The delta region between Rotterdam and Antwerp is a prime example of an area where spatial developments face increasing complexity. Local initiatives for developing urban expansions, recreation areas, nature and industrial complexes must harmonize with measures such as adequate flood protection, sufficient freshwater supply, restoration of ecosystems and large-scale infrastructure over the longer term.

This complexity demands a new approach to spatial planning and design. This book is the result of a research project that aimed to develop such a new planning practice. The research was carried out in collaboration by a consortium of universities, centres of expertise, and engineering and design firms. The research conceived of the Southwest Delta of the Netherlands as a laboratory for the new approach, which has nonetheless also proven relevant to other regions dealing with a similar level of complexity.

New perspectives on urbanizing deltas

must

Integrated Planning and Design in the Delta (IPDD)

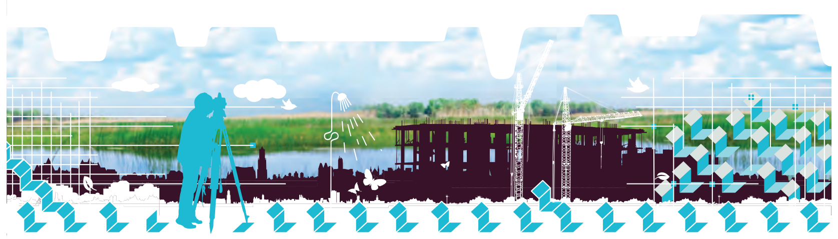
New perspectives on urbanizing deltas

a complex adaptive systems approach to planning and design

Urban Regions in the Delta

Research team

Urban Regions in the Delta



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VALORISATIEPROGRAMMA DELTATECHNOLOGIE & WATER

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Integrated Planning and Design in the Delta (IPDD)

New perspectives on urbanizing deltas

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THE RESEARCH PROJECT AND ACKNOWLEDGEMENTS

This book calls for a new approach to spatial planning in complex urbanized delta regions. It is the result of the research project entitled “Integrated Planning and Design in the Delta” (IPDD), carried out in the framework of the “Urban Regions in the Delta” programme of the Netherlands Organisation for Scientific Research (NWO).

The research was conducted between 2011 and 2013 by a consortium of universities, centres of expertise and private-sector consulting firms, playing in a 3-4-4 formation: three universities (Delft University of Technology, Wageningen University and Erasmus University Rotterdam), four centres of expertise (Deltares, TNO, the PBL Netherlands Environmental Assessment Agency and Geodan) and four consulting firms (MUST Stedebouw, H+N+S Landschapsarchitecten, Royal Haskoning DHV and HKV Consultants).

The research was guided by an advisory group made up of the Delta Programme, the World Wide Fund for Nature (WWF) and the Port of Rotterdam. It focused mainly on the area of the Southwest Delta between Rotterdam and Antwerp. Many agencies and individuals from this region contributed to the research by participating in interviews, supplying information and taking part in workshops. We thank them all for these contributions, without which this book would not have been possible.

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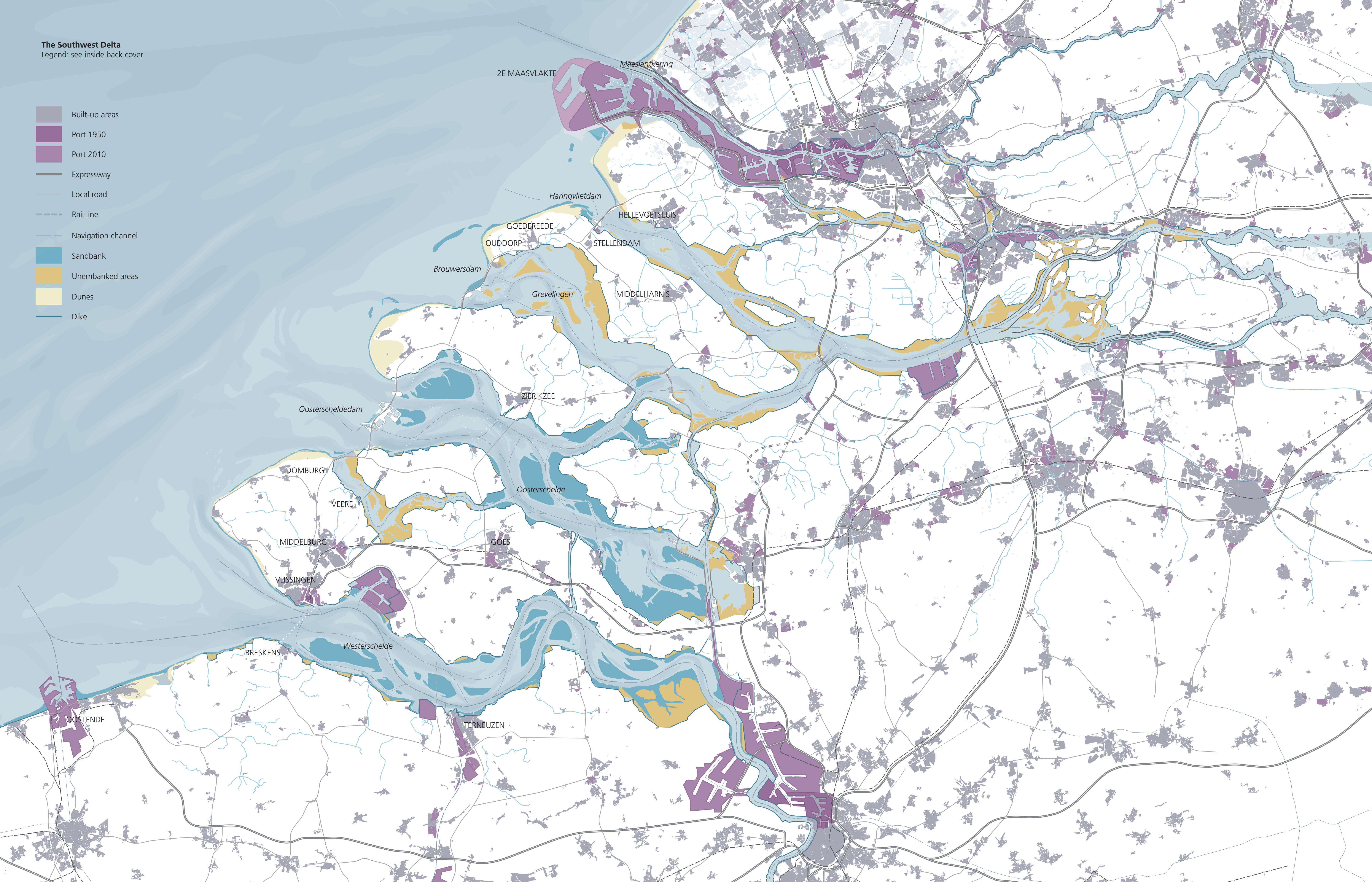


The Southwest Delta
Legend: see inside back cover
Built-up areas
Port 1950
Port 2010
Expressway
Local road
Rail line
Navigation channel
Sandbank
Unembanked areas
Dunes
Dike
2E MAASVLAKTE
Maeslantkering
Haringvlietdam
HELLEVOETSLUIS
GOEDEREEDE
OUDDORP
STELLENDAM
Brouwersdam
Grevelingen
MIDDELHARNIS
ZIERIKZEE
Oosterscheldedam
DOMBURG
VEERE
Oosterschelde
MIDDELBURG
GOES
VLISSINGEN
BRESKENS
Westerschelde
OOSTENDE
TERNEUZEN

Chapter 1

Introduction

After nearly half a century of the "Dutch Planning Doctrine", the time is now ripe for a new approach to spatial planning and design. In complex urban areas in particular, the question is no longer how to register and guide spatial development. Instead, the question is how to enable conditions so that areas can adapt to changing circumstances. The Southwest Delta can be viewed as a laboratory for such an adaptive approach to planning.

1.1 Background and purpose

Nowhere on earth are urbanization, population growth and economic development occurring more explosively and on a larger scale than in the world's large river deltas (UN Habitat, 2006). At the same time, these regions are increasingly vulnerable to flooding, and their natural environment is under immense pressure. For these regions in particular, new approaches to planning are needed that can help achieve a dynamic balance between safety, ecological values, economic growth and quality of the living environment.

The delta of the Rhine, Meuse and Scheldt rivers is a prime example of such a region. This large river delta has long been the subject of a strong planning and design culture. In the postwar decades, the Netherlands developed an institutional framework for spatial planning policy characterized by a strong role for the national government, which acted as the driver and "director" of spatial planning. With this brand of policy, which gained international currency under the label "Dutch Planning Doctrine" (Faludi and Van der Valk, 1994), the Netherlands acquired a leading global position as a model country for spatial planning.

The effectiveness of this doctrine, however, has been exhausted, though development of plans according to its precepts has continued undiminished. These many plans come from a variety of different sectors, pertain to a variety of different scales and moreover also work with a variety of different time horizons. Many of the more recent plans and initiatives have remained unimplemented and – despite their attractive launch presentations – have disappeared forgotten over time, often because of their failure to fully convince the many different stakeholders. In this complex situation, the national government can no longer succeed in the role of central "director" keeping the overall process on track. At the same time, many of the stakeholders are increasingly asking themselves how a situation could be created in which the many different objectives of the many different actors, at the different scale levels and with their different time horizons, could be linked with one another in such a way that new prospects for action might emerge.

In this book, the delta of the Rhine, Meuse and Scheldt rivers serves as the "laboratory" for developing such a new perspective on planning, in the form of an adaptive approach to planning. Development of this renewed planning strategy was given added impetus by the Netherlands' Second Delta Programme, which entered a new phase in 2014.

1.2 Features of the Southwest Delta

In this book, we focus particularly on the "Southwest Delta" region – roughly, the area between Rotterdam and Antwerp, and between the North Sea and the line connecting the Dutch cities of Dordrecht and Bergen op Zoom, with emphasis on the region surrounding the Haringvliet and the Hollands Diep rivers. In this area, the traditional "Dutch Planning Doctrine" was applied especially actively and often during the postwar decades. Construction of the

Delta Works, alongside active industrial, agricultural and spatial planning policy, transformed this region within a matter of decades from a disadvantaged, peripheral and vulnerable area into a prosperous, accessible and safe region of the Netherlands.

The Southwest Delta is a complex system of spatial units (cities, ports, agricultural lands, nature areas and basins) interconnected via networks of roads, waterways and flows of people, goods and information. It is also a dynamic system that is developing under the influences of changes in demography, global economics, mobility and climate.[1]

Economic and urban development

The Southwest Delta can be viewed as a particular type of urbanized delta region. With regard to economic and urban development in such regions, a variety of challenges can be identified. Humans settled early on in the deltas due to the highly fertile lands and plentiful food and water available there, as well as the strategic positioning in relation to global transportation networks. Agriculture, fisheries, cargo traffic and goods processing are core activities encountered in almost any delta, including the Southwest Delta. Two of the largest ports in Europe, Rotterdam and Antwerp, are located here, as are agricultural lands that rank among the most fertile in Europe, alongside multiple fishing ports and the heart of the Dutch mussel and oyster cultivation industry. All of these sectors are in a constant process of evolution, towards innovation, intensification and extensification, with these often occurring side by side and competing with one another. Given the burgeoning challenges of food provision worldwide and the fact that deltas offer immensely fertile lands for agriculture, livestock and fisheries, this mutually evolving, dynamic development can increasingly be considered a threat to the global food supply (De Cock Buning, 2008).

Flood safety

Growth of the population and economic activity in delta regions has also meant that a growing segment of the population and economy is increasingly vulnerable to flooding and diminishing freshwater supplies. This vulnerability is compounded by ongoing climate change, the consequences of which (such as rising sea level, increased river discharge and more erratic precipitation) place delta regions under increasing stress (Bucx, Makaske & Van de Guchte, 2011). However, the introduction of new flood prevention and water management systems has in most cases become extremely complex, due to financial, technical, administrative and/or spatial limitations (Stalberg & Vrijling, 2009).

Nature values

Urban and economic development in deltas, coupled with the introduction of new flood prevention and water management systems, have had drastic consequences for the natural environment and ecosystems of the deltas. In economic terms, deltas can be viewed as the richest ecosystems on earth (Costanza D'Arge, Farber, Grasso, Hannon, Limburg et al., 1997). It is the delta regions' role to link the freshwater ecosystems of the rivers with the saltwater ecosystems of the seas and oceans. As a result, the effects of changing or even completely disappearing delta region ecosystems extend much further than just the delta regions themselves (Saeijs, 2008).

[1] This development perspective is explicit, for example, in the mandate of the Second Delta Committee, officially named the "Committee for Sustainable Coastal Development" (often abbreviated as the "Veerman Committee" after its chairperson, the former Minister of Agriculture Cees Veerman). This government committee was established in September 2007 to advise the Dutch government on the impact on the Dutch coast of the expected rise in sea level, discharge from the large Dutch rivers and other climatic and social developments up to the twenty-second century as well as to provide recommendations on strategies for the sustainable development of the Dutch coast and the added value of these strategies in the long term for the Dutch hinterland and society. The committee published its report in September 2008 (Deltacommissie, 2008).

The energy transition

The issue of energy transition is also one that has been discussed extensively in relation to delta regions. While in recent years the Southwest Delta has developed into a foremost hub for global transportation and fossil fuel processing (with the port and industrial areas of Rotterdam, Antwerp, Moerdijk and Terneuzen), this same delta region is also considered a key location for the generation, storage and processing of new forms of energy. Various ongoing studies are investigating the potential of the Southwest Delta as a location for biomass storage and processing (Port of Rotterdam in 2012), placement of large numbers of wind turbines (Feddes, 2010) and construction of tidal power stations (Vrijling, Duivendijk & Jonkman, 2008)

The evolving challenge

The nature of the challenge posed by urban development is undergoing fundamental change. Throughout history, urban forms of settlement have always evolved in close association with the dominant economic activities: agriculture, fisheries, ports and industry. However, the considerable improvements achieved in labour productivity in these sectors in the latter twentieth century sharply diminished the direct relation between the urban population and these economic sectors (in terms of employment). Since then, cities in the Southwest Delta region, such as Rotterdam, Antwerp, Dordrecht and Vlissingen, have attempted to create a more diverse economic profile, emphasizing for example, services and knowledge-based activities. For their part, the "traditional" delta commercial sectors – such as ports, industry, agriculture and fisheries – have also come to realize that their survival in the global marketplace will also depend on knowledge generation and excellence in service delivery (Vanelslander, Kuipers, Hintjens & Van der Horst 2011). The types of companies active in today's knowledge- and innovation-intensive sectors and the workers they employ place new demands on their urban environment; that is, it has to be appealing not only from an economic standpoint, but also an attractive place to live and enjoy leisure time.

Delta regions have a major advantage in this regard. Since the 1980s, numerous new urban waterfront locations have been developed in port cities and delta areas both within the Netherlands and abroad, in anticipation of this evolution (Meyer, 1999). On the scale of the delta region as a whole, there is also a growing awareness of the significance of the region as a valuable landscape in relation to sustainable urban development (Verbeeck, De Koning & Elshout, 2006).

In sum, we can conclude that a key issue in the Southwest Delta is to find a dynamic balance between economic development, urban development, agricultural development, safety (especially flood protection) and ecology. Achievement of such a balance, however, is complicated by the high degree of uncertainty, especially over the longer term, regarding many aspects of urban and economic development, as well as on the issue of climate change and its consequences for sea level rise, river discharges and precipitation.

1.3 The challenge: Towards a dynamic balance between sectors, scales and time horizons

At the time this book was published, the issue of ensuring the adequacy of the Netherlands' flood protection system into the future had again become a topic of debate, particularly in relation to the plans set out by the Delta Programme. In addition, plans and objectives were being presented by a variety of actors, such as the Rotterdam Port Authority, which had announced plans to improve its linkages with other ports in the region, and various municipal governments, private developers and environmental organizations, which had launched ideas for relatively small-scale urban developments, recreation areas, nature conservation zones or combinations of these. Yet on the question of how all these different plans and objectives might relate to one another and how they could be combined, no clear answer had as yet emerged. On the larger, national scale the Dutch government would like to restrict its involvement in spatial planning to a limited number of key tasks, including infrastructure development for shipping and transportation and for flood protection (Ministry I & M, 2012).

A significant field of tension and uncertainty has arisen where developments, plans and initiatives emerging from these two different scale levels – the national and the regional – meet. At both scale levels, the developments proposed affect not only a range of different sectors and scales, but also involve different time horizons. While many of the smaller-scale initiatives focus mainly on achievement of short-term and medium-term goals (1–10 years), large-scale infrastructure requires a much longer period of planning and construction, meaning furthermore that there is a greater degree of uncertainty about the necessary magnitude and nature of the infrastructures concerned. This is particularly true regarding infrastructures for flood protection and freshwater supply. Given the longer term uncertainties regarding climate change, sea level rise and river discharges, it is impossible to determine exactly how high and strong flood defences will need to be over a period of 50 to 100 years. There is thus a good chance that small-scale, relatively short-term initiatives and large-scale, longer-term projects will get in each other's way, which could cause delays and/or capital destruction of either or both. The question is how we can transform the risk of delays, paralysis and capital destruction into opportunities for linkages and mutual support among the various different initiatives and objectives.

1.4 Adaptivity in planning and design: The urbanized delta as a complex system

In all branches of science a shift of thinking is taking place, away from thinking in controlled systems towards a style of thinking that pays more attention to the complexity of systems. Applied to spatial planning, complex systems theories offer opportunities for insights into the extent that subsystems are defined by their own dynamics and pace, while at the same time influencing and being influenced by others. This connectivity between subsystems gives rise to unpredictability, for example, uncertainty about how exactly subsystems, and hence also the system as a whole, will develop into the future. This results in a very limited ability to manage these complex systems and guide them towards outcomes that have been set out in advance (see, e.g., Almendinger, 2002; De Roo & Porter, 2007).

Spatial planning that is based on complexity theory is not geared to the question of how systems can be planned and controlled, but rather towards determining how systems can sustain themselves and recognizing factors that might bring a system completely out of balance and lead to a "critical transition", a fundamental change of the entire system (Scheffer, 2009).

Factors that influence the nature and development of a complex system are robustness, resilience and adaptability. "Robustness" refers to the extent that a complex system is capable of resisting sudden, unexpected extreme conditions so that such conditions do not lead to a breakdown of the entire system. In the Netherlands, we expect (hope) that our flood defences are robust enough to withstand severe storms – of a gravity that can statistically be expected to occur only once every 10,000 years.

"Resilience" refers to the extent that a system is, over time, able to recover, after it has suffered severe damaged, disruption or disturbance due to extreme conditions. "Adaptability", finally, refers to the ability of a system to adjust adequately to changing conditions that were difficult to foresee or prepare for or extremely uncertain.

The Southwest Delta itself can be viewed as a complex system with many subsystems, such as the flood protection system, the ecosystem, the economic system and the urban system. Each of these subsystems has its own dynamic, and this factor alone makes it very difficult to closely connect or to integrate them.

