IN FLOOD SAFETY Local dike enforcement in urban and inner-city areas	reactive hardening		targeted upgrades	integrated urban renewal	uneven reinforcement	minimum	focused protection	consistent protection
	High exposure and rapid growth force rapid upgrades; spatial conflicts and unequal protection are likely.	Investment capacity is weak; upgrades lag behind risk, increasing vulnerability over time.	Limited budgets but a strong public mandate: phased reinforcement prioritizes critical areas and social protection.	Major investment and planning capacity allow dikes, public space, and pumping strategies to be integrated into the city.	Growth drives upgrades, but fragmented governance leads to inconsistent standards and local disputes.	Lower growth reduces pressure, but poor maintenance and deferred upgrades perpetuate latent risk.	Focus on protecting essential assets and vulnerable groups through steady, incremental works.	Strong regional planning supports consistent standards and upgrades with multiple benefits across municipalities.



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Estuarine Strategy



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Intervention for areas outside the flood defense system	expansion of exposure	neglected edge	planned retreat and adaptation	adaptive urban waterfront	risk by market	slow decline	minimal-impact adaptation	resilient waterfront areas
	Development pressure increases the number of assets in risk-prone zones; adaptation is uneven and often takes place only after damage has occurred.	Fewer resources and weak public support lead to insufficient adaptation; risks become concentrated in vulnerable communities.	Lower growth reduces new exposure; policy supports adaptive reuse, retreat, and protection of critical functions.	High investment enables floodproof buildings, amphibious typologies, and clear risk management.	Some areas protect themselves, others do not; risks are distributed unevenly and become politically contested.	Lower growth curbs new development, but existing areas lack funding for improvements; risk quietly accumulates.	The focus shifts toward affordable, local measures (safe access, flood-proof buildings, evacuation capacity) and social safety nets.	Regional coordination enables clear standards, risk communication, and systematic adaptation in exposed zones.



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PORT/LOGISTICS: Relationship with Moerdijk / Dordrecht / Antwerp	reliability undermined	disruptions and inefficiencies		coordinated megadelta cluster	strategic con-solidation	budget cuts		managed, integrated network
	Rotterdam focuses on maximum growth and short-term gains. With the storm surge barrier, routes remain open, but increased traffic leads to congestion and greater variability along shared corridors. Weak collective governance makes coordination more ad hoc and competitive, undermining the reliability of integrated industrial chains.	Volumes are declining, which reduces pressure, but poor coordination and budget cuts are undermining maintenance and traffic management. Access remains possible, but the network is underperforming due to disruptions and inefficiencies, not high volumes. Opportunities for regional recovery are being lost because ports operate in isolation.	Lower volumes and strong governance make it easier to reorganize flows and manage peaks. The storm surge barrier keeps connectivity intact, while shared planning and environmental regulations support stable cooperation. The relationship becomes more focused on resilience and quality of life than on throughput.	Green growth stimulates activity and increases the need for coordination between ports. With the storm surge barrier, connectivity is maintained, but peaks in congestion and variability require continuous coordination. Cooperation is strengthened through joint planning and regulations, keeping the network functional, although active governance remains necessary.	Regional growth increases traffic flows, but fragmented decision-making and low social responsibility intensify competition. Even with the storm surge barrier, congestion and travel-time variability become strategic bottlenecks, allowing Rotterdam to consolidate its advantages while smaller hubs risk being sidelined.	Demand declines, and budget cuts reduce maintenance, staffing, and operational capacity. Routes remain open, but reliability declines and disruptions have greater knock-on effects. Parties prioritize survival over integration, weakening cooperation and making the regional system more isolated.	Flows are smaller, more local and more predictable, and strong social responsibility supports cooperative governance. The storm surge barrier maintains connectivity, while shared standards and planning keep congestion manageable. Cooperation remains stable, even though overall trade volumes are limited.	Regional green growth stimulates short-distance traffic and increases dependence on shared corridors. The storm surge barrier guarantees access, but performance depends on corridor management, incident response, and agreed standards. The network can remain integrated but requires continuous coordination to manage peak loads and disruptions.
Shipping capacity on the waterways (M–L)	capacity bottleneck	fragile reliability	controlled reorganization	smart traffic flow	strategic prioritization	cascade risk	high-value network	delta-robust
	Growth pushes maximum volumes through the system, but the 8 m-deep Nieuwe Maas structurally shifts short-sea shipping to the Oude Maas. Without strong coordination, chronic congestion develops, incident risk increases, and quality of life deteriorates; competitiveness declines because of unreliable transit times.	Total volumes contract, but the route constraint remains: peak pressure on the Oude Maas during storms / closures remains high. Limited investment in Vessel Traffic Services (VTS) and maintenance increases vulnerability to disruptions; delays are less frequent than in Turbo-Global but more disruptive.	Contraction is actively managed: slot booking, caps, and prioritization (essential transport, inland navigation windows). The 12× pressure is leveled off through consolidation and modal shift (rail / inland hubs). The result: greater safety and less disruption, in exchange for accepting lower peak capacity.	Growth and the 8 m-restriction on the Nieuwe Maas structurally move more short-sea / feeder traffic to the Oude Maas. With strong coordination and public support, smart traffic management can handle this in a controlled manner, improving reliability and quality of life, but with less flexibility at peak times.	EU block logic makes short-sea shipping in Europe more important; the Oude Maas becomes a strategic corridor with ~12× passages. Capacity is allocated to 'strategic' flows; smaller operators and local interests lose out. Congestion remains high and social friction increases.	Less funding is available for maintenance / enforcement, while the barrier + shallower water structurally shift pressure elsewhere. Minor disruptions (collision, malfunction, low water) quickly lead to multi-day blockages. Safety and insurance costs increase; cities and supply chains farther inland suffer disproportionate damage.	Volumes decline and value per ton increases: less bulk pressure and predictable circular flows. Traffic on the Oude Maas is tightly regulated and better planned (clean vessels, quiet periods, efficiency standards). Disruption declines and safety and quality of life improve. Capacity remains tight only during exceptional peaks.	Growth with strong regional coordination: integrated water and logistics management (freshwater, nature, shipping) and investment in holding areas, shore power, and incident response. The 12× short-sea pressure on the Oude Maas is accommodated through planning + modal shift + infrastructure measures; the system remains reliable during storms / droughts.
Shallower access depth (Nieuwe Maas becomes 8 m deep)	depth = bottleneck	low relevance	managed downscaling	costly mitigation	loss of competitiveness	maintenance over depth	shallow-ready	two-stage system
	Demand for deep-sea access is high; forced transshipment creates additional costs and supply-chain delays. Without strong coordination, the system becomes overloaded and competitiveness declines.	Trade volumes contract, making the loss of XL access less important. The restriction is noticeable but not decisive.	Lower volumes and strong planning make it easier to reorganize flows. The port adapts with less pressure and fewer stranded assets.	Growth keeps pressure high, but good governance makes a planned offshore hub and an efficient feeder system possible. A major change: not necessarily negative, but one that requires extensive coordination and investment.	Regional trade grows, but fragmented decision-making weakens the connection between the coast and the hinterland. Some freight shifts to more accessible ports.	The 8 m restriction is less constraining, but resources to adapt the supply chain are lacking. Reliability is the bottleneck: deferred maintenance and lower operational quality make the system prone to disruption, with rapid effects on planning, costs, and transit times. Depth is not the problem – the risk of disruption and recovery time are.	A sufficiency / circular economy reduces dependence on deep-sea shipping. The system is well suited to smaller vessels and regional logistics.	Growth stimulates demand for logistics, but strong coordination allows the two-stage system to work: offshore / deep sea + clean feeders toward the hinterland.