The question is how can we make this delta system, in addition to robust and resilient, in particular, adaptive, so that it can cope with uncertainties such as those in the area of climate change and sea level rise, in ecology and biodiversity and in economics and urban development.

For development of the Southwest Delta into a "complex adaptive system" (CAS), a good understanding is needed of what this exactly entails. Chapter 2 elaborates on this in more detail.

Current debate on spatial planning, design and governance

Changes in spatial planning practices and new insights derived from complexity theory have given rise to a variety of new planning methods over the past decade. These planning methods have focused primarily on the evolving social and administrative context. Important cornerstones for renewal in the spatial planning field were laid, for example, by Forester (1989), Healy (1997), Faludi and Altes (1994) and Innes (1998), with the introduction of communicative planning (also known as participatory or collaborative planning). This approach to planning is strongly opposed to top-down, blueprint-like planning models. The concept of the self-organizing city (Portugali, 2000) is another approach that arose as a reaction against the traditional planning model. In the self-organizing city, bottom-up processes are considered to be the key driving forces that shape cities and urban regions. In the Netherlands, too, a variety of models have been developed in response to the traditional approach to planning. These have included the "Actor Relational Approach" (Boelens, 2009; 2010), "4B-Step Planning" (De Rooij, 2006), "Mixed Scanning 'New Style'" (Zonneveld, Waterhout & Trip, 2009) and "Adaptive Delta Management", this last of which is being applied in the Delta Programme (Rhee, 2012).

In most of these planning methods, design plays primarily a following role. The main idea is that actors within a region usually have the clearest notion of what should happen there and, with the support of expert data and via consultative processes, they will be able to arrive at a consensus, which can then be "translated" into an urban design. Two major exceptions are "A Plan that Works" by Hajer, Feddes and Sijmons (2006) and the "Design Dialogue" approach by De Jonge (2009). Both of these call for design to function as a research tool for delivering novel, unexpected and surprising solutions to complex spatial planning issues, leading to new understandings and serving to bring actors together. In the "Design Dialogue" approach by De Jonge, design has the additional task of providing opportunities for new governance concepts.

The method developed in this book builds substantially on De Jonge's "Design Dialogue". Figure 1.1 illustrates how the various calls for new spatial planning methods can be positioned in relation to one another.

1.5 Towards an adaptive approach to planning: A guide for readers

The adaptive approach to planning developed within the IPDD project consists of three stages of activities: conceptualization, envisioning and development of an action perspective. First, we have to understand how the complex system of the Southwest Delta fits together, how it works. Second, based on that understanding, improvements can be elaborated as part of a coherent vision. Third, an action perspective is developed with which the vision is rendered practically applicable and achievable.

- Conceptualization refers to theory-forming and generation of the knowledge necessary for understanding the system and its environment. We view the system's current state as just one point in its long-term overall evolution. Conceptualization activities, therefore, involve parallel study of, for example, theories of complex adaptive systems (Chapter 2), the historical evolution of the system (Chapter 3), possible futures for the system (Chapter 4) and actors' current desires and plans (Chapter 5 and Chapter 6).

- Envisioning refers to the joint identification of core qualities and possibilities for synchronization, during which a collective process of vision-forming can take place, for example, in *"soft spaces"* (Chapter 7). Knowledge derived from conceptualization activities will considerably accelerate this process.

- The action perspective refers to implementation: the development of a tangible master plan and projects to be implemented following from it. Development of the action perspective requires study of the technical, financial, procedural and legal feasibility of the proposed actions (Chapter 8).

An important question is to what extent the approach developed in this book might also be relevant to other urbanized delta regions in the world. There is also the related question of to what extent other delta regions might provide inspiration for and new perspectives on the situation in the Netherlands. Chapter 9 addresses these questions, analysing three urbanized delta regions outside the Netherlands.

Finally, Chapter 10 draws conclusions on the significance of the research presented for science, for professional practice and for policies related to complex areas such as the Southwest Delta.

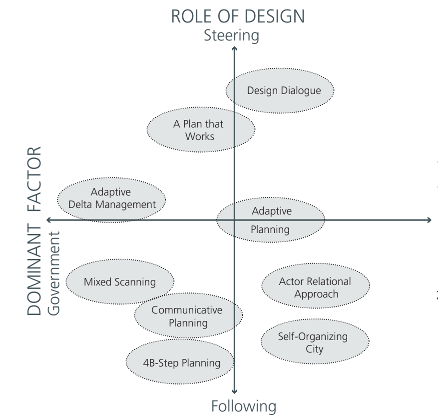


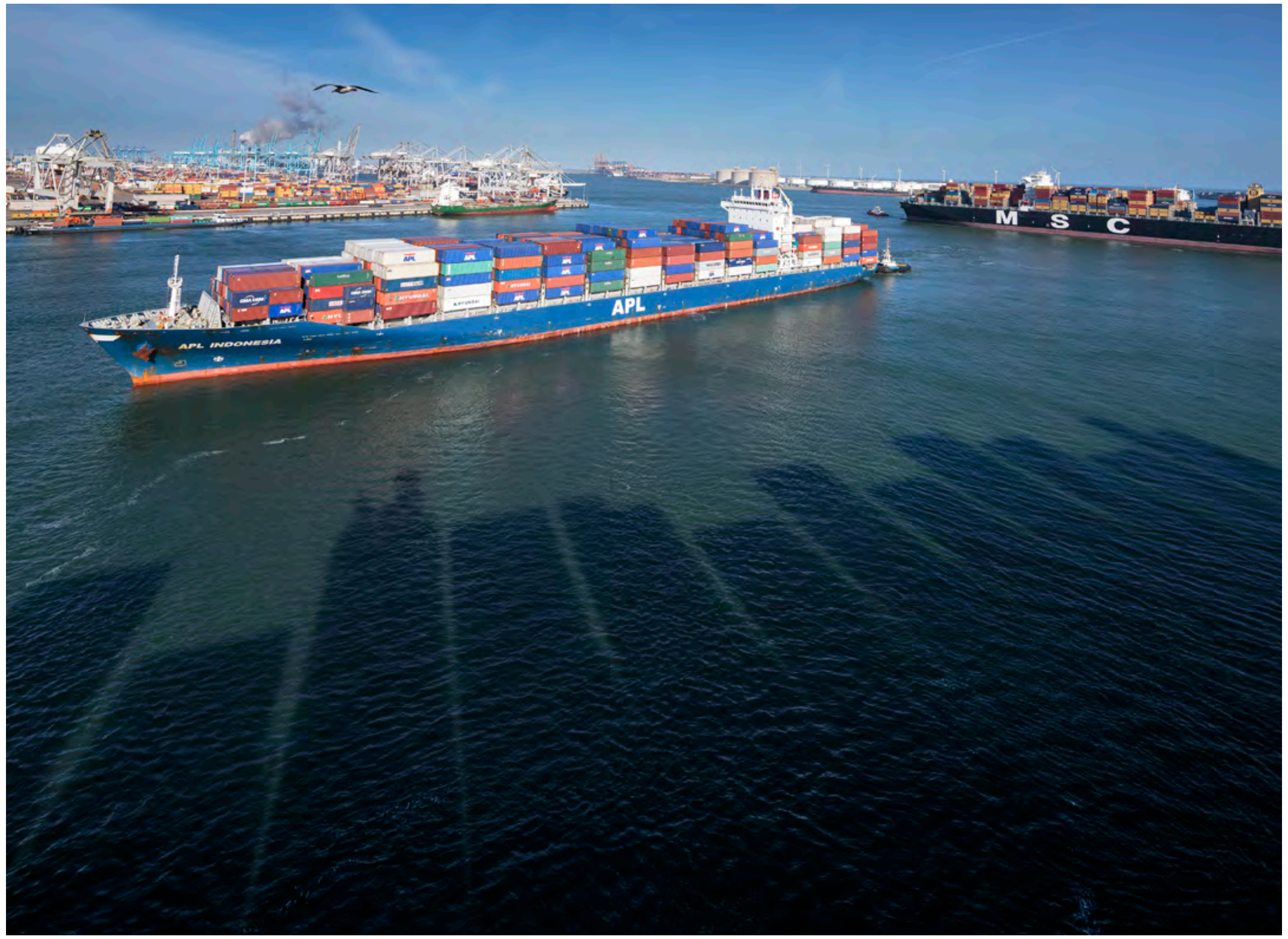
Figure 1.1 New planning methods in relation to one another

Maeslantkering

Maeslantkering

Second Maasvlakte under construction

Second Maasvlakte under construction



Rotterdam, Europort

Rotterdam, Maashaven

Rotterdam, Botlek

Rotterdam, Caland Canal

Ouddorp

North Sea beach

Goedereede

Stellendam

Hellevoetsluis

Hellevoetsluis

Hoeksche Waard

Hoeksche Waard

Goeree-Overflakkee, Middelharnis

Goeree-Overflakkee, Middelharnis

Voorne-Putten, wetlands near Zuidland

Hoeksche Waard, Zuid-Beijerland

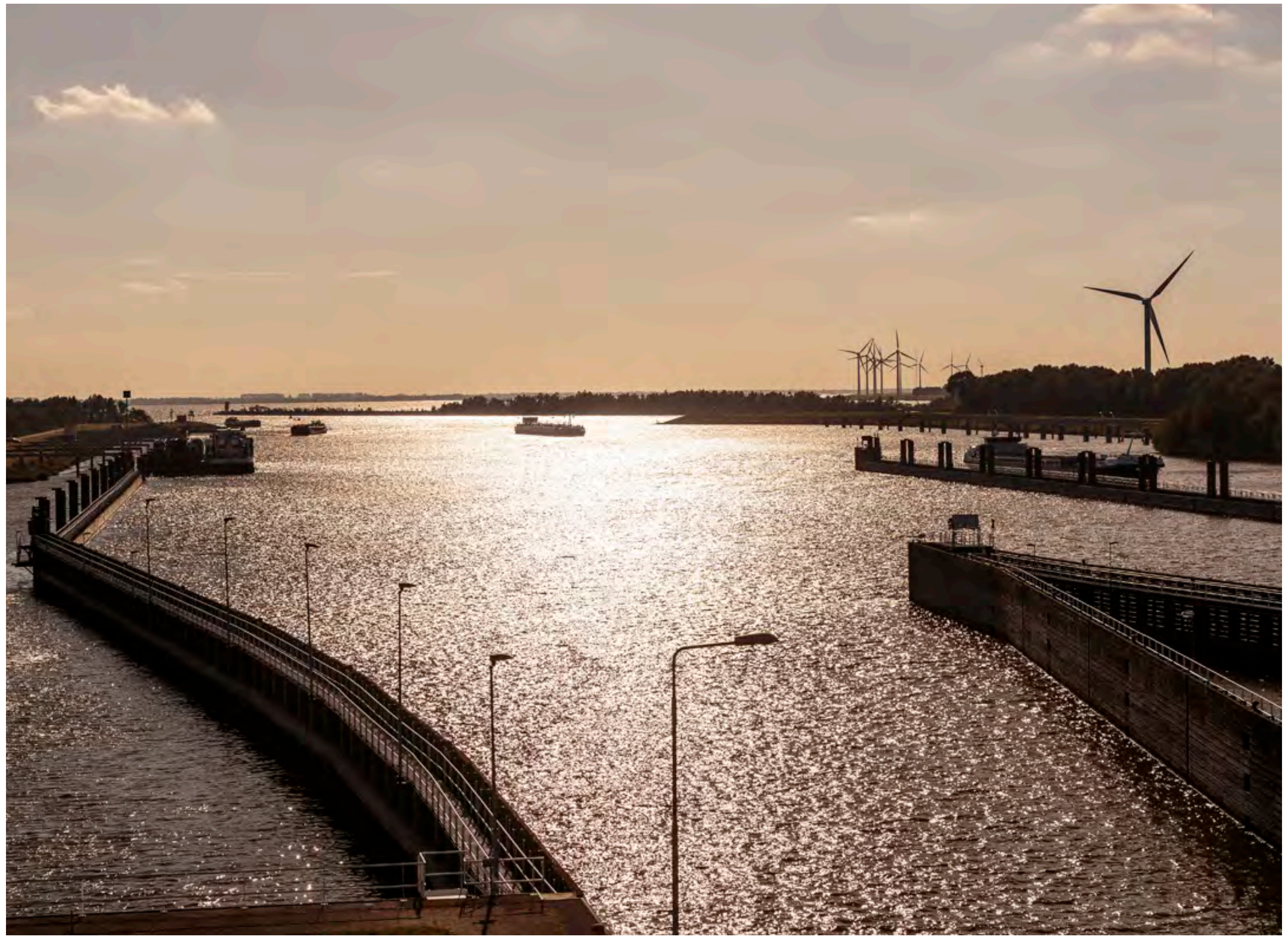
Hoeksche Waard, Zuid-Beijerland

Goedereede, Goeree-Overflakkee

Hoeksche Waard, Oud-Beijerland

Hellegastplein, Haringvliet Bridge

Haringvliet



The Volkerak Locks

The Volkerak Locks

The Haringvliet Dam

Chapter 2

Urbanized deltas as complex adaptive systems

An urbanized region such as the Southwest Delta can be viewed as a complex system, in which numerous subsystems influence each other and are dependent on one another. A complex system is also influenced by its environment, which itself is in constant change. The nature of these changes is uncertain however, especially over the longer term. If conditions are in place that enable the system to adapt to uncertain future changes, we can then speak of a *"complex adaptive system"* (CAS).

2.1 Introduction

Application of complex systems theories can help designers, planners, policymakers and stakeholders in urbanized deltas find appropriate responses to the considerable challenges facing these regions and assist them in dealing with the uncertainties that these challenges present. By viewing a delta as a complex adaptive system (CAS), key planning issues can be identified more easily and new perspectives on planning can emerge. The essence of the "CAS" approach is that an urbanized delta is perceived as a complex and dynamic whole made up of different component parts (sectors) which continually influence one another and together as a whole are influenced by many different types of social, biological and physical developments (Giacomoni, Kanta & Zechman, 2013).

Applied to a delta region, the CAS approach targets the *adjustment* ("adaptation") of the region to possible future developments and events. To enable such adaptation to occur, sectors in the region must be *aligned* ("synchronized"). To actually achieve such adaptation and synchronization in practice, policymakers and stakeholders have to be *activated* ("mobilized") (compare Teisman, Van Buuren & Gerrits, 2009). The CAS approach also provides suggestions for effectively organizing activities such as conducting foresight studies for a region, envisioning and governance. These suggestions are mainly aimed at helping policymakers and stakeholders gain a better grasp on the issues at stake, given their complexity, dynamism and unpredictable nature.

2.2 The importance of the CAS approach

The systems approach to planning has been in wide use since the 1960s. This was initially mainly due to the influence of the physical sciences. The basic principle was that systems existed not only in physical, but also in biological and social constellations, and that the character of these systems changed and evolved in response to changing roles in and interrelationships between subsystems. In the field of spatial planning, a system was seen as a mechanism that could be adjusted and managed via communication between its component parts (Banham, 1967; McLoughlin 1969). Planning as an activity was considered a form of social management, and application of "scientific" knowledge and "objective" methods was emphasized in all aspects of the planning process. The focus of planning, according to the systems approach, should be on changes in society, and planning itself also had to take potential changes into account. This approach was very different from the design tradition previously dominant in planning. Design had formerly been seen as an activity focused on creation of a final product; similar to the role of design in an industrial production process. Application of this product-oriented approach in the field of spatial planning, however, had been a strong contributor to a growing disconnect between the disciplines of spatial planning and spatial design.

The systems approach is still in widespread use, but over time has changed considerably in character, not least (again) under the influence of newer sciences, such as the social sciences, which gradually began to pay greater attention to the often erratic, intermittent and unpredictable ways that systems evolve (M. Mitchell, 2009; S.D. Mitchell 2009). Small changes in the environment of a system or in relationships between subsystems were often found to lead to large, unanticipated changes in a system as a whole. This recognition put the "planning as a control mechanism" idea into a more modest perspective. In recent years, more emphasis has been placed on concepts related to complexity, chaos, uncertainty and the fact that many processes are often marked by non-linear paths of evolution (De Roo & Silva, 2010).

Instead of aiming for desired end-situations, greater emphasis has come to be placed on preventing undesired situations, such as the seizing up of a system or total disruption or collapse of a system. Scientific research and, increasingly the disciplines of planning and design as well, have begun to focus more on reducing systems' vulnerability and to explore how systems can be made more robust, resilient and adaptive. For this reason, systems theories have in recent years paid particular attention to complex adaptive systems. Complex systems are characterized by a large number and diversity of components and relationships between the components, as well as a high degree of uncertainty regarding the system's current state and its path of future development. If a complex system is capable of adapting to its environment, either by itself, with human intervention or by some other means, then it is called a "complex adaptive system" (CAS) (Van Bilsen, Bekebrede & Mayer, 2010).

This shift in systems theory can be seen as a transition from a mechanical worldview to an organic worldview. Instead of attempting to bend systems entirely to our own will and purposes, we now recognize the impossibility, and even the undesirability, of absolute control and manipulation of complex systems. In the physical sciences, in the social sciences, and increasingly also in the spatial disciplines, objectives have shifted towards the evolution of systems and, insofar as possible, creating space for and accommodating systems' continued evolution. It has become clear that any effort to pursue a "final blueprint" for a system is likely to become a straightjacket that actually hinders the system's further evolution, leading ultimately to its failure. The accent has shifted to the detection of critical factors that could stand in the way of the further evolution of a system.

One critical factor for the survival of a complex system is its ability to cope with both sudden, short-lived disturbances (e.g., a severe storm) and longer-term structural changes in the environment (e.g., climate change). As already noted in Chapter 1, a system can try to protect itself against short-term disruptions (robustness) and prepare itself as well as possible to recover from a short-term disturbance (resilience), but in the long term it is the system's capacity to adjust to changing conditions (adaptation) that is of foremost importance. This refers to the system's ability to adjust to the structural changes in its environment. If a system is unable to do this, it enters a state of critical transition, or crisis (Scheffer, 2009).

The need for an urbanized delta to have sufficient adaptive capacity relates both to possible structural changes in the delta's environment (e.g., increased river discharges and sea level rise due to climate change, or structural economic and demographic changes) and to new developments in subsystems within the delta itself (e.g., large-scale interventions to reduce vulnerability to flooding and smaller scale interventions by farmers, recreation businesses and urban residents).

2.3 The Southwest Delta as a complex adaptive system

The Southwest Delta can be considered a complex adaptive system made up of subsystems with different spatial functions and characteristics, such as urban patterns, ports, shipping and transportation systems, water and flood prevention systems, and ecosystems. Each subsystem can in turn be further broken down into subcategories.

The subsystems have many different kinds of relationships with one another. As such, urban patterns are influenced by, among other things, port development and freight transportation networks – for example, the restructuring of city ports and expansion of hinterland freight connections. Figure 2.1 provides an overview of the subsystems typically found in an urbanized delta and the interrelations between them. The figure depicts an overall picture only; thus, the subsystems and interrelations shown are not exhaustive. Moreover, some subsystems and interrelations are more important than others, and subsystems and the relationships between them may change over time.

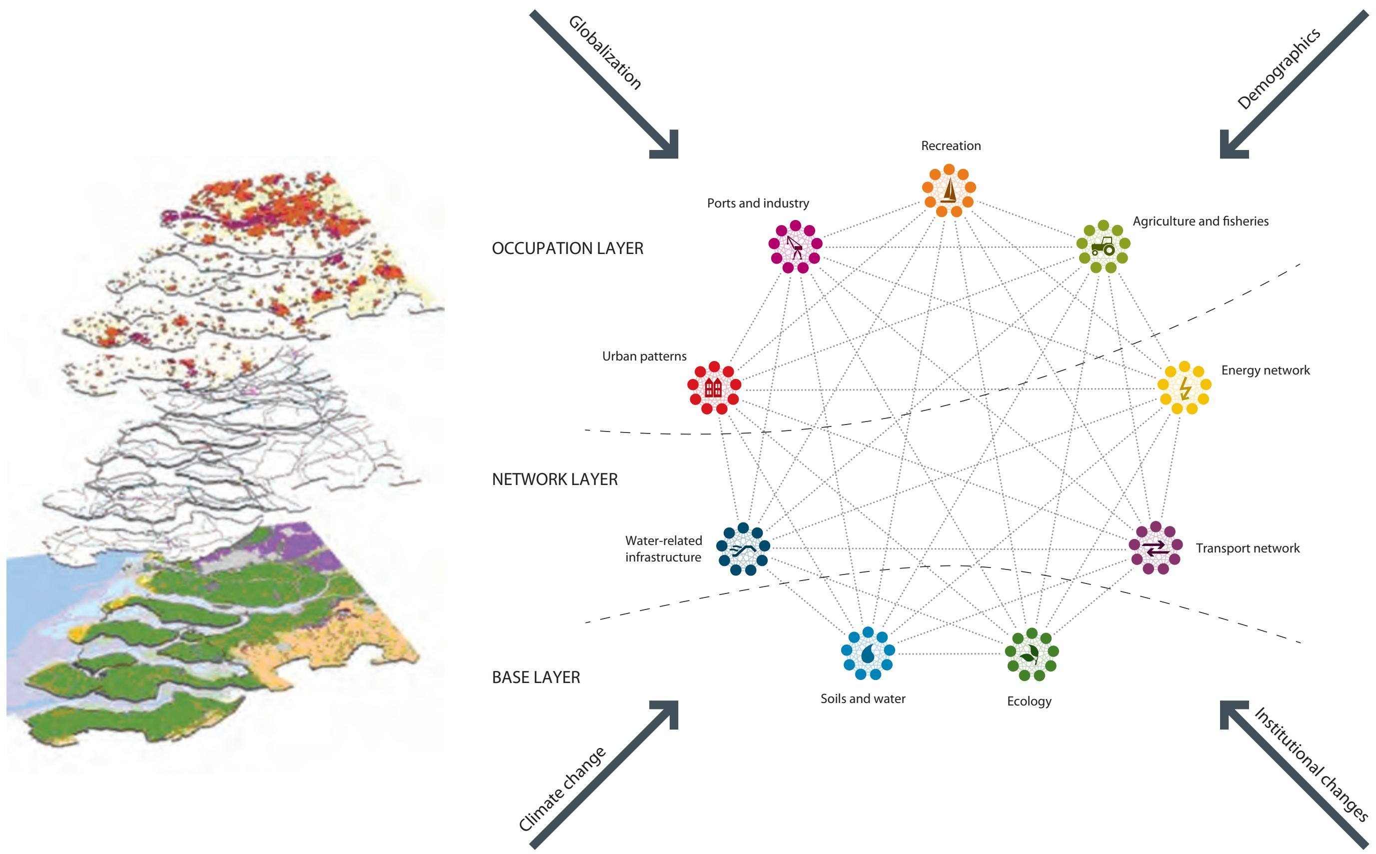
The issue of differences in system dynamics and the paces of various types of spatial developments, and of differences in the types of uncertainties associated with these in the medium and long term, place particular demands on spatial design and on the role of design in planning processes.

In the 1980s, the "layered approach" was introduced in Dutch design and planning as a step towards visualization of an urban landscape as a complex system. In it, different "layers" represent clusters of subsystems that are interrelated with and influence one another, while each also has its own characteristics and autonomous processes. The layered approach initially originated in the USA in the 1960s (McHarg, 1969), but its further development occurred mainly in the Netherlands (Sijmons, 1991; Tjallingii, 1996; De Hoog, Sijmons & Verschuuren, 1998; Meyer, Bobbink & Nijhuis, 2010). In the layered approach, interactions are investigated between three layers which are said to determine the spatial contours of a region:

- the "base layer": the substratum, made up of the system of water, soil and the life forms inherent in them;
- the "network layer": the physical infrastructure of shipping routes, road transportation and railways;
- the "occupation layer": the spatial patterns resulting from human use of the substratum and networks, for example, urbanization and agriculture.

Each of these layers is characterized by its own relatively autonomous pace of development. In broad terms, the substratum develops relatively slowly; the networks develop at an intermediate pace; and the occupation layer develops

Figure 2.1 The Southwest Delta as a system with subsystems and environment. With (left) the Southwest Delta as a layered system, analogous to McHarg (1969)



relatively quickly. Interventions in one layer are said to influence the structure and development of the other layers. The primary contribution of the layered approach is to provide insight into the nonsimultaneity of development and the different levels of uncertainty associated with development of the different layers. Thus far, the layered approach has been used mainly to analyse existing land use functions and the interrelationships between them as well as for conceptualization exercises (see, e.g., Nota Ruimte, VROM, 2005). The IPDD research applied this approach in development of an operationalizable planning methodology. This required that the delta be defined and elaborated in some detail as a layered system.

2.4 The openness of the system necessitates adaptation

A complex adaptive system has the following characteristics:

- *A CAS is an open system.* It not only interacts with its environment, but is also subject to external influences (Grus Crompvoets & Bregt, 2008). Interactions take place through flows of substances (water), people (traffic), goods (freight transport) and information (communication) between the system and its environment. Thus, water management in the delta is influenced by water discharges in the catchment areas of the rivers and by the currents and level of the sea, as well as by port activities, for example, the arrival of goods via the sea and freight transport to the hinterland.
- *The environment is defined in relation to the system.* There is nonetheless no clear distinction between system and environment. First, there is no clear or definitive boundary that delimits the constellation of spatial functions in the delta. Second, each subsystem has a different environment. Third, system boundaries change over time, because every new link that is made creates a new boundary, or redefines an existing one. Finally, system boundaries are defined differently by different actors (Teisman & Edelenbos, 2011).
- *The distinction between system and environment repeats itself at different levels.* While a system forms the environment of a subsystem, it is itself surrounded by an environment, which in turn is also composed of different systems. As such, the constellation of spatial functions in the delta (urbanization, water management, the transport network, etc.) forms the environment in which, for example, port activities occur. At the same time, the environment of this constellation of spatial functions is made up of, for example, the catchment areas of the Rhine, Meuse and Scheldt, the economy of the Northwest European heartland and global climate change.
- *A CAS is dynamic.* The factors that influence the system, such as population size, economic activity and climate, are ultimately themselves subject to change. Some developments arise as a series of minor events, resulting in them progressing at a gradual pace. For example, national population growth is largely determined by the number of people who are born, die or migrate annually. These types of incremental changes are often characterized by path-dependence, in which the course of an event is strongly influenced by the events that preceded it. A development can also take the form

of a “transition”, or in other words a fundamental change (Rotmans, 2006). An example of this would be the possible transformation of a national energy supply from fossil fuels to largely renewable energy sources. In such a case, a critical turning point can be identified that triggered the turn to a different direction of development (Scheffer, 2009).

- *Relationships between developments are likewise changeable.* Mutual adjustment or coevolution is often observed. If trends are harmonious or reinforce one another, they may result in symbiotic coevolution, as for example rapid economic growth and increased mobility are likely to reinforce each other. If one development causes disruption of another, then we can speak of interfering coevolution. Considering again the developments mentioned above, rapid economic growth and increased mobility might lead to pressure on the quality of nature and the environment.
- *The diversity of developments, the different paces of developments and the various relationships between developments result in an uncertain future.* This is particularly true for the longer term. Adaptation is focused on this aspect. The actors that are part of a system can respond to the changes occurring in the environment, but they can also anticipate on these. For example, the Netherlands constructed the Delta Works in response to a flood that devastated the southwest region of the country in 1953, and it established the Delta Programme in 2009 to prepare the country for the expected sea level rise and higher peak discharges from the rivers. The Delta Programme has investigated multiple future scenarios and based on these generated potential response strategies. The Dutch government has considered these and selected the most promising and preferred ones for further action (Ministry IenM & Ministry of Economic Affairs 2013).
- *That a system will adapt to its environment is not a given.* In fact, a system may not respond to its changing environment, or it may respond insufficiently or too late, for example, due to entrenched modes of thinking, established ways of doing things and institutionalized relationships – in other words, path-dependence. One of the causes of the flooding in the Netherlands in 1953 was that inadequate investments had been made in the country’s flood defence infrastructure during the previous years. These types of mechanisms make it especially difficult to anticipate on changes that may affect a delta region.
- *As a result of continual adaptation, a system is said to evolve; and via this evolution “path-dependence” develops.* In the past, as well as the present, complex systems have had to continually adapt to changes in their environment. Interventions made in the past to adjust the system as it was then to its changing environment therefore continue to play a role. Even many years later, they are among the determinants of whether it will or will not be possible to adapt the system to new environmental changes. History cannot be reversed. In the Southwest Delta, a centuries-old process of dike construction, polder drainage and turf digging (excavating peatlands to produce salt) created a situation in which large expanses of land are very low-lying. Dikes or other types of flood barriers remain necessary to protect these lowlands against flooding. “Path-dependence”, in this context, means that this situation cannot be undone. It is possible to investigate whether further subsidence can be prevented or slowed and whether conditions can be improved for “developing with the rising sea level”.

The evolutionary nature of a complex system means that the system’s current state cannot be taken as the starting point from which all possible options for the future are conceived. Instead, in mapping the possible future evolution and adaptive capacity of a system, we must also look at how the system evolved in the past. A retrospective analysis can be done to trace the measures that were deemed necessary in the past to adapt the system in critical phases, alongside the effects these measures had on the character of the system. A retrospective analysis will shed light on the path-dependence of a system, which then will need to be considered when looking at the possible future directions of system development.

2.5 The diversity of subsystems necessitates synchronization

The composition of a system, made up as it is of many different subsystems, can lead to conditions of fragmentation, hindering the system as a whole from developing and adapting to changing conditions. Within subsystems, too, fragmentation may also arise, as a by-product of specialization between social, economic, technical, planning and other activities. Fragmentation is reinforced by the different values and belief systems held by the various actors, the different tasks they are responsible for, the different procedures they use, the unintended and unforeseen effects of their activities on other subsystems, and the like. The actors, furthermore, often inhabit different worlds, for example, that of water management, or of spatial planning, design or legal thinking.

The diversity of subsystems and layers, the variety of relationships, the changes that occur within these and the substantial fragmentation make the challenges in dealing with these complex and uncertain. *Synchronization* is aimed at aligning subsystems and layers in such a way as to contribute to symbiotic coevolution (compare Teisman & Edelenbos, 2011). Synchronization means that actors consider effects of their activities on other subsystems and the system as a whole, for example, with the aim of achieving a more sustainable equilibrium between subsystems. They do this by recognizing and acknowledging the different characteristics and different paces of development of the different subsystems and trying to establish links between them. Synchronization is less far-reaching than coordination; it is not usually done by a single actor or from a single point of view.

With synchronization, activities can contribute to a symbiotic coevolution through which, instead of fragmentation, synergy can occur. However, this only happens to a certain extent. This is because each synchronization brings its own limitations with it, and therefore leads to new fragmentation. Actors that operate in a number of different subsystems are important as “bridge builders”. This is because they are ideally placed to establish relationships across boundaries and to help discover and explore many different synergies between the subsystems, as well as helping to realize these.

2.6 The variety of actors makes mobilization important

Both subsystems and a system in its entirety can be labelled as “steered” or “steering” (see Figure 2.2). A steered subsystem is one that is deliberately influenced. This may be a social, a biological and/or a physical subsystem. A steering subsystem is composed of a set of physical factors, social actors and the interactions between them that influence (purposefully or not) a subsystem or a system in its entirety (Klijn, Edelenbos & Steijn, 2010). An example of a steering subsystem in the Netherlands is the flood defence system constructed and managed by the Dutch Public Works Department (Rijkswaterstaat), water boards and engineering companies. This influences the flow and the discharge distribution of rivers (steered subsystem) and also has a strong effect on the river ecosystem. The reverse may also be true: a steering subsystem may be influenced by the subsystems it steers. As such, the increased river discharges experienced in the Netherlands from 1995 to 2005 gave rise to the understanding that adjustments were needed in the flood defence system in the riverine region. It also generated strong social pressure to pay greater attention to the ecosystem of the riverine region. These two processes combined precipitated initiation of the “Room for the River” programme. If a steered subsystem is a social subsystem, actors within it might try to influence the steering subsystem. This was the case, for example, when environmental organizations successfully tried to exert influence on the design of new flood defences (Edelenbos, 2005).

Activities aimed at deliberately influencing subsystems include drawing up designs, developing plans, conducting research, implementing projects, organizing governance arrangements and so forth. Collaborative action includes the more or less systematic ways in which these activities are organized. To influence subsystems effectively, it is important that the steering and the steered subsystems be well aligned with one another. For example, the effectiveness of water management policy is increased if the administrative authority of a water board corresponds to the scale level of a polder. This applies, among others, to the actors involved in steering, to the ways they define the subsystems and the ways they plan and execute projects.

Mobilization is aimed at the organization of joint activities to adapt the subsystems or the system as a whole to the changing environment and/or to bring subsystems into alignment. The goal, of course, is to achieve mutually coherent results, but there is no central direction of activities towards a predetermined outcome or decision (compare Teisman, Van Buuren & Gerrits, 2009). This can be done, for example, by organizing “soft spaces”. These are informal forums in which a variety of different actors come together to share or identify challenges facing the delta region, to discuss their objectives with one another, to build relationships and the like (Allmendinger & Haughton, 2008; Dammers & Hajer, 2011). Examples of soft spaces are innovation networks, transition arenas and interactive focus groups.

In these kinds of forums, actors meet one another in person; they exchange knowledge, experiences and ideas; challenge one another, develop new ways of thinking and form coalitions. In the process, actors develop common visions, which help them form a shared perspective on the direction the delta region, or a particular area within it, should be developing. They may identify strategic projects in which they are willing to invest money, labour or other resources and think about governance arrangements to ensure that steps towards implementing the visions they’ve developed are actually taken. To be successful it is important for these types of forums to be organized on a regular basis, that they be held over a longer period of time and that the results are anchored in “hard spaces”, meaning in regular planning processes.

The IPDD project experimented with the creation of a “soft space” via development of the DENVIS (Delta Envisioning Support System) methodology (see Chapter 7).

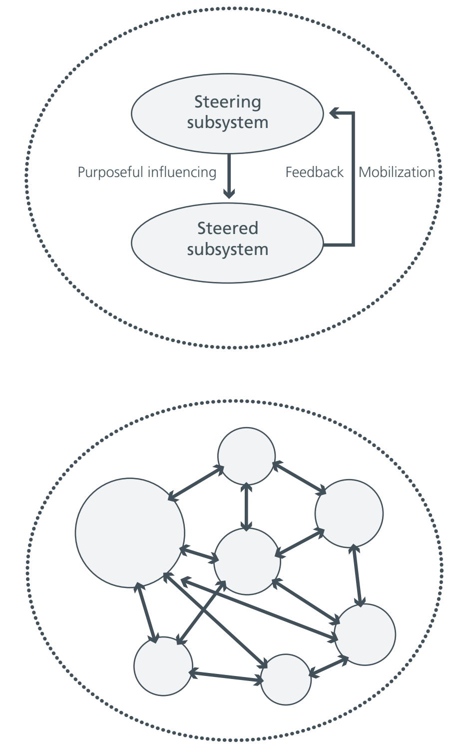


Figure 2.2 Steered and steering subsystems

2.7 Significance for design, governance and knowledge

What significance could thinking in terms of complex adaptive systems have for design, governance and knowledge? The transition from a mechanical to a more organic systems approach has fundamental implications for these three domains, and especially for the relations between them. While the mechanical systems theory greatly contributed to the deep disconnection between design, governance and knowledge, the complex adaptive systems perspective makes new relationships not only possible but even necessary.
For design, the accent on adaptation means that emphasis is placed on creating conditions in which a region can adjust in the future to (still uncertain) changes in the environment. Although these environmental changes are uncertain, they can nonetheless be explored, and this is an important task for the research-oriented disciplines. Methods of designing for changing conditions place new demands on governance arrangements. Synchronization requires that actors from different subsystems be involved in creating a design (governance) and that the intended and unintended effects of a design be explored (knowledge).

Mobilization can be successful only if the actors that develop a design, pursue policy objectives and conduct research also succeed in aligning these activities with each other. This does not happen automatically, because these undertakings are largely carried out independently of one another. These are, after all, very different types of activities, with different objectives, different ways of thinking, different vocabularies and different forms of action (Dammers & Hajer, 2011).

The idea has long prevailed that governance, knowledge and design should follow one another in chronological order. First, a request for development of a region would be issued from the central policy level. Then academics and researchers would calculate the numbers of houses, facilities and green spaces that would be needed. Finally, designers would be called in to create and shape the project as a whole. Recognition of the complexity of spatial issues, however, has made this sequential and centrally led approach obsolete. Indeed, in some cases, new knowledge about a region brought forward by researchers at their own initiative stimulates public debate, which in turn leads to new design initiatives and, ultimately, to new governance arrangements.

Design, too, has increasingly been given the role of an initiating and exploratory activity, capable of revealing hitherto unknown and surprising potentials for a region (De Jong, 1992). With "research by design", specific questions can be posed regarding the knowledge needed. Furthermore, designers can propose new planning options for a region to policymakers and stakeholders. The question here is how to ensure that design, governance and knowledge are organized as productively as possible in relation to one another.

Design is a thinking process with analysis, synthesis and evaluation as its main ingredients (De Jong, 2009). Yet these ingredients cannot be structured in any logical or straightforward way in a design procedure or methodology. Rather, design is more accurately described as a process dependent for its success on the personality of the designer and on the circumstances of the moment. Designs illustrated on a map always contain a variety of differences in the nature (legend) and position (distribution) of spatial functions (De Jong, 1992).