large impact
medium impact
small impact

positive impact
neutral impact
negative impact

Estuarine Strategy

ECONOMIC

	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
ENERGY TRANSITION / CIRCULAR ECONOMY Opportunities in the circular economy and use of sediment	fragmented policy			sustainable development and upscaling				strong opportunities
	Given the focus on growth and economic development, unsustainable practices or limited local regulation may result in negative environmental and economic consequences.	While global contraction limits economic growth, the lack of social responsibility reduces opportunities for circular economy projects and sediment use, resulting in minimal development.	Economic contraction reduces economic activity, but the focus on strong social responsibility will encourage sustainable solutions and create modest opportunities for circular economy projects, particularly in sediment management.	Economic growth combined with a high degree of social responsibility will promote sustainable development and the upscaling of circular economy initiatives, particularly in sediment-related industries.	Regional growth may stimulate certain economic activities, but the lack of attention to social responsibility will hinder the development of sustainable circular economies and sediment-related industries.	Regional contraction combined with a low degree of social responsibility will reduce opportunities for circular economy initiatives, limiting the impact of sediment use and related industries.	Although contraction reduces economic activity, the focus on high social responsibility will enable local solutions, but the overall impact on circular economy projects will remain limited.	Regional growth, combined with a high degree of social responsibility, will create strong opportunities for circular economy initiatives, promoting a sustainable future through sediment use and environmentally responsible development.
LANDSCAPE / NATURE Risks to agricultural land	critical risk of salinization	prolonged exposure	managed vulnerability	strategic importance	uneven exposure	residual risk	adaptive	controlled trans-formation
	With global growth and little social responsibility, rapid industrial and agricultural expansion can exacerbate soil degradation, such as salinization, if no measures are taken. This leaves areas vulnerable to saltwater intrusion and agricultural losses.	Although economic contraction may limit agricultural expansion, a lack of social responsibility results in little investment in protection and adaptation against salinization. The impact remains moderate: pressure decreases, but vulnerability persists.	With global growth and little social responsibility, rapid industrial and agricultural expansion can exacerbate soil degradation, such as salinization, because measures are not taken. This leaves areas vulnerable to saltwater intrusion and agricultural losses.	Although global growth may increase demand for agricultural products, high social responsibility encourages investment in sustainable agriculture to limit salinization. Growth may nevertheless exceed the capacity for protection, leaving substantial risks in some areas.	Regional growth would still lead to some agricultural intensification, but low social responsibility would likely result in poor water-resource management, leading to a moderate risk of salinization as mitigation is neglected.	Economic contraction reduces the scale of agricultural expansion, while the lack of social responsibility limits efforts to counter salinization. Although salinization risk remains, overall pressure on these lands is lower, resulting in a lower overall impact.	Contraction reduces agricultural activity, but high social responsibility leads to mitigation measures, such as protecting agricultural land and adopting more sustainable practices against salinization. The impacts therefore remain limited.	Regional growth would stimulate agricultural expansion, but a high degree of social responsibility would likely lead to protective measures. Growing demand for agricultural land could nevertheless still create some salinization risk, although effective policy would reduce its impact.
Role of Westland	disrupted competition	limited survival	strategic reorientation	sustainable growth	reduced integration	downscaled operation	adaptive shift	successful adaptation
	High competition for water / energy + weak governance make costs volatile and salinity difficult to manage.	Demand and investment decline; adaptation is limited, causing the cluster to consolidate and struggle to modernize.	Limited growth reduces pressure; policy support steers the cluster toward efficient and resilient water use.	Strong planning provides a water strategy (reuse, buffers) and clean energy, maintaining export capacity despite salinity stress.	Regional markets grow, but fragmented water allocation and infrastructure decisions lead to uneven performance and local conflicts.	Lower demand limits expansion; the cluster continues to exist, but with limited innovation and weak long-term resilience.	The cluster becomes smaller but more resilient: closed-loop water use, energy efficiency, and a partial transition in land use.	Regional coordination secures water and energy supplies and positions Westland as a high-tech, environmentally responsible food cluster.

large impact
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positive impact
neutral impact
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Estuarine Strategy

SOCIAL

	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
POPULATION / CITY Potential for the formation of a new community	fragmented Rapid growth and market-driven development leave little room for community formation. Social ties remain weak and individualized.	social erosion Economic stress and limited public capacity reduce collective initiatives. Communities withdraw rather than reorganize.	community stabilization Strong social structures prevent breakdown, but limited resources constrain the emergence of new communities.	citizen-driven communities Investment, participation, and shared water challenges enable new forms of neighborhood organization and social cohesion.	unequal social outcomes Growth creates opportunities in some places, but weak coordination limits broader community formation.	social fragmentation Contracting economies and weak institutions limit trust and collective action despite shared risks.	solidarity under pressure Strong social values encourage mutual support and local networks, but economic constraints limit their ability to upscale.	place-based gemeenschappen Regional coordination and inclusive planning support new community identities around water, landscape, and shared infrastructure.
FRESHWATER DEMAND Competition for freshwater supply	intense competition Rapid growth in demand from industry and cities overloads freshwater systems. Weak coordination leads to conflicts, shortages, and high systemic risk.	scarcity stress Overall demand declines, but underinvestment and weak governance create unequal access and recurring local shortages.	managed scarcity Lower demand reduces pressure, but limited resources constrain system improvements. Allocation is coordinated but vulnerable.	balanced allocation High demand is accommodated through strong governance, efficiency measures, and prioritization. Competition exists but remains manageable.	fragmented competition Growing regional demand collides with weak coordination. Some sectors secure their supply, while others face shortages and political tensions.	conflict in decline Declining capacity and weak governance increase competition. Emergency measures predominate, with a high risk of social and economic conflict.	priority rationing Demand is lower and allocation more equitable, but scarcity remains. Trade-offs are explicit and politically sensitive.	resilient sharing Coordinated planning, reuse, and regional agreements allow multiple sectors to coexist with limited pressure on freshwater.
INVESTMENTS IN FLOOD SAFETY Addressing increased water risks in the urban area	critical overload Rapid urban growth increases exposure, but weak governance delays investment and coordination. Flood risks rise faster than protection capacity, resulting in systemic vulnerability.	 Economic contraction limits public budgets, while low social responsibility constrains collective action. Water risks steadily increase as maintenance and upgrades are deferred.	plans without funding Awareness and planning are strong, but lower economic capacity limits implementation. Water risks are recognized but only partly addressed.	managed risk High growth increases exposure, but strong institutions and early investment keep urban water risks under control through proactive adaptation.	uneven protection Growth increases risk levels, but fragmented governance leads to uneven investment. Some districts are protected while others remain vulnerable.	erosion of safety Contracting budgets and weak coordination reduce maintenance and emergency capacity. Urban flood safety therefore gradually deteriorates.	minimal resilience Despite limited resources, strong social coordination prioritizes essential protection. Risks remain but are managed at a basic level.	resilient adaptation Coordinated regional investment and broad public support enable gradual improvements. Urban water risks are actively reduced step by step.