From a CAS perspective, it is important for a design to take into account and explore the potential for changes in the environment (adaptation), as well as to consider a range of sectors (synchronization) and for designs to be developed jointly with policymakers, stakeholders and others (mobilization). Governance relates to interactions between the steering and the steered subsystems. In a CAS, governance has multi-actor, multi-sector, multi-level and multi-timeframe aspects (Edelenbos, Bressers & Scholten, 2013). The multi-actor aspect relates to the fact that diverse public, private and social actors are engaged in intentional influencing. The multi-sector aspect is important for finding a sustainable balance between the various subsystems. The multi-level aspect is relevant because the distinction between the system and its environment repeats itself at different scale levels; this is reflected, for example, in the different administrative levels. Multi-timeframe relates, for example, to the different paces of change characteristic of the three layers and the different time horizons that this entails. We must therefore look farther back and farther ahead when investigating changes in the base layer than we would when investigating changes in the network layer or the occupation layer, because changes in the base layer proceed at a slower pace. In addition, different actors utilize different time horizons (short, medium or long term).

The great complexity and dynamics of a CAS and its environment implies that planning activities will involve mobilization and integration of a large amount and diversity of knowledge. To adequately deal with this complexity and dynamism requires knowledge integration in the form of interdisciplinarity or transdisciplinarity (Duin, Rijnveld & Van Hulst, 2010). The diverse subsystems and range of developments that influence them, furthermore, will necessitate involvement of a wide spectrum of academic disciplines in planning activities: physical and social geography, hydrology, ecology, economics and public administration among others. Interdisciplinarity will play a primary role here, in which a variety of scientific disciplines work together and via joint learning processes develop a shared focus, language and approach (Haapasaari, Kulmala & Kuikka, 2012). For adaptive planning, this will additionally involve transdisciplinary knowledge, or in other words, integration of different kinds of scientific knowledge with knowledge derived from practical experience (Edelenbos, Van Buuren & Van Schie, 2011).

A productive relationship between design, governance and knowledge can be achieved by regularly organizing "soft spaces", in which the three domains meet, exchange ideas, make new discoveries and collaborate. Then, in each domain, the consequences of these encounters can be further thought through, evaluated and elaborated, after which they then meet again, and the process continues to repeat itself (Figure 2.3). Within a "soft space" actors meet one another in person; they exchange knowledge, experience and ideas; and they challenge one another, develop new ways of thinking and form coalitions. For successful integration of design, governance and knowledge, it is important that a "soft space" stimulate unexpected encounters, shared understanding and joint envisioning (Dammers & Hajer, 2011).

Unexpected encounters

By organizing face-to-face meetings with a diversity of people involved in governance, knowledge and design for a delta region, different perspectives on the region are brought together, discussed and challenged. The diversity of perspectives can be further enhanced by involving, in addition to people closely involved in the region, creative outsiders, including policymakers, researchers and designers from other delta areas or areas facing similarly complex challenges.

Shared understanding

By exchanging and reflecting on different types of knowledge about the region, the actors can develop a shared foundation of knowledge, for example, about the core qualities of the region and the challenges facing it. Geo-information and geo-information technology can provide significant support in this, helping to streamline the dialogue and information exchanges taking place between the participants. The design discipline is essential in this process, as designers interpret and select geo-information and can transform it into intuitive map images that depict both core qualities and emerging issues and challenges.

Joint envisioning

During meetings (e.g., in the form of design workshops), actors can explore how and to what extent stakeholders' various objectives can be accommodated in the design, and the extent to which these objectives can be combined or conflict with one another. After such a meeting, designers can continue to

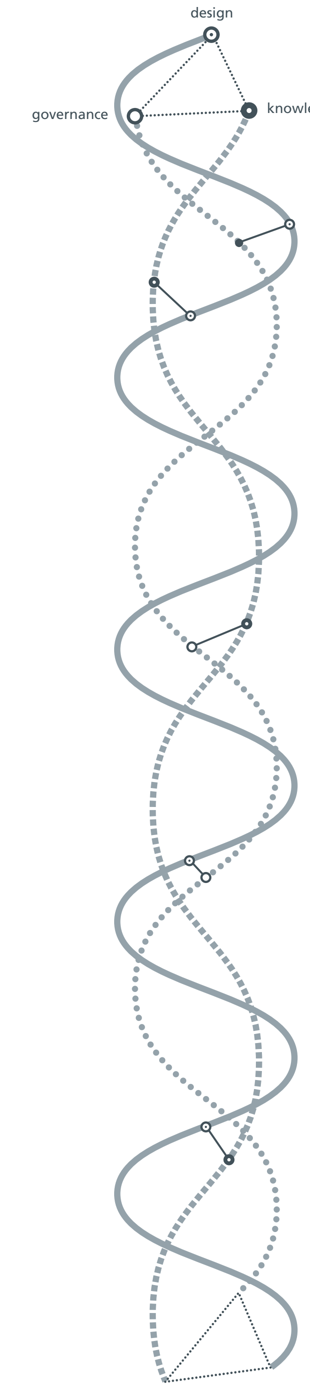


Figure 2.3 Relationship between design, governance and knowledge over time

work on possible solutions, which can then be resubmitted and discussed at a subsequent meeting. As such, an iterative process is created of design, governance and knowledge.

2.8 The practical and scientific significance of the CAS approach

Despite the abstract nature of the CAS approach, it has proven helpful in exploring and identifying concrete planning issues. This applies particularly to planning aimed at adapting a delta region to changing conditions and to unexpected events that (may) have far-reaching impacts on the region, such as socio-economic developments and more extreme river discharges. In addition, synchronization between the sectors is important, as it can prevent changes in one sector from having negative consequences for other sectors. Finally, CAS is about the organization of joint action, given the fragmentation of planning practices in the delta.

Application of the CAS approach to a delta region is scientifically relevant as well. Up to now much has been published about the various domains of systems theory, but little has been written about the application of systems theory in real-world practice. Similarly in recent decades, physical scientists have sought to understand complex regions, including delta regions, as layered systems, but in doing so have placed most of the emphasis on the ecological or physical aspects. Social scientists, for their part, have sought to understand planning activities in complex regions as steering systems, but in doing so have focused only on the social and political aspects. The CAS approach conceptualizes all of these aspects in an integrated manner as well as operationalizing them in a practical sense.

Chapter 3

A retrospective analysis of the delta: *Mapping the system's evolution*

Major changes have been implemented in the past in the system of the Southwest Delta. These were considered necessary to adapt the system to a changing environment. In the twentieth century, strong emphasis was placed on close alignment of the different subsystems. This set the stage for a considerable leap forward in terms of economic and urban development over the medium term; however, because of the strong interdependence between the subsystems that resulted, the system was left with very little adaptive capacity in the longer term.

3.1 Introduction

This chapter presents a retrospective analysis of the evolution of the Southwest Delta as a complex adaptive system. Undertaking such an analysis provides a fuller understanding of the nature of the complex system and the system's current state.

Our aim in analysing the history of a region as a complex adaptive system is specifically to obtain information about the system's "evolutionary behaviour". In particular, we seek insight into the past changes that have occurred within the system and subsystems (incremental changes, transitions), the influences exerted by various developments in the system's environment (driving forces) and the interventions undertaken to bring about changes (deliberate influencing). This knowledge will enable designers, policymakers and stakeholders to improve their understanding of the delta region and, on that basis, work from a more informed perspective (evidence-based) towards new interventions for the region. A retrospective perspective can also help clarify how and to what extent new interventions link to earlier ones. This may reveal possibilities that perhaps had not been considered before, while also pointing out limitations not yet taken into account.

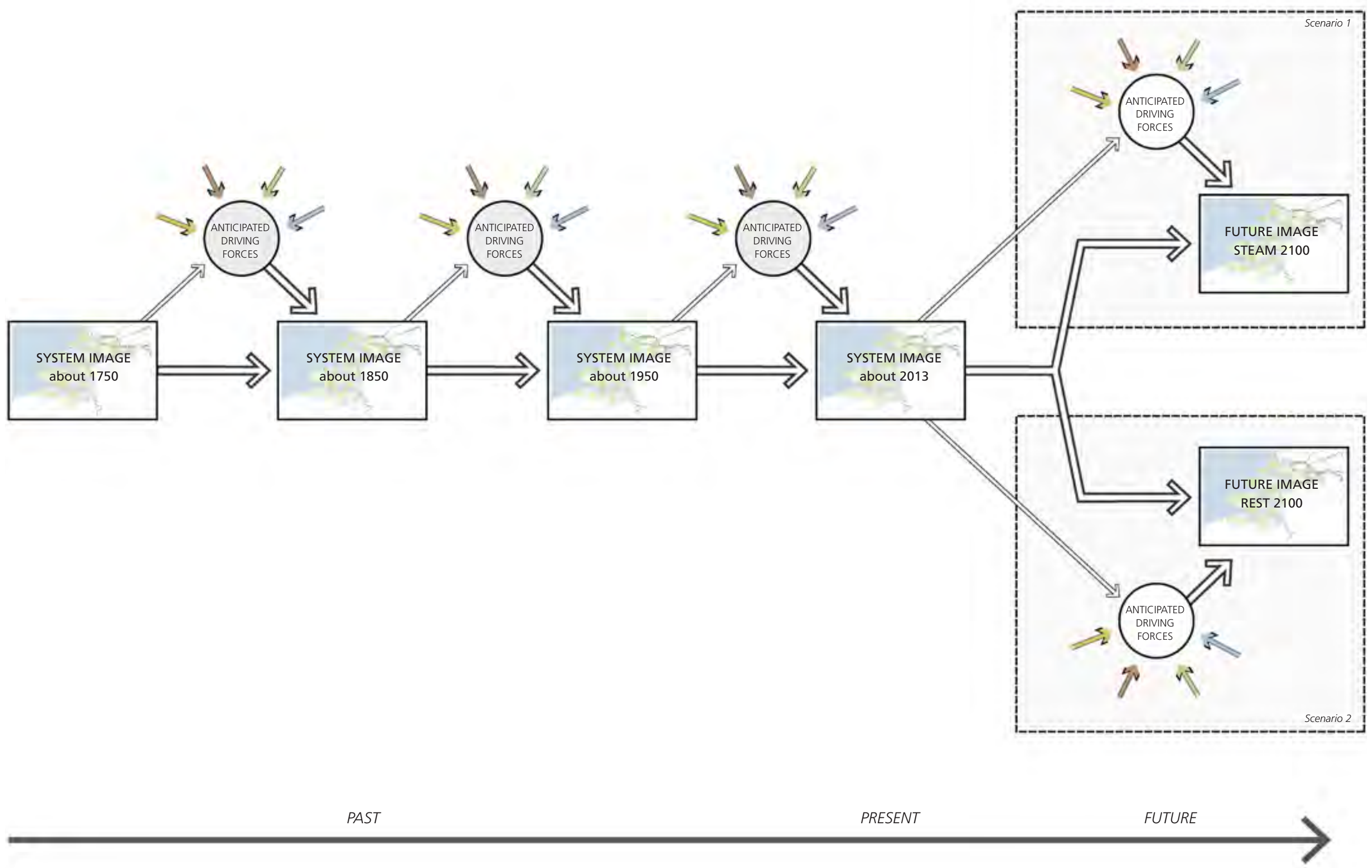
The way we apply a particular representation, or image, of the system and analyse the system's critical limitations in the retrospective analysis is analogous to that in the future analysis examined in the next chapter. In doing so, we hope to tap the retrospective analysis as fully as possible for knowledge about the system that might be useful for system policy, planning and design in the future, as shown in Figure 3.1.

Method: A central role for cartography

A cartographic analysis is an indispensable research tool for determining how the different subsystems have developed, how they have influenced one another, what interventions have been undertaken in them and to what extent these interventions have influenced both other subsystems and the system as a whole. Design research has a long history of application in many different variants (De Jong & Van der Voordt, 2002; Meyer, 2005; Steenbergen, Reh, Nijhuis & Pouderoijen, 2009). In the current study of the Southwest Delta, it takes the form of a mapping exercise, in which a new series of maps is produced with similar legends and drawn to the same scale. These provide a systematic depiction of the individual subsystems, the relationships among the subsystems, and the evolution of the system in its entirety.

Development of a cartographic "storyline" with its own cartographic language is an essential part of this approach. The cartographic language has an overarching central role, as the future analysis should be able to build further on this storyline in the same language, making use not only of the same words and concepts, but also of the same kinds of map images and similar comparisons. Crafting such a cartographic story requires a range of different knowledge and skills. For this reason, development of the storyline presented in this chapter involved an interdisciplinary team includ-

Figure 3.1 Analysis of the Southwest Delta as a CAS: Representation of the relationship between the system image and the forces driving changes and transitions in the system, past, present and future



ing urban planners, landscape architects, public administrators, hydraulic engineers, ecologists and GIS experts.

The choice of the appropriate window into the past and an appropriate periodization for the retrospective analysis depends on the time horizon required for the future projections (Chapter 4). The rule of thumb is "look at least as far back as you look ahead" (Dammers, Bregt, Edelenbos, Meyer & Peel, 2013). The time horizon for looking ahead is determined mainly by the period of time considered relevant to anticipate any relevant changes in the environment, such as climate change and major changes in socioeconomic terms. The Delta Programme set its time horizon at 2100, which means that it also needed to look back about a century into the past, to gain an adequate appreciation of the nature and magnitude of changes that could occur over a period of such a length.

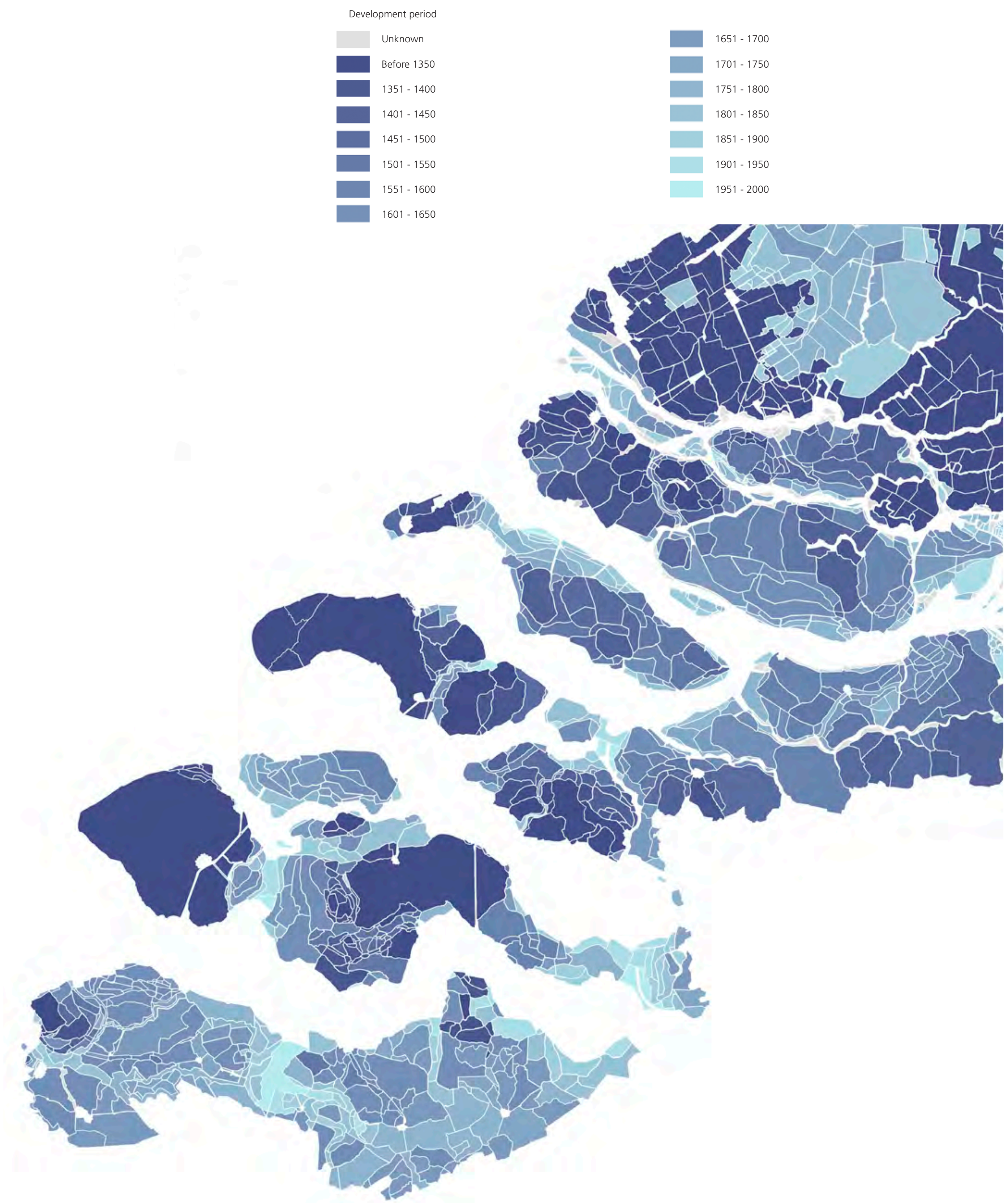
A second and more important criterion in determining the time horizon for looking back is the need to understand the highs and lows of the period in which the currently-dominant system image developed and matured. This means we have to go back at least to a previous period when another system image was dominant, which for some reason, warranted interventions leading to a transition to the system image that currently prevails. It also means that a hypothesis has to be formulated early on in the analysis about which periods represent a coherent system image and which periods are marked by interventions and transitions. Figure 3.1 presents the hypothesis initially applied in the current analysis. In the figure, the system images are given reference years, which taken together demarcate different periods:

- a dynamic relationship between water and land, from the eleventh to the mid-nineteenth century;
- the opening of the delta, from the mid-nineteenth century to the mid-twentieth century;
- the closure of the delta, from the mid-twentieth century to the end of the twentieth century.

For the last two periods, there is an open question of whether they should in fact be considered as separate periods, or instead as two consecutive stages of a single period leading slowly, via various interventions, to a new dominant system image. Our analysis begins with the first period, prior to the mid-nineteenth century. For each period the dominant system image is described, the emerging changes and driving forces are investigated and, finally, the interventions and transition to the next system image are explored. The extent that our hypothesis regarding the periodization is proven correct is discussed in the conclusion section.

The map resources presented in this chapter represent only a selection of those developed in the retrospective analysis

Figure 3.2 Land reclamation and dike rings in the Southwest Delta between 1300 and 2000



3.2 A dynamic relationship between land and water: Up to the mid-nineteenth century

Interventions and transitions of the system

From the eleventh century to the mid-nineteenth century the delta landscape was transformed from a region of accretion and deposition to a landscape of dikes and polders, with large expanses of farmland and a series of small towns. These settlements, in addition to their involvement in export agriculture, also engaged in fishing, trade and at times in warfare as well. The accent of interventions in the delta system at this time was on *land reclamation by means of dike construction*.