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Estuarine Strategy

SOCIAL

	SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4	SCENARIO 5	SCENARIO 6	SCENARIO 7	SCENARIO 8
	global growth low responsibility	global contraction low responsibility	global contraction low responsibility	global growth high responsibility	regional (EU) growth low responsibility	regional (EU) contraction low responsibility	regional (EU) contraction high responsibility	regional (EU) growth high responsibility
Adapting to water conditions in areas outside the flood defense system.	poor adaptation	poor adaptation	plans, but no funding	planned adaptation		poor adaptation	plans, limited implementation	
	Rapid growth increases exposure in areas outside the flood defense system, but weak governance and low social responsibility delay coordinated adaptation. Private actors act largely independently, resulting in uneven protection and high vulnerability to flooding.	Economic contraction severely limits public and private investment. Areas outside the flood defense system lack the resources to adapt, resulting in deferred maintenance, increasing risks and, ultimately, insufficient flood resilience.	There is considerable awareness and planning but limited economic capacity hampers implementation. Adaptation strategies largely remain on paper, leaving areas outside the flood defense system only partly protected.	High growth combined with strong governance enables proactive, coordinated adaptation. Investment in flood-resilient design and emergency access keeps areas outside the flood defense system operational despite greater exposure.	Growth increases risks, but fragmented governance produces uneven outcomes. Some strategic zones are upgraded, while others lag behind, resulting in spatial inequality in flood protection.	Contracting budgets and weak coordination undermine adaptation. Emergency measures predominate, long-term resilience declines and areas outside the flood defense system become increasingly vulnerable.	High social responsibility supports basic coordination, but economic contraction limits investment. Adaptation measures remain selective and modest: risks are managed but not structurally reduced.	Regional coordination and sustained investment enable the gradual upgrading of areas outside the flood defense system. Flood risks are actively managed through flood-resilient design, shared standards and long-term planning.
LANDSCAPE / NATURE Local cultural tensions	cultural conflict	entrenched resistance		guided transition	uneven acceptance	cultural polarization		cultural coadaptation
	Rapid changes in land use, driven by top-down water and economic priorities, displace farming communities. Weak social dialogue increases resistance, particularly in conservative rural areas. Tensions are acute and politicized.	Economic pressure hardens positions. Farmers and villages resist changes in land use as a survival strategy. Limited state capacity hampers mediation, resulting in prolonged cultural stalemates.	Strong social structures enable dialogue and compensation even under conditions of scarcity. Cultural resistance remains, but conflicts are contained through participatory planning and trust-building.	Changes in land use are accompanied by public participation, cultural recognition and long-term support. Tensions remain but are incorporated into a broader shared narrative of adaptation and stewardship.	Regional priorities displace local identities. Some areas adapt, while others strongly resist. Cultural tensions become spatially uneven and politically sensitive.	Dwindling resources and weak governance increase distrust. Changes in land use are seen as an imposed sacrifice. Conservative rural communities become focal points of resistance and identity conflict.	Although change is difficult, strong local networks and shared responsibility prevent escalation. Cultural identity is respected, slowing transformation but preventing major conflicts.	Regional coordination makes it possible to frame changes in land use as collective protection. Local traditions are integrated into landscape design and governance, turning tension into negotiated change.