System image

For many centuries the system of the Southwest Delta was characterized by a dynamic relationship between land and water, driven by both natural processes and by human interventions. The dynamics of river, sea and tidal flows and of precipitation and sediment transport led to processes such as flooding, accretion and gully-forming, and to permanent changes in the delta's spatial structure, soil composition and waterways. These processes continued to dominate formation of the delta until the eleventh century (Figure 3.2).

A great variety of gradual transitions is a common feature of estuaries. These give rise to the rich diversity of flora and fauna that places estuaries among the world's most ecologically valued landscapes (Costanza et al., 1996). The food abundance associated with this richness was initially one of the main reasons for humans to settle here. Sediment deposition and accretion led not only to the formation of lands above sea level, but also to numerous shallow areas. These shallows were found to be favourable habitats for seafood and shellfish.

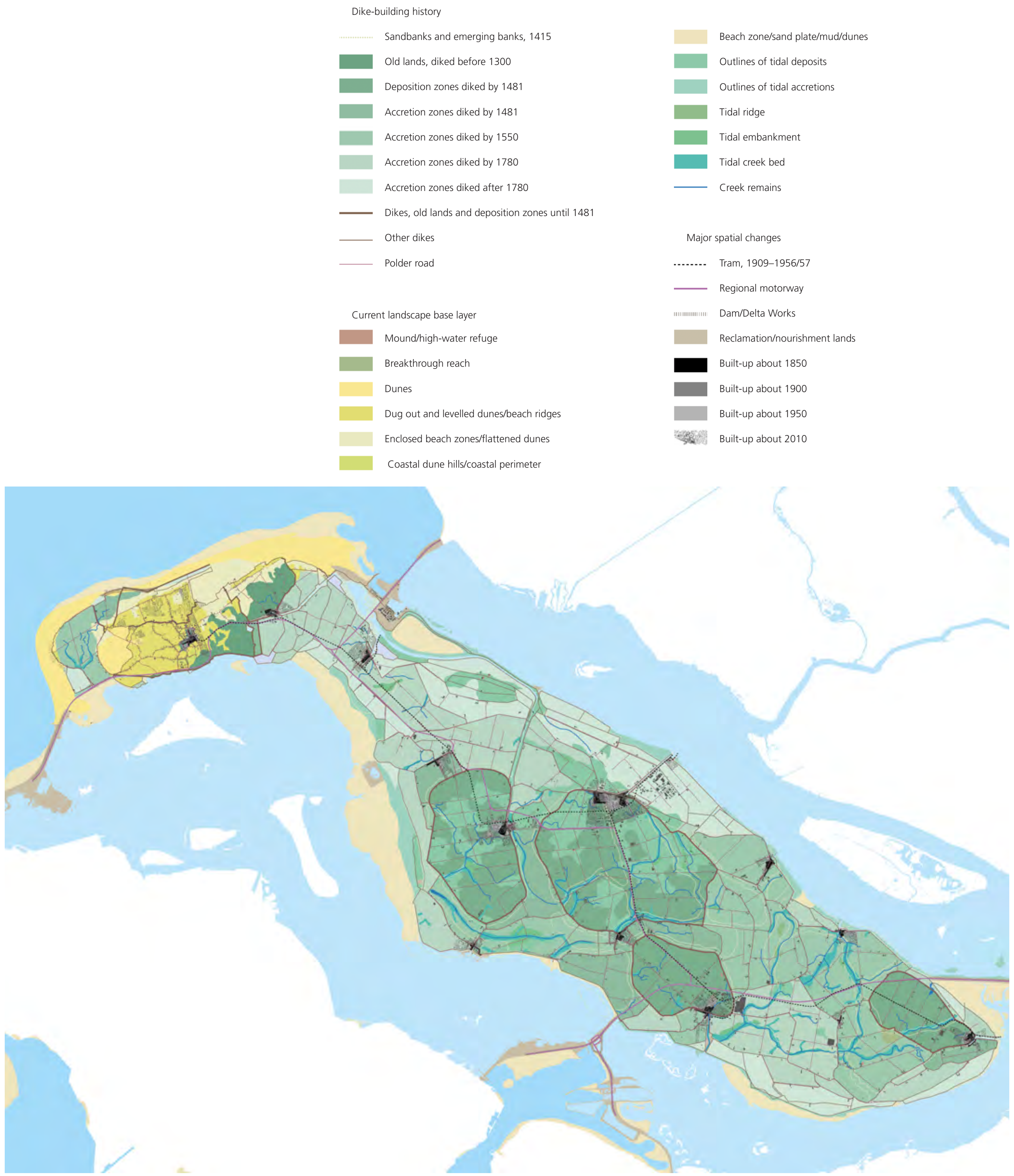
The first organized flood defences in the Southwest Delta were built in the twelfth century (Dekker, 1971). For a long time the distinction between the zones inside and outside of the dikes was less sharp than it is today. In many cases, gradual transitions could be found, from the undiked marshlands, via marshy grasslands with a low quay and built lands with a higher quay, to the "real" dikes, which protected villages and cities.

The polder system slowly expanded as a result of a process of gradual deposition of ever-new sediment, which after new dikes were built then also became polder compartments (Figure 3.2). Older secondary dikes were maintained as a "backup" in case the primary dike broke through.

Depending on their position relative to the system of tidal channels and accretion, different kinds of urban settlements were established. New accretion zones that developed alongside reclaimed lands were then also diked and reclaimed. Figure 3.3 shows the island of Goeree-Overflakkee, on which the outline of the first generation of diked polders, settlements and harbours is still clearly visible.

Over time, these settlements were closed in by new generations of reclaimed accretions. This process took place throughout the delta, creating "silt cities", or settlements that when confronted with the accumulation of silt in their port

Figure 3.3 Goeree-Overflakkee, marked by several generations of sediment deposition and accretion. Urban settlements with harbours are located along the first generation of polders. The irregular meandering of streams can still be seen within the polders' rational division into farmable lands



resorted to canal-digging to preserve their access to open water (Figure 3.4).

Construction of dikes, embankments and canals took place mainly on a local scale during this period. Local communities, private investors and financiers, small landowners and commercial developers, bit by bit, reclaimed this region of tidal flats, alluvial deposits and accretion, bringing the lands under cultivation (Beenakker et al., 2007; Borger et al., 2011; Dekker & Baetens, 2010). Higher administrative levels, such as the provincial and national governments, played a role only if the costs of a dike or canal construction were prohibitively high for local authorities and private developers to bear.

An opposite process occurred in the "erosion cities", located along the deep channels where, due to strong currents, gully-forming was the dominant process. Most of these were located on the southwest sides of the delta islands. Throughout the region, strong currents dug deep channels, in some cases up to 30 meters deep, creating good conditions for shipping with navigable channels and easy to access ports (e.g., in Vlissingen and Hellevoetsluis). But this also resulted in difficultly in maintaining flood defences, which were always at risk of collapsing into the deep channels, and breaches were extremely difficult to fill when the dikes did break through. The main weak spots in the delta, particularly in Vlissingen, could be maintained only with continual repair and replenishment of the eroded material.

In summary, up until the early nineteenth century, natural processes of water and land formation (the abiotic system) were predominant in the overall system of the delta. The processes of dike-building, land reclamation, bringing the newly reclaimed lands into cultivation and urban development were primarily following throughout this entire period, as they made use of and responded to the dominant system of land and water.

Changes and driving forces

After the mid-eighteenth century it became clear that the existing system image had reached its limits. On the scale of the riverine system as a whole, two developments occurred that triggered radical intervention in the system.

The first development was a series of severe floods in the upstream riverine area as a consequence of the ongoing silting up of the delta. In the latter eighteenth century, the provinces of Utrecht and Holland sounded the alarm bell, as flooding of the riverine lands had begun to pose a real threat to these regions (Lintsen, 1993). The threat of flooding in these two economically important and powerful provinces came not only from the North Sea and the Zuiderzee, but increasingly also from the rivers.

The second development was emergent industrialization and the increasing scale of commercial shipping activities, although the rivers and estuaries were at the same time becoming increasingly difficult to navigate due to ongoing deposition and sedimentation processes. The rising industrial core in Germany's Ruhr Area faced increasing inaccessibility. The Netherlands' powerful neighbour, Germany, increased pressure on the Dutch to improve the navigability of the rivers (Lintsen, 1993). The existing system was un-

Figure 3.4 Urban development in the delta with the changing relationship between settlements and water: "Silt cities" with port canals, "erosion cities" and diked towns

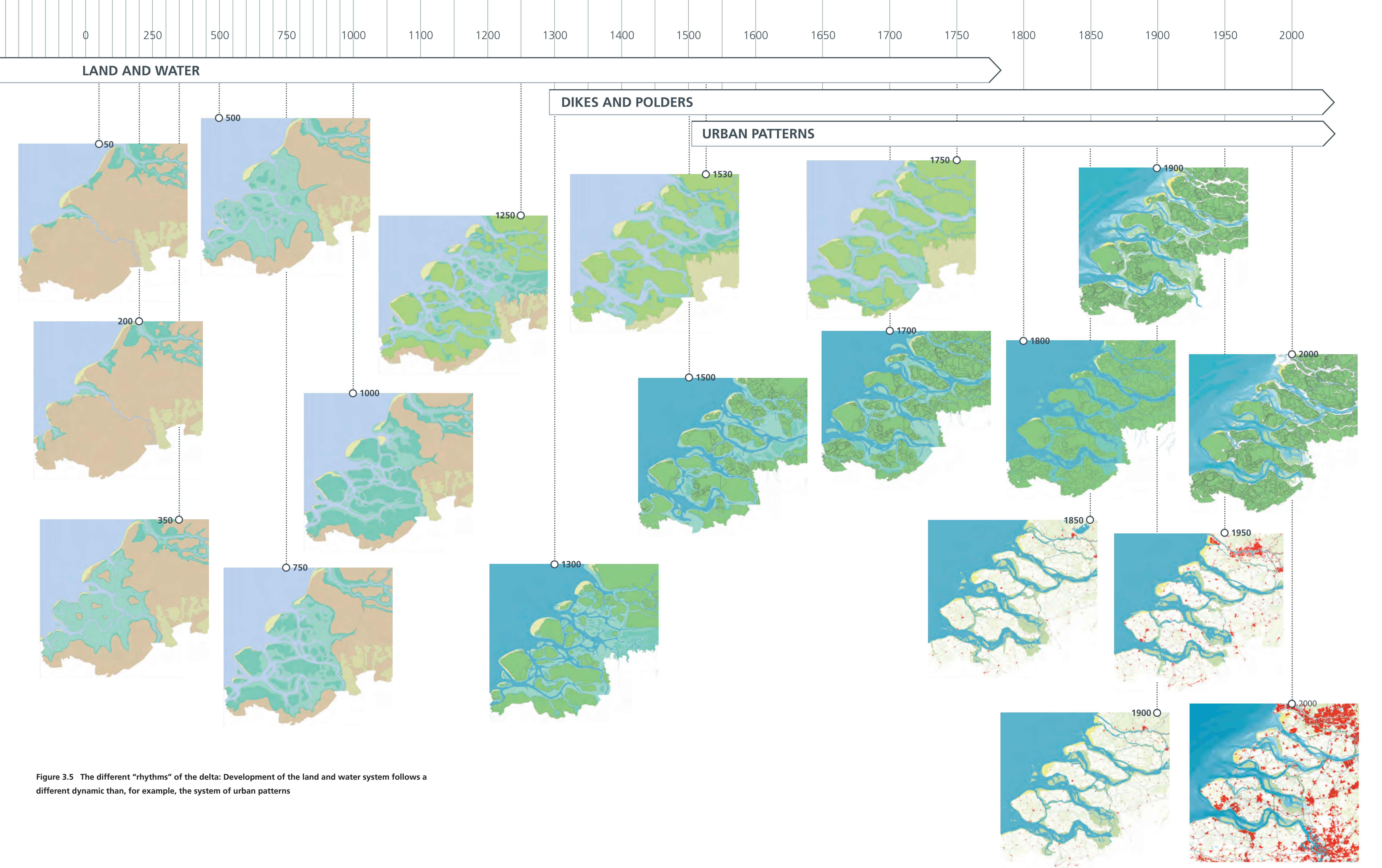


Figure 3.5 The different "rhythms" of the delta: Development of the land and water system follows a different dynamic than, for example, the system of urban patterns

Figure 3.6 The second half of the nineteenth century: Driving forces and interventions in the Southwest Delta

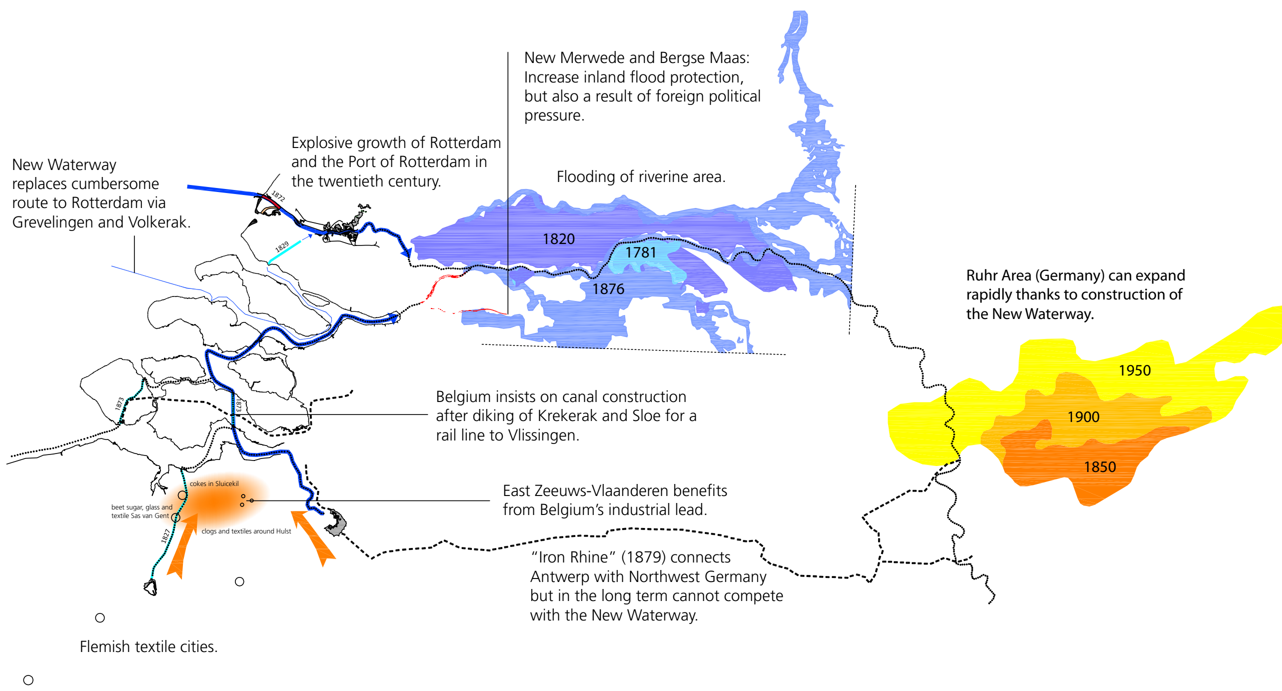
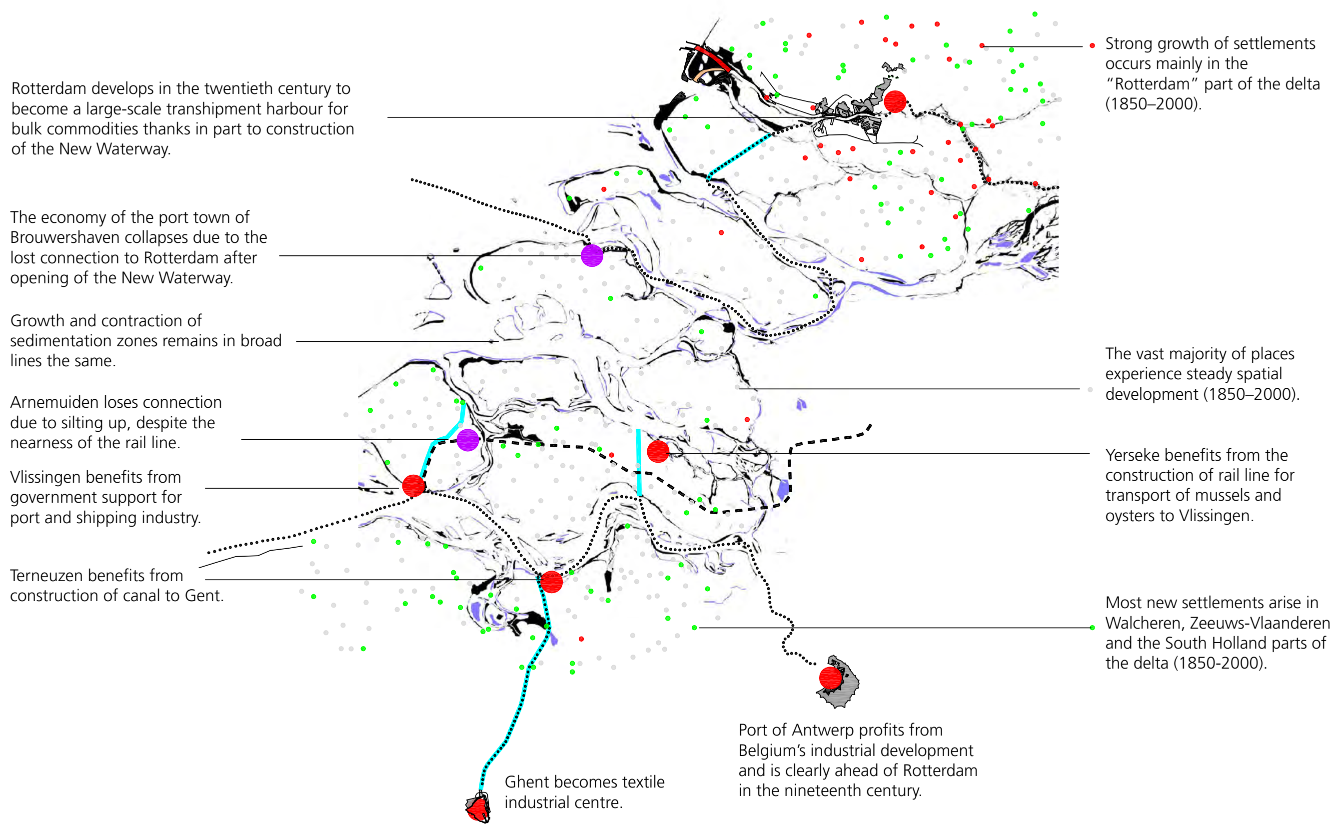


Figure 3.7 Consequences of interventions within the Southwest Delta itself



able to adapt sufficiently to this changing context – neither to the increasing pressure to make the rivers navigable, nor to the need to reduce the threat of flooding in the riverine region (Figure 3.6). New interventions, of a completely different magnitude than hitherto, appeared increasingly necessary.

3.3 The open delta: Late nineteenth to mid-twentieth century

Interventions and transitions of the system

Starting in the mid-nineteenth century, a major change took place in the nature of interventions in the system of the delta: the *accent shifted* from land reclamation by dike construction to *increasing the discharge capacity of the rivers.*

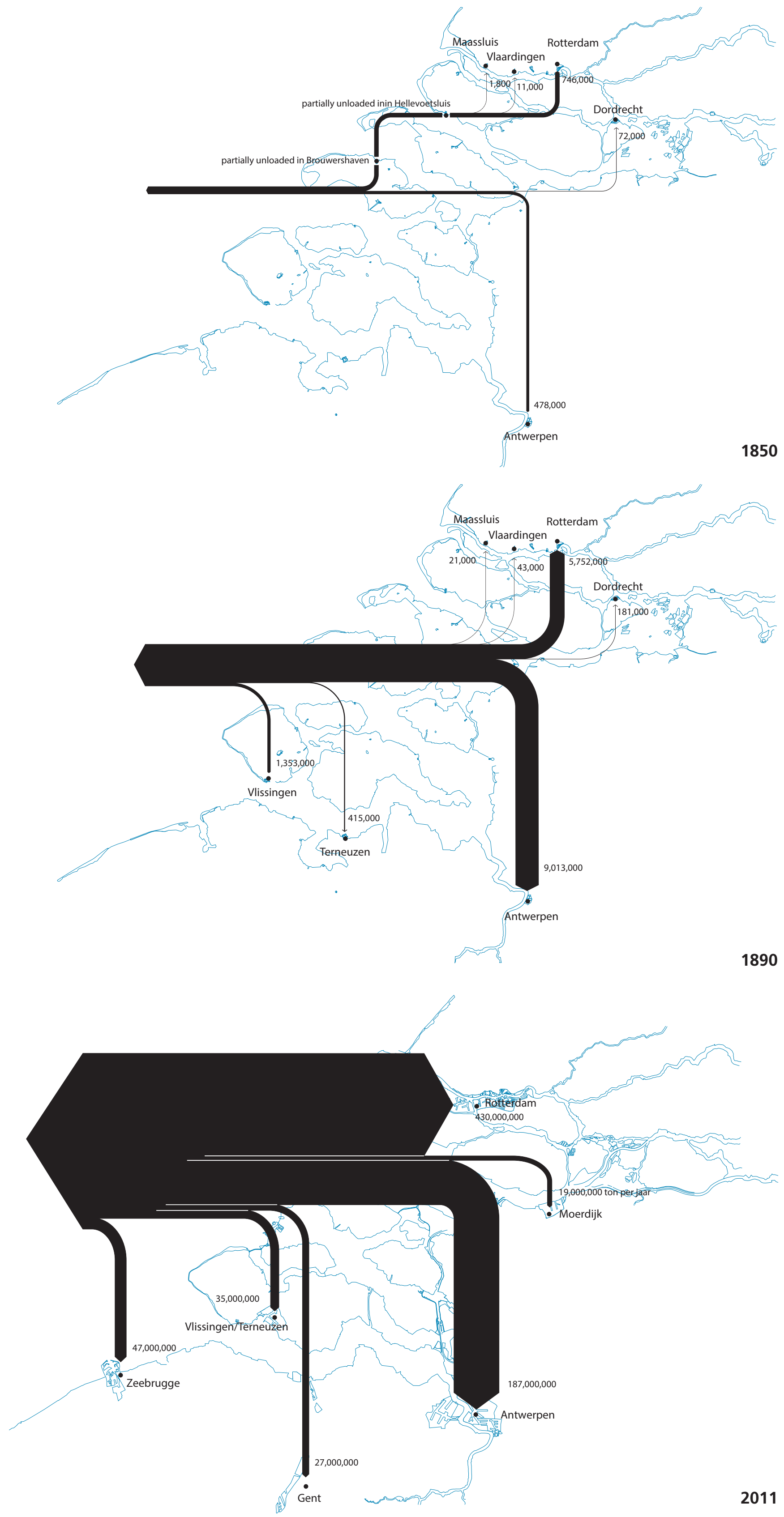
From the Napoleonic era, and to an accelerated extent after establishment of the Netherlands as a unified nation-state, opportunities presented themselves, facilitated by new technological developments, to intervene on a much larger scale in the system of the delta. Ideas and plans to do so had already been on the drawing board since the late eighteenth century. The various plans devised over this period of three quarters of a century sought to combine two aspects: in the first place, realization of the shortest route possible between the largest port, Rotterdam, and the sea, and in the second place improvement of the discharge capacity of the major rivers. Attempts to reach the port of Rotterdam by digging a canal through Voorne were short-lived. The most important of the plans drafted during this era was written by the young engineer Pieter Caland. He proposed artificially fixing the mouth of the Rhine by digging the New Waterway, which would serve as the new mouth to the sea for the New Meuse river. The plan was controversial, however, and considered a risky venture, both technically and from a political-economic perspective (Ten Horn-Van Nispen et al., 1994).

Nonetheless, implementation of Caland's plan was supported by the national Public Works Department (Rijkswaterstaat), and it also had the backing of Rotterdam port entrepreneurs and the water boards in the riverine region. The New Waterway, together with the New Merwede and the Bergsche Maas, was part of a series of large-scale river improvement projects with which the rivers' discharge velocity would be increased and navigability would be improved (Figure 3.11).

System Image

An important consequence of the change in accent to river improvement projects, especially the digging of the New Waterway, was to concentrate economic growth along the outskirts of the delta (Rotterdam and Antwerp) and marginalize the islands in the delta region. The economic stagnation of the Southwest Delta that had in fact begun in the eighteenth century was not reversed, with few exceptions, among them places where shipbuilding (Vlissingen) and mussel and oyster cultivation (Yerseke) had provided a new economic impetus. Cities like Brouwershaven and Hellevoetsluis lost their

Figure 3.8 Port economics: Import and export of goods in 1850, 1890 and 2011



significance as main ports. Figure 3.7 depicts these partly deliberate but also unintended and unforeseen consequences of the interventions.

Eventually other effects were also observed, due (in part) to the interventions in the delta. While port activities in Rotterdam expanded significantly (Figure 3.8), the core of the Southwest Delta became increasingly impoverished and seriously side-lined (Brusse & Van den Broeke, 2006). Furthermore, the head start that the islands of the delta had initially enjoyed – as regards agriculture – became a handicap in the first half of the nineteenth century. Because of the good quality of their lands farmers in the delta initially had no reason to seek improved cultivation practices, but they were now being overtaken by other regions that had modernized earlier. Grain prices dropped sharply around the middle of the nineteenth century as corn from the USA flooded the European market, ironically, thanks to the development of Rotterdam as a major import and transit port for grain. Wheat had long been the main crop grown in the Province of Zeeland, but it lost much of its significance in the latter nineteenth century. Cultivation of madder – a specialty of Zeeland – collapsed when in France a synthetic alternative was found for the red dye extracted from this commodity.

Farmers soon abandoned wheat and madder in favour of sugar beets, potatoes and other crops. Though sugar beets were amply cultivated in the Zeeland delta, they were not processed here – this was done in West Brabant and Flanders (Figure 3.13). Lack of sufficient freshwater was cited as the reason for this, a deficiency that hampered all industrial development in the Southwest Delta.

Summarizing, the change in accent from land reclamation by dike construction to increasing the discharge capacity of the rivers was accompanied by a shift from a dominance of agricultural interests to a dominant position for harbour and industrial interests. At the same time, the local scale was no longer most dominant in planning; instead the national scale began to play the larger role, stimulated and at times even under pressure by the international scale of neighbouring countries. This reorganization led to a strengthening of economic and urban development on the outskirts of the Southwest Delta, but also contributed to an (unforeseen) weakening and marginalization of the heart of the delta region.

Changes and driving forces

In the 1860–1940 period, large numbers of people left the Zeeland and South Holland delta islands for larger cities to earn their livelihood in the emergent ports and industries. The islands themselves were caught in a vicious downward spiral of impoverishment, to the point where the water boards no longer had the capacity to maintain the dikes. Warnings about the weakened state of the islands' dikes were voiced as early as 1920 (Van der Ham, 2003). Ultimately, however, the situation climaxed in the dike breaches and disaster of the 1953 North Sea flood (Figure 3.9).

This series of interventions, developments and effects can be considered a

Figure 3.9 Flooded areas after the disaster of 1 February 1953 (VBBBA 1953)

second cascade of events: from river improvement projects through growth of the Port of Rotterdam, impoverishment and depopulation of the Zeeland and South Holland delta islands, lack of dike maintenance to the flood disaster of 1953.

However, the flooding of 1953 was not the only stimulus underlying the substantial transition of the entire system of the delta. Other important developments also played a role, among them, promotion of the new industrial economy, modernization and intensification of agriculture and stimulation of urbanization along the outer periphery of the Randstad conurbation – to prevent the Randstad from developing into a tangled amalgamation of unmanageable cities.

Moreover, the flooding of 1953 had proven the value of the older dikes behind the primary flood barriers. Without these older dikes, some of the effects of the floods would have been much worse. The flood map of 1953 (Figure 3.9) suggests that these dikes protected various parts of the islands from the worst of the flooding.

3.4 The closed delta: The latter half of the twentieth century

Interventions and transition of the system

Interventions in the system again underwent a change of accent in the latter half of the twentieth century, this time towards an emphasis on shortening the coastline.

In choosing between the strengthening of existing dikes or the closing off of coastal inlets, the newly established Central Planning Bureau (CPB) – a government agency that had been set up after the war – observed that shortening the coastline would provide greater opportunities for renewed economic development of the delta region, which would ultimately benefit state coffers (Tinbergen, 1961). The CPB-advocated approach was furthermore a good opportunity to coordinate interventions in the water system with economic and spatial planning policies and objectives. In the initial post-war period in particular this led to development of a synergy not seen before between different policy areas, such as flood protection, spatial planning, traffic engineering, and industrial and agricultural development (Schuyt & Taverne, 2000).

Using a new method to calculate future peak water levels (the "probabilistic method"), dams were dimensioned with a failure risk of 1:4,000. This took into account a steady rise in sea level in the future (Stive & Vrijling, 2010).

At the national level, spatial planning was the responsibility of the National Planning Department (RPD), an agency established during the war. In addition to countering too large urban concentrations in the Randstad, the RPD attached great importance to the development of sufficient green recreational space, as these were considered an essential feature of a modern industrial society. The delta region offered excellent opportunities in this respect. As a result, the heart of the delta (Grevelingen and Oosterschelde with Schouwen-Duiveland as the central island) became a primary destination for city dwellers to enjoy leisure activities and nature parks. This open area was to be part of a larger open corridor of the riverine region.

The Delta Plan and the Second National Policy Memorandum on Spatial Planning anticipated intensive urbanization and industrialization around the Haringvliet and South Beveland. To contribute to these developments, plans were also made for substantial increases in the density of the national motorway network (Figure 3.10c).

System image

The Delta Works introduced a strict compartmentalization of the delta waters, with each given its own non-variable content: sweet with varying water levels (the Haringvliet), stagnant sweet (for the Volkerak-Krammer and Veer lakes) and stagnant salt (for the Grevelingen); the Eastern Scheldt was also planned as stagnant salt. The Western Scheldt would remain as the only estuary in the entire delta (Figure 3.12). The compartmentalization would have major consequences for nature and the environment, but these had been anticipated from the start of the Delta Works project and considered acceptable (Duursma, Engel & Martens, 1982). The eroding away of sandbanks in the estuaries, today known as "sand starvation", was also foreseen.

Besides the absence of saline-to-freshwater gradients, land-to-water gradients also fell away. The contrast between open water and diked lands was heightened not only by the increased elevation and strength of the dikes as a result of the Delta Works, but also by the disappearance of many inlets in the process of land consolidation.

This integral approach brought distinct advantages for the delta region. Its ports and industry grew, especially on the outskirts of the delta, where urban growth was concentrated. Calculations done in 2003 indicated that the growth actually achieved was six times greater than that originally forecast by the CPB (Don, 2003). Moreover, the compartmentalization of the former estuaries meant that large supplies of freshwater could be provided, establishing excellent conditions for increased agricultural productivity and establishment of processing industries in the Port of Rotterdam, which expanded to become the second largest petrochemical industry centre in the world.

However, many goals for the delta itself were not realized. A planned "delta city" on the Island of Goeree-Overflakkee was never established (Province of South Holland, 1957), nor did many of the planned industrial zones materialize. In addition, less than half of the planned roadworks were completed.

The system image in this period can be characterized as an attempt to "direct" the development of the various subsystems from the central government level, while also ensuring coherence and synergy between these systems. A leading role was reserved for the system of hydraulic engineering and flood barriers. The delta area was equipped with a dependable safety system, ushering in an unprecedentedly long period without flooding. In addition, this part of the country became considerably more prosperous; the economic backwardness of the delta region evaporated. The consequences for the natural system, both biotic and abiotic, were extremely large, but these had been foreseen and considered acceptable.

Figure 3.10 Three national plans: (a) Delta Plan, 1959; (b) Second Memorandum on Urban Planning, 1966 (excerpt); (c) Highway Structure Scheme, 1966 (excerpt)

Changes and driving forces

Since the final decades of the twentieth century, a new situation has arisen, placing this system image of the Southwest Delta under increasing pressure for a number of reasons:

- *Increasing focus on nature and the environment.* The impacts of the Delta Works on nature and the environment were certainly not unforeseen. But what the designers and implementers did fail to anticipate was the considerable change in the societal value attached to nature and landscape, environment and ecology. This public concern became manifest in the Southwest Delta as early as the 1970s, when it induced a drastic modification of what was to have been the culmination and climax of the Delta Works: the Eastern Scheldt Dam. Under immense public pressure the original design for a closed dam was transformed into a storm surge barrier, which meant that the Eastern Scheldt would remain salt and the tidal environment would be maintained (The Skipper, 2008). Since then, interference of environmental organizations in the Southwest Delta and public support for retaining the region's nature values has only grown. Since the 1990s, moreover, this trend has been amplified at the European scale, by the European Commission's pursuit of the "Natura 2000" ecological network. It was within this framework that the "Delta Nature" project was initiated in the Southwest Delta, in which the provincial government joined forces with environmental organizations to implement a series of projects aiming to restore natural land-water and saline-freshwater gradients. The WWF has advocated, in this context, the wholesale reopening of all coastal inlets (WWF, 2009).
- *New insights and opinions on flood protection.* The field of flood protection policy has undergone a cultural transformation since the 1990s based on two factors: First, the calculations that served as the basis for designing the Delta Works flood barrier system have been under revision since near-flooding struck the inland riverine region of the Netherlands in 1993 and again in 1995. Since then, ample predictions have been made about climate change and its implications for sea level rise and possible peak river discharges – though these have varied rather widely. In any case, there is no longer consensus on the linear evolution of future sea level rise. The shifting projections and opinions in this field prompted the Dutch government to establish the Second Delta Committee, to formulate a vision on the long-term protection of the Dutch coast and hinterland. The report of this Committee (Delta Committee, 2008) points to the Southwest Delta as a region warranting closer examination, where a new equilibrium needs to be found between flood protection, ecological development and economic development. Second, in the wake of the rising interest in nature and the environment interest in natural means of flood protection has increased. Concerns about damage to ecosystems play a role here, as well as, in particular, worry about the increasing erosion observed in the Dutch delta region. Though the coastline has been subject to erosion for more than 800 years, the blocking of sediment transport in the rivers and tidal inlets has also led to erosion of sandbanks and foreshores in the delta estuaries, and thus also to increased vulnerability of the primary flood defences (Mulder, Cleveringa, Taal, Van Wesenbeeck & Klijn, 2010). "Building with Nature" is one of the new approaches along these lines and is being applied on a large scale for the first time in the national "Room for the River" programme (Quality Team Room for the River, 2012). The Delta Committee has also stressed the need for such an approach, even titling its final report, *"Working Together with Water"* (Delta Committee, 2008). For the Delta Programme, a crucial decision is whether to maintain the current river discharge distribution or modify the discharge distribution. Earlier in this chapter, we mentioned Caland's early plans for water management in the region. In the nineteenth century, Caland discovered that river mouths have a natural tendency to shift southward. Construction of the New Waterway went against this tendency by artificially fixing the river mouth. The question is whether in the future the New Waterway will continue to play its current role in the discharge of river water, or if river water will be discharged mainly via the Haringvliet with discharge via the New Meuse–New Waterway reduced, possibly in phases.
- *Political and social changes.* The Southwest Delta in its present form is the product of a large-scale national project aimed at closely coordinating various different policy areas (e.g., flood protection, spatial planning, transportation and economic development) by what Faludi and Van der Valk have labelled the "Dutch Planning Doctrine" (1994). This doctrine of "integration" and "synchronization" has lost its potency, however, and its application is no longer feasible in the current context (Roodbol-Mekkes, Van der Valk, Korthals Altes, 2013). Since the 1990s, a liberalizing trend has swept into political thinking, propelling the central government to withdraw as the dominant figure. Tasks related to urban planning and landscape development, according to the now-dominant government philosophy, are mainly viewed as a matter for local government levels and/or private parties. Aside from this retreat from spatial planning, the central government has developed another role: that of caretaker for the spatial quality of the most valuable "national structures". It has expressed this role, for example, by commissioning a series of "Architecture Notes", by appointment of a number of government advisors (on landscape, infrastructure and cultural heritage) and by establishment of spatial quality teams for key priority areas such as "Room for the River". This has led to a somewhat paradoxical situation in the field of spatial planning policy: there is both an emphasis on deregulation and an accent on greater "spatial quality".
- *Economic and demographic developments.* The spectacular population growth that was forecast in the 1960s did not in fact come about. The Dutch population has now largely stabilized, with population declines expected starting in 2025 (Dijkstal & Mansfield, 2009). The predicted growth of tourism and recreation did occur initially, but after the peak year of 2003 (in which 12 million overnight stays were recorded) a decline of no less than 35% has been registered (Kenniscentrum Kusttoerisme, 2010). The most important economic factor in the delta, the major seaports, are facing a context of growing global competition. Ports are seeking opportunities

Figure 3.11 Water dynamics: Interventions in the water system of the delta

- River discharge in %
- Tides
- Lands not diked in 1850
- New lands established since 1850 not diked
- Sandbanks not shifted since 1850
- Sandbanks newly established between 1850 and 1950
- Sandbanks vanished between 1850 and 1950
- Newly dug river
- Dune newly established between 1850 and 1950
- Dune 1850
- Landfill
- Primary flood barrier 1950
- Primary flood barrier 1850
- Bank protection, breakwater

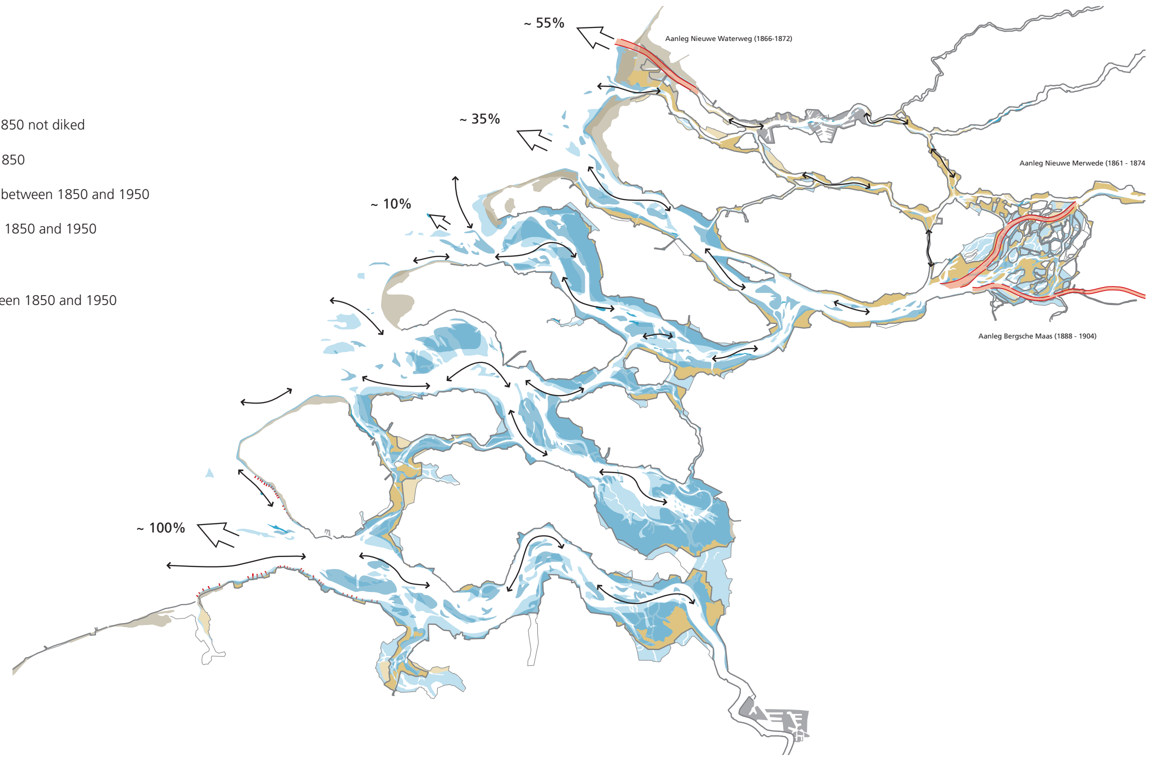


Figure 3.12 Water dynamics in the Southwest Delta after construction of the Delta Works: Erosion of sandbanks and edges

- River discharge in %
- Tides
- Reduced tides
- Lands not diked in 1950
- New lands established since 1950 not diked
- Sandbanks not shifted since 1950
- Sandbanks newly established between 1950 and 2010
- Sandbanks vanished between 1950 and 2010
- Bank protection, breakwater
- erosion zone
- Dune
- New landfill since 1950
- Landfill 1950
- Primary flood barrier

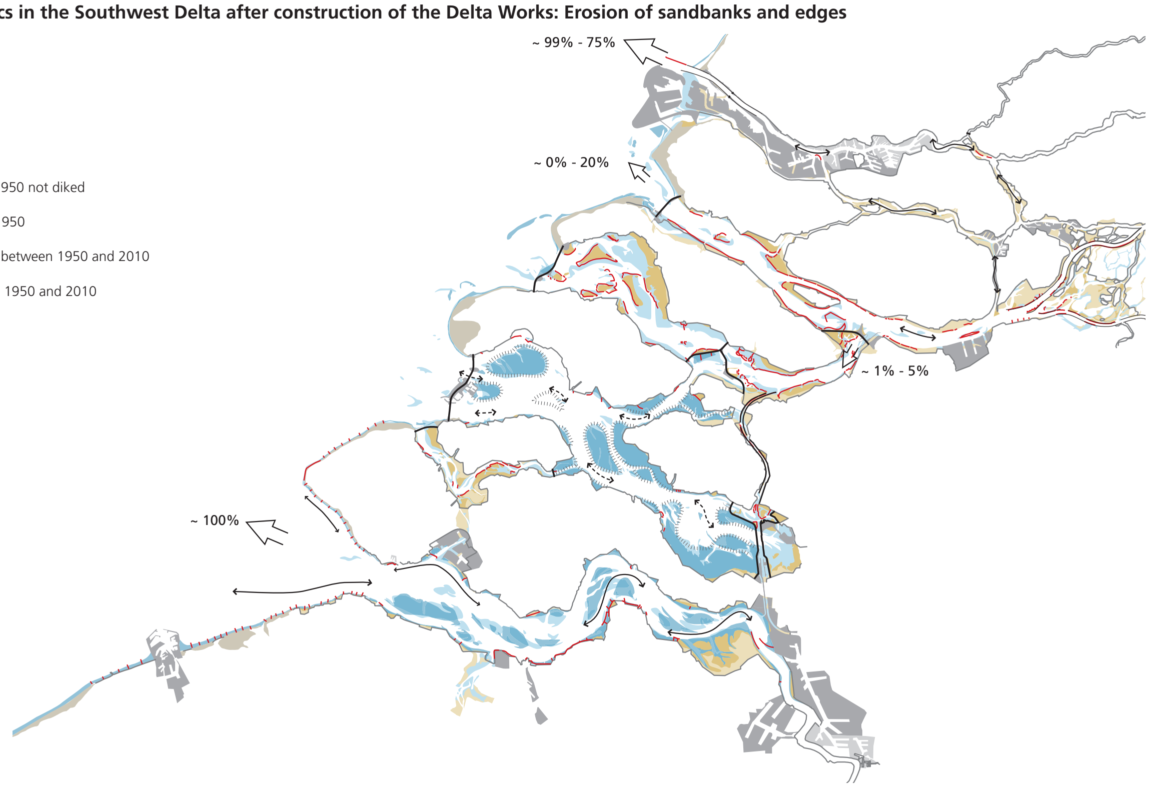


Figure 3.13 Agriculture in the Southwest Delta between 1850 and 1950

- Land parcelling structure (indicative)
- Fruit-growing area
- Sugar factory (year of establishment)
- Rail line
- Tram line
- Ferry
- Boundary between freshwater and saltwater

Percentage of land in 1930 cultivated to:

- Corn
- Legumes
- Sugar beet
- Potatoes

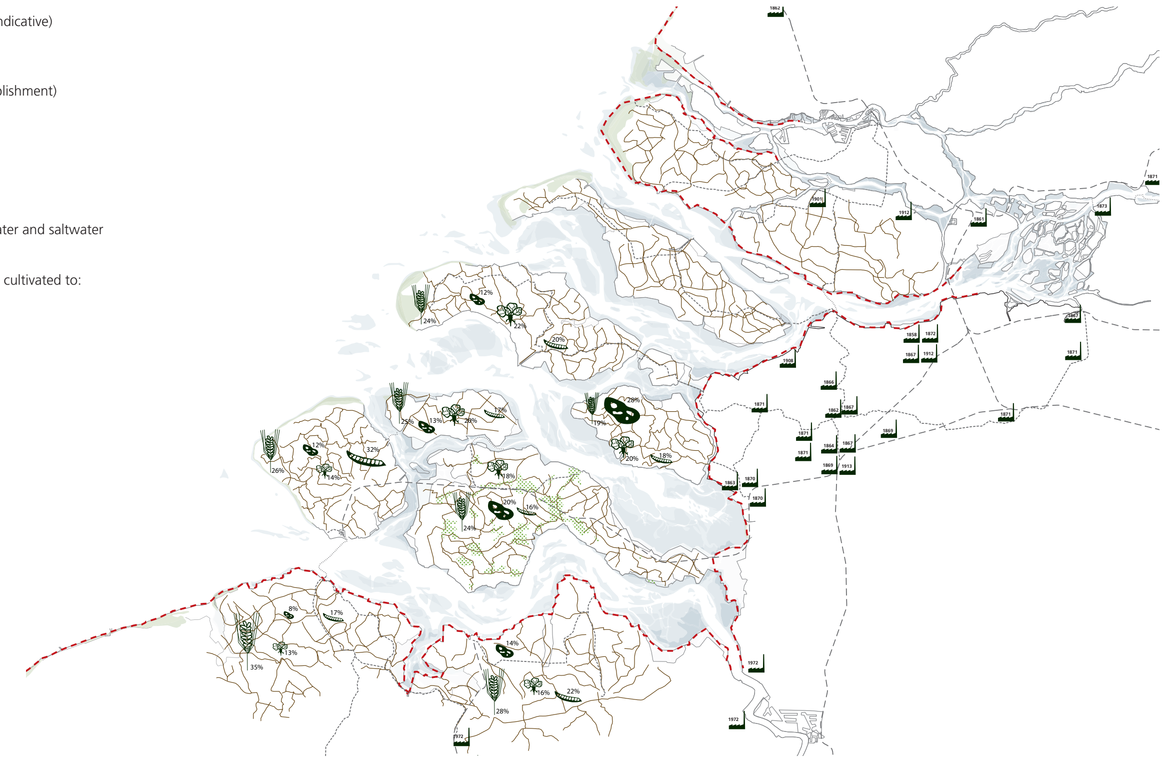


Figure 3.14 Agriculture in the Southwest Delta in 2010

- Land consolidation (indicative) between 1925 and 1950
- Land consolidation (indicative) between 1950 and 1975
- Land consolidation (indicative) between 1975 and 2010
- Fruit-growing area

Percentage of land in 2010 cultivated to:

- Grain
- Sugar beet
- Potatoes
- Greenhouses
- Fruit
- Flower bulbs

Depth interface region 1,000 mg Cl/

- Strongly salinized soil : 0 m-hv to 15 m-hv
- Moderately salinized soil: 15 m-hv tot 50 m-hv
- Boundary between freshwater and saltwater
- Industrial/drinking water supply
- Agricultural water supply
- Reservoir
- Sugar factory

Figure 3.15 Port development, 1850–1950

- Commercial port
- Fishing port
- Oyster and mussel parcels
- Naval port
- Shipyard
- Navigation channel (shipping)
- Navigation channel (shipping) important from 1830 to 1884
- Main shipping route to Antwerp and Rotterdam
- Port/city in 1850
- Port in 1950
- Excavated river
- Rail line to Ruhr Area

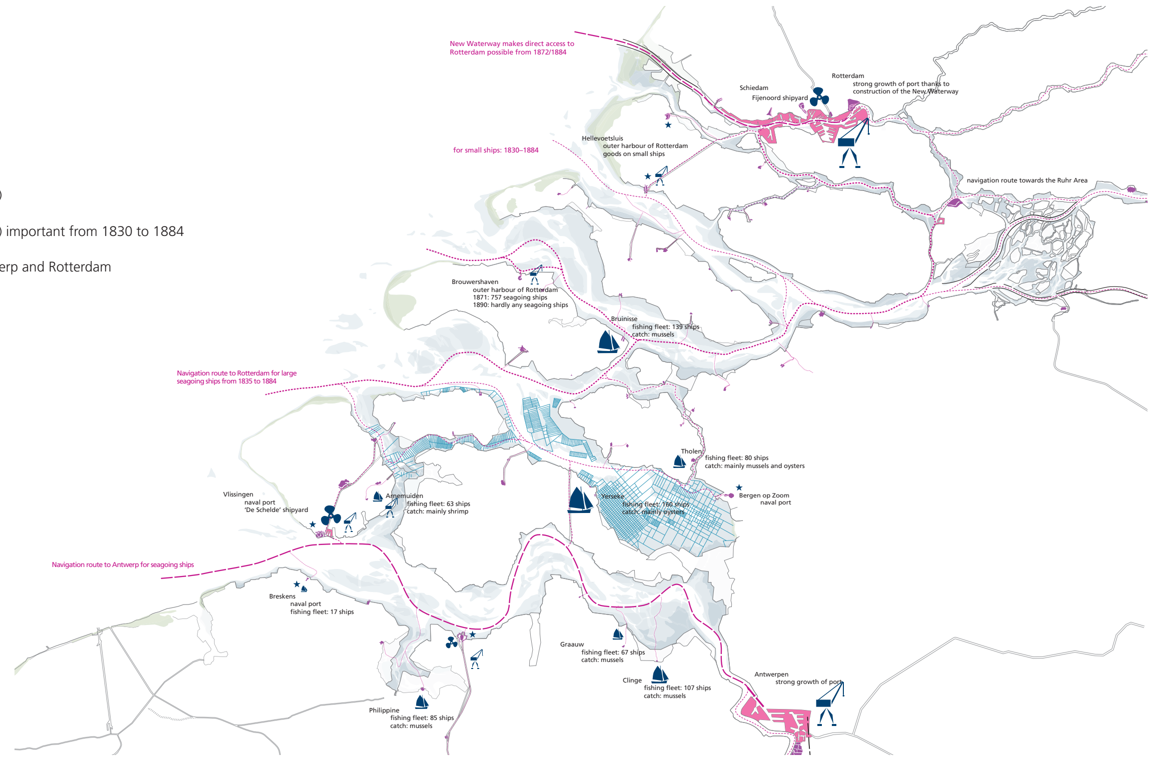


Figure 3.16 Port development, 1950–2010

- Commercial and industrial port
- Yacht harbour
- Fishing port
- Oyster and mussel parcels
- Shipping industry
- Important navigation channel (shipping)
- Navigation channel (shipping)
- Betuwe rail route
- Rail line
- Expressway
- Port/city in 1950
- Port expansion between 1950 and 2010

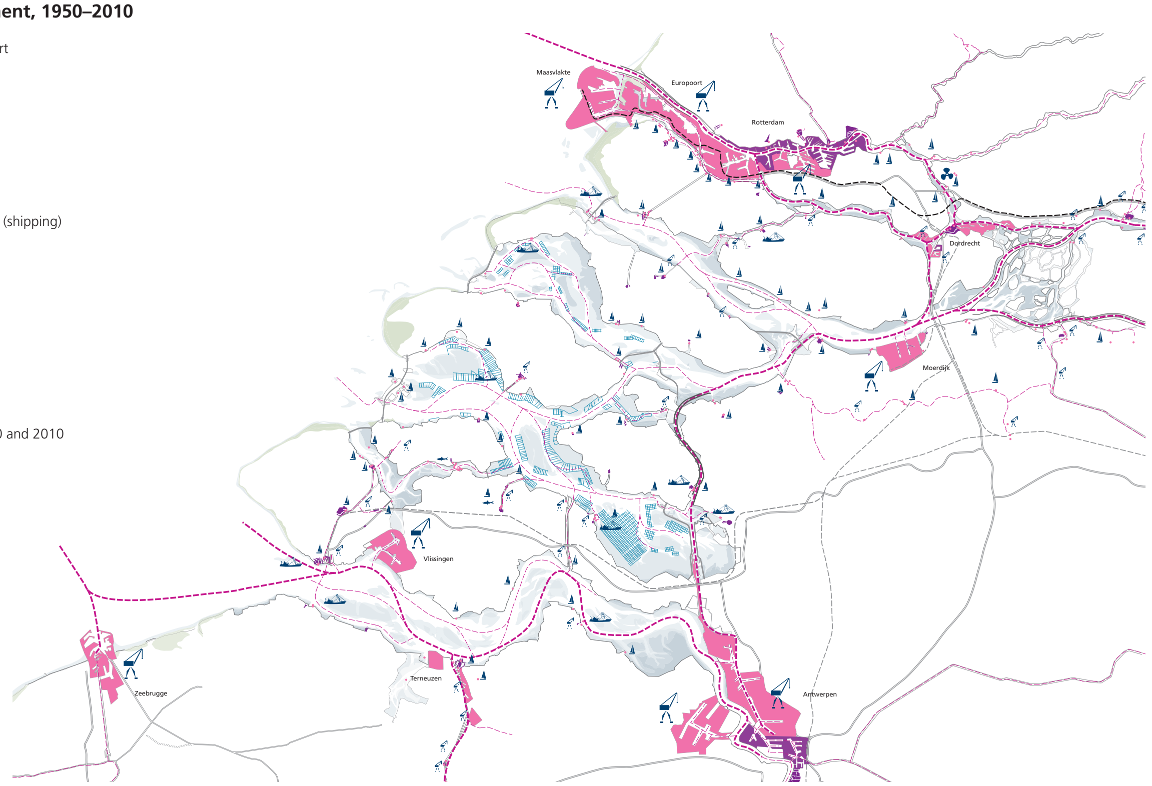


Figure 3.17 Flood defences, 1850–1950

- Dam (year of construction)
- Excavated river (year of construction)
- Dike relocation between 1850 and 1950
- Dike 1950
- Former dike 1850
- Artificially constructed land
- Canal before 1850 (year of construction)
- Canal after 1950 (year of construction)
- Canal (filled in)
- Discharge sluice (before 1850 and after 1850)
- Shipping lock (before 1850 and after 1850)
- Dune

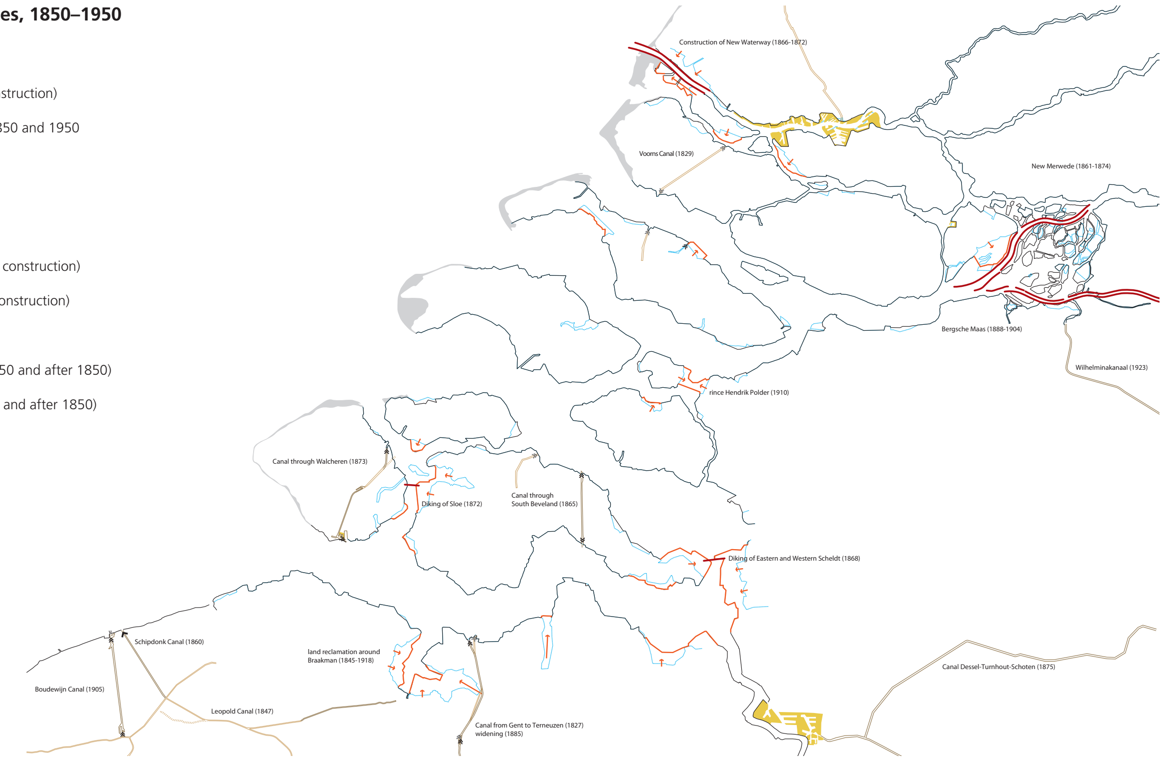


Figure 3.18 Flood defences and port infrastructure realized between 1960 and 2000

- Dam (year of construction)
- Storm surge barrier
- Excavated river (year of construction)
- Dike relocation between 1950 and 2000
- Dike 2000
- Former dike 1950
- Artificially constructed land
- Canal before 1950 (year of construction)
- Canal after 1950 (year of construction)
- Canal (filled in)
- Canal (no longer required)
- Discharge sluice (before 1950 and after 1950)
- Shipping lock (before 1950 and after 1950)
- Bridge, tunnel (longer than 1 km)
- Dune

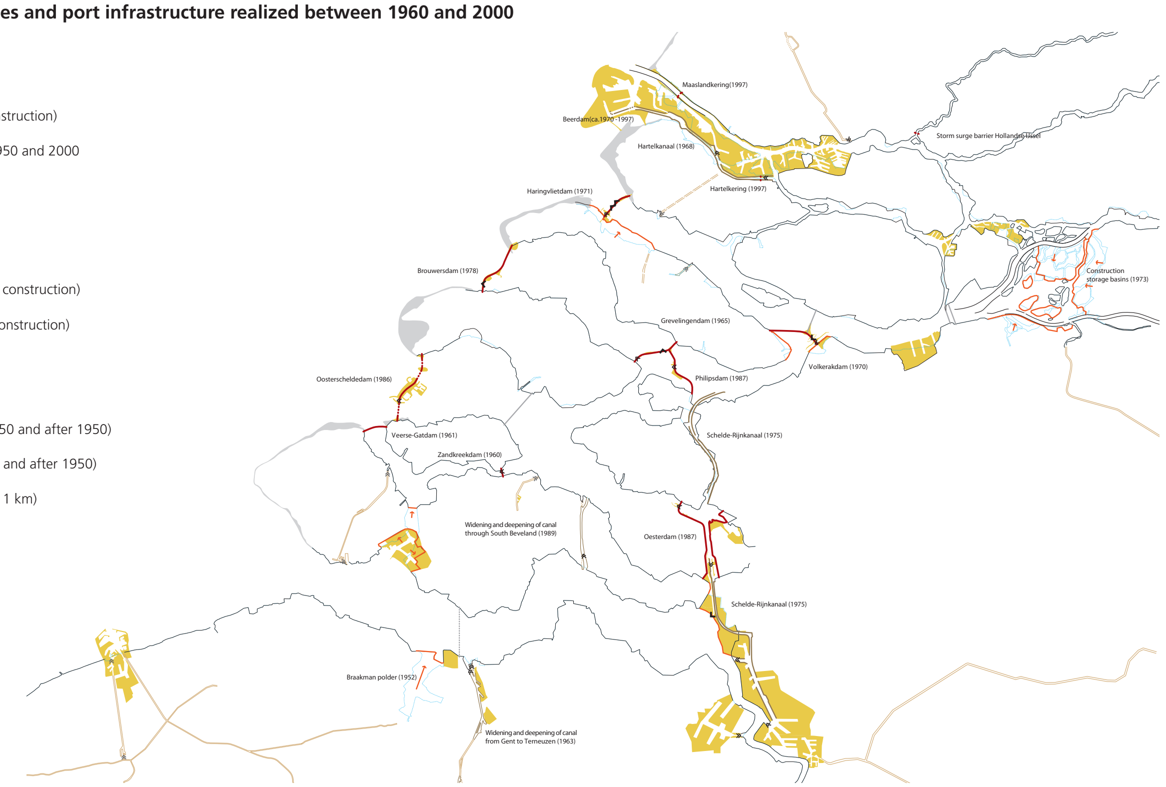


Figure 3.19 Urban development and networks, 1850–1950

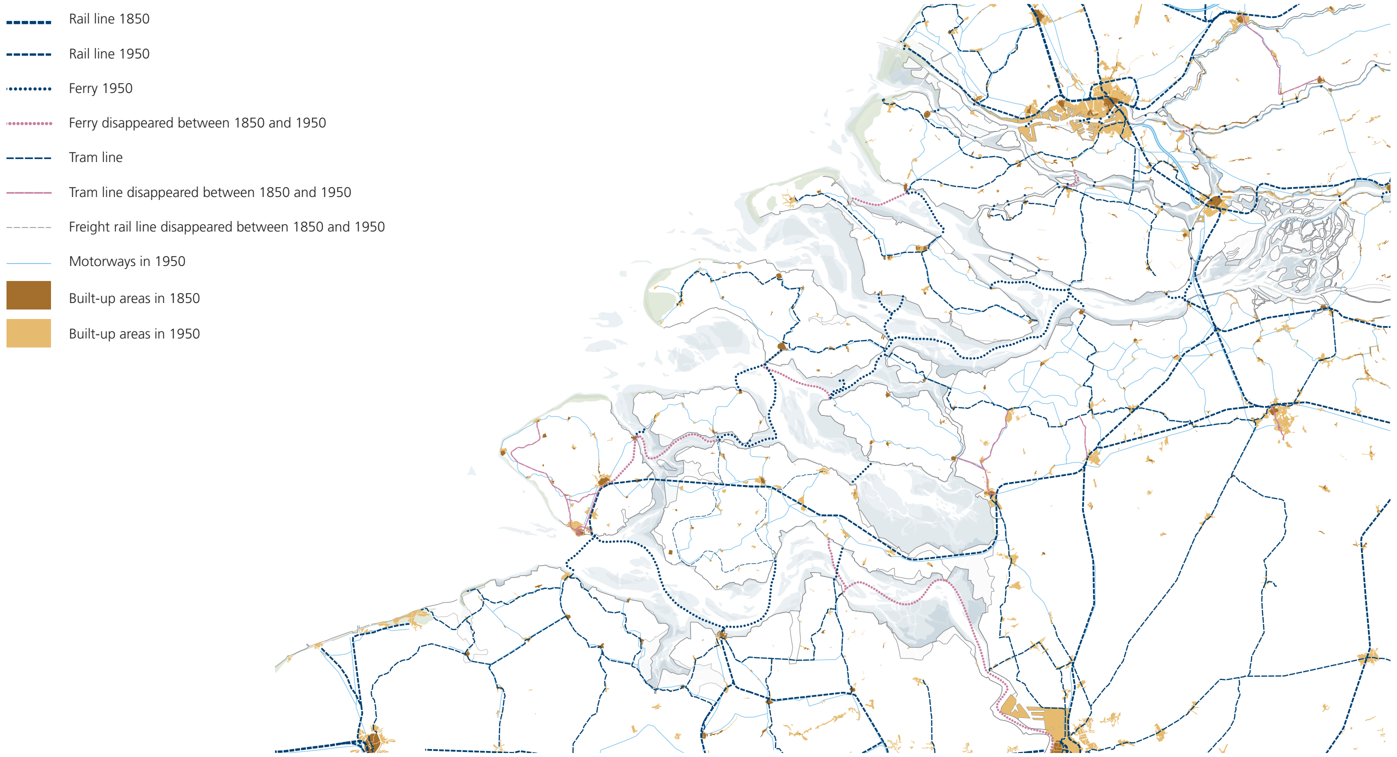
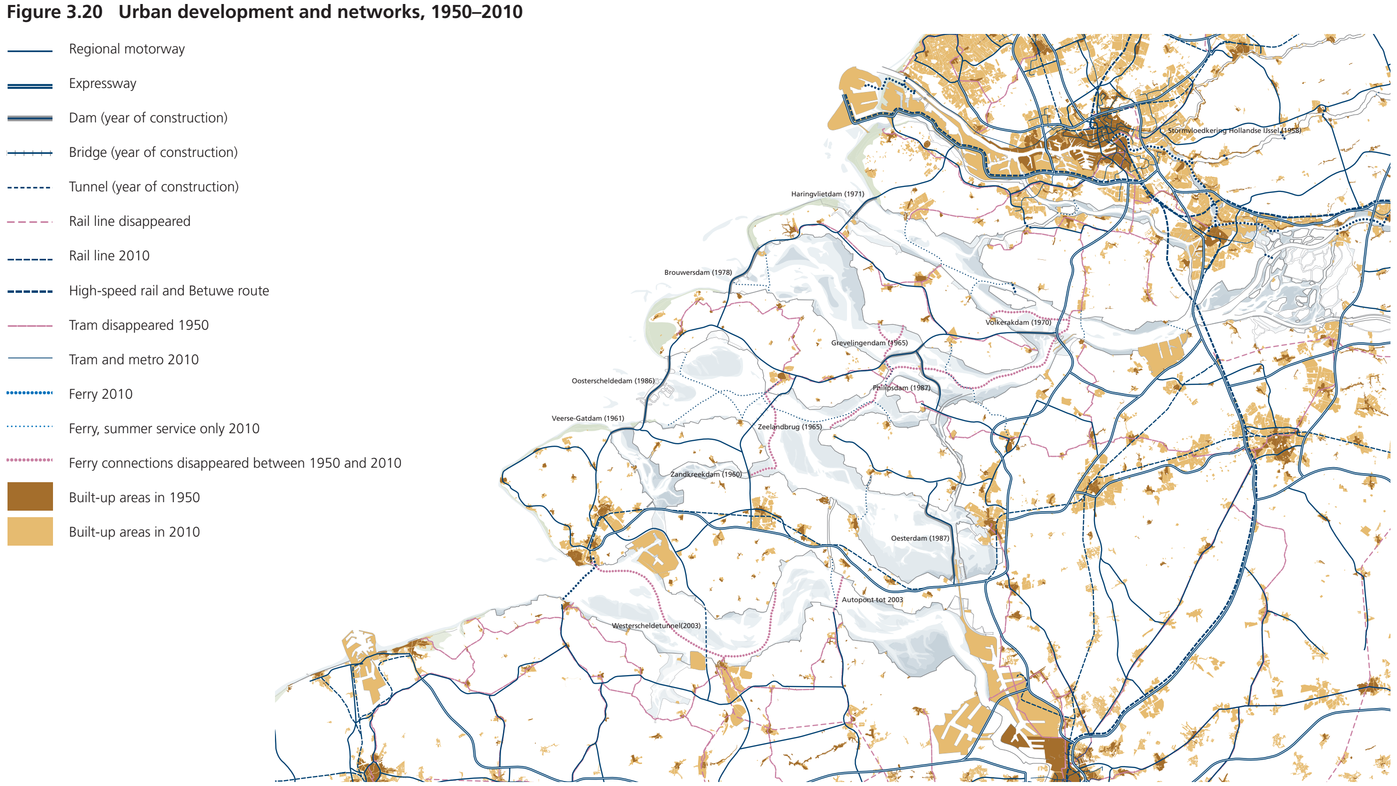


Figure 3.20 Urban development and networks, 1950–2010



for increased cooperation at the regional level, to position themselves better to compete with other port regions in the international market (Wang, Olivier, Noteboom & Slack, 2007). In the Southwest Delta, too, the Rotterdam Port Authority is following this trend and working to develop alliances with other ports in the region (Port of Rotterdam 2012; Vanelslander, Kuipers, Hintjens & Van der Horst, 2011). With respect to agriculture, numerous farmers and research institutes have begun experiments to prepare for possible modifications of the strict separation of freshwater and saltwater environments: trials have been done with saline crops (Guldemond, Tolkamp & Van der Weijden, 2007) and with autonomous freshwater supply systems for use in commercial agriculture (Old Ensink, 2013).

New alliances

In this changing context, many parties are looking for ways to achieve their own objectives, and to respond to the changing situation around them, without the national government playing the role of central "director" any longer. With the increasingly sophisticated organization and political influence of interest groups and nongovernmental organizations, such as the WWF and the Dutch Nature Conservation Association (Vereniging Natuurmonumenten), the diversity of special interests and viewpoints initially resulted in a variety of conflicts and (near) stalemates on matters of spatial development in the region. The Port of Rotterdam had to negotiate long and hard with the Milieufederatie (an environmental NGO) on construction of the Second Maasvlakte (a land reclamation project for example port activities). Ultimately it will have to implement a long series of compensatory measures for nature and environment. Farmers on the Hoeksche Waard have opposed a plan to open the Haringvliet sluices for fear of salinization of the groundwater.

At the same time, there is also talk of new alliances. The most notable of these is probably the collaboration between the Port of Rotterdam and WWF. Since the experiences with the Second Maasvlakte, these parties have acted jointly, for example, in realization of the "Green Port" project in the Rotterdam harbour area (Port of Rotterdam, 2013; WWF, sa). On the shores of the Haringvliet, these same partners are seeking other locations where projects could be initiated that would lead to restoration of estuarine nature.

Many other alliances are in development as well. The Rotterdam Municipal Government has joined hands with the Port of Rotterdam, private developers and research institutes like Deltares to investigate new urban planning concepts in relation to its city ports (Stadshavens Rotterdam, sa). Municipal governments in the Haringvliet–Hollands Diep area have developed projects with environmental organizations, recreation businesses and water boards for new forms of nature and regional development. For the Southwest Delta, questions have been raised about how responsibility for an adaptive flood protection system as the core task of government relates to the interests, initiatives and plans of the many different actors in the region, which may or may not be organized into more or less sustainable alliances. This new situation calls for crystallization of a new "governance culture", and also new kinds of spatial solutions that can combine a generic, large-scale long-term oriented line of policy (such as in the area of flood protection) with the numerous different initiatives and plans developed by actors from different backgrounds and often focused on smaller-scale projects which can be realized in the shorter term. This new situation requires, in short, a new "system image" for the twenty-first century.

3.5 Conclusions: More space for the different rhythms of subsystems

This chapter distinguished three periods in the spatial development of the Southwest Delta, each characterized by its own "system image". Taking a more general view, three ideas in particular are of note:

1. In the recent history of the Southwest Delta, we found that the relationship between the natural system of rivers, deltas and sea and the human-made system of flood barriers was a decisive factor in development of the system of the Southwest Delta as a whole. Furthermore, the changing relationship between these two subsystems has been a decisive factor in the development of various subsystems as well, such as ports and industry, agriculture, urbanization, traffic and transport networks, and the ecosystem. Interventions in the delta system were, up to the nineteenth century, focused on land reclamation and dike construction. In the nineteenth century, the accent shifted to increasing the discharge capacity of the rivers. In the twentieth century, the emphasis moved again, this time to coastline shortening. At the start of the twenty-first century, with the "Room for the River" programme, it appears that a new change of accent is at hand, namely to increase the storage capacity of the rivers. With the increased discharge capacity of the rivers in the nineteenth century and the coastline shortening of the twentieth century, the water system was engineered such that the New Waterway took on a major role in regulating the discharge of river water into the sea. These interventions set the stage for the explosive development of ports and industry, and the productivity of agriculture and horticulture was enormously expanded as well. One downside has been the increased influence of the sea on the urban areas of Rotterdam and Drechtsteden, with as a result, a greater threat posed by high water levels in areas outside the dikes (where 60,000 people live) and increased salt intrusion. Also, the natural estuarine ecosystem has been lost in waters that were formerly delta estuaries, like the Haringvliet.
2. The Rijnmond-Drechtsteden delta sub-programme has indicated that in regard to flood protection and freshwater provision, the current system can be maintained until 2050 (Stuurgroep Rijnmond-Drechtsteden, 2014). What happens after that is still highly uncertain. A further increase in peak river discharges and sea level rise are expected to place increasing pressure on the current flood protection infrastructure. Right now, due to the substantial economic clout of ports, industry and agriculture, it seems inconceivable that the current role of the New Waterway in the discharge of river outflows would cease and that the Haringvliet would start to play the primary role in this respect. However, if the current trend of port activities shifting westward were to continue into the future and agriculture were to become more self-sufficient in freshwater supply and oriented more towards saline crops, new prospects would likely appear on the horizon. An exploration of these prospects is the subject of the next chapter. The Delta Programme works with a time horizon of 100 years. In such a period, it turns out that much can happen that was initially totally unforeseen, and interventions in one subsystem can lead to effects in other subsystems, which also may have been unforeseen. When in 1865 a start was made in digging the New Waterway, while it was envisaged that the channel would stimulate rapid growth of the Port of Rotterdam, it was not anticipated that it would contribute to the impoverishment of the delta region as a whole, to the point where local authorities were no longer capable of maintaining the dikes, ultimately leading to flooding such as that in 1953. Similarly, while the Delta Plan of 1958 did foresee that its implementation would have far-reaching consequences for nature and the environment of the delta, it did not at that point expect strong social resistance to arise (1973) leading to a completely new design for the Eastern Scheldt barrier, and later (2005) to a programme like "Room for the River". In less than half a century, the social context and public opinion radically changed. Studies of future scenarios must then also be done taking the possibility of such change into account.
3. In the post-war decades in particular, policies were implemented that attempted to combine – or in other words, to synchronize – the flood protection system with national policy in the areas of economic and spatial development. However, no true synchronization of control over nature, space and economy was actually achieved. Economic and spatial development have gone on in other directions than originally considered and planned. These developments were stimulated by construction of the new water management infrastructure, but they cannot be said to be synchronized.

This brings us to a second conclusion: that different subsystems all have their own dynamics, with different speeds or "rhythms" of change. The rate of change of the natural system, for example, influenced to a large extent by changes in the environment, is very slow compared to the rate of change of spatial and economic developments.

Central government policy was aimed at organizing the Southwest Delta (and in fact the entire land area of the Netherlands) as a "strictly coupled system". In such a system, various subsystems are so closely intertwined with each other that when one of the subsystems unexpectedly develops differently, the whole system becomes disordered. The environmental sciences have already documented the high vulnerability of these kinds of systems (Turner, R. Kasperson, Matsone, McCarthy, Corell, Christensen, Eckley, J. Kasperson, Luerse, Martello, Polsky, Pulsiphera & Schiller, 2003). Much less vulnerable are "loosely coupled systems", whereby there are possibilities for subsystems to benefit from each other's presence, but they are not completely dependent upon each other.

The Southwest Delta now finds itself