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negative impact

Appendix C

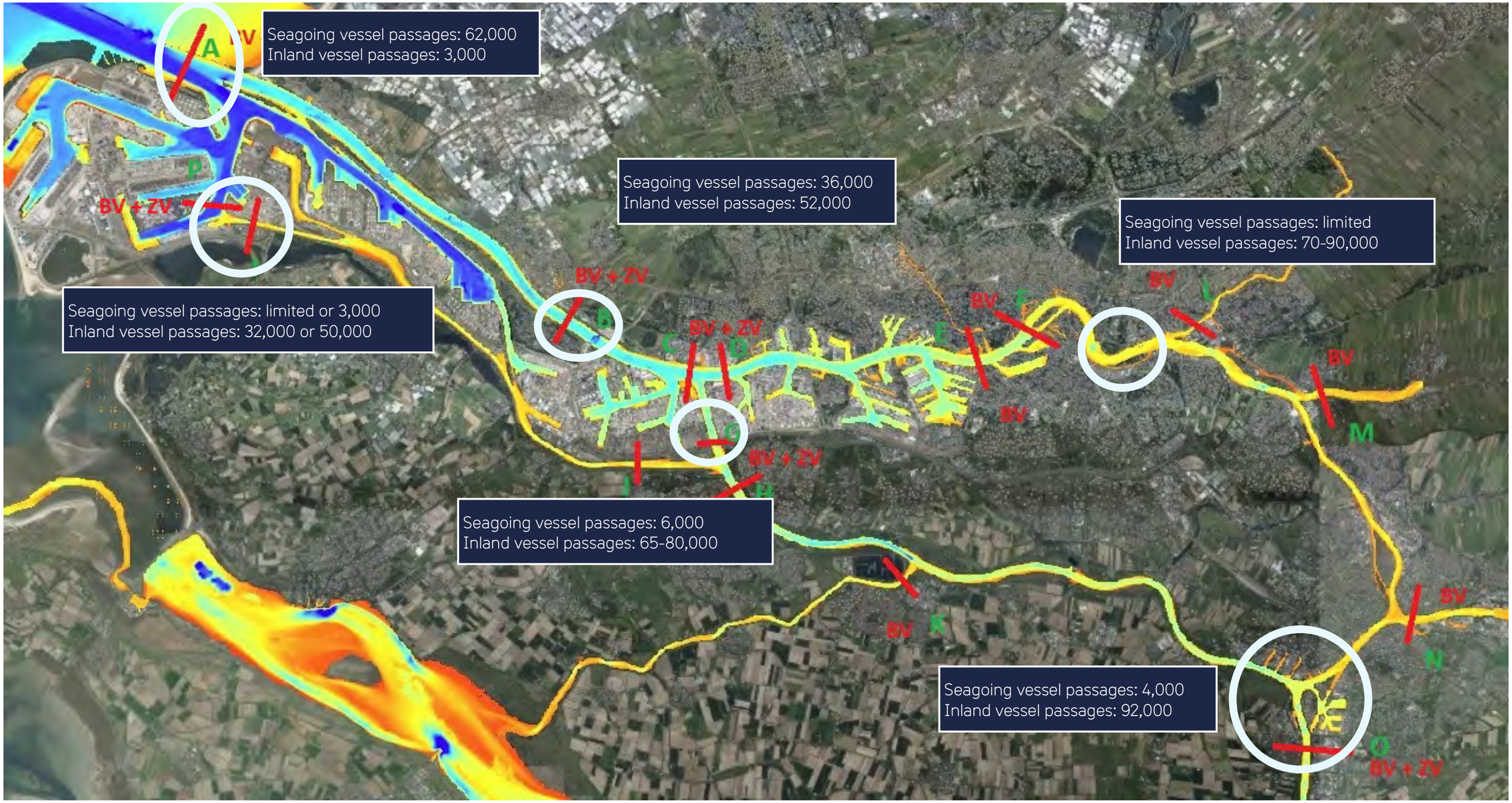
Shipping – Passages and Locks

IJmuiden Sea Lock:

- 10,000 to 12,000 seagoing vessels
- Space required: 3,000 × 600 meters
- Rotterdam factor 3–6

Volkerak Inland Shipping Lock:

- approx. 115,000 inland vessels + recreational vessels
- Space required: 3,000 × 400 meters



Shipping – passages per year (Port of Rotterdam Authority N.V., 2025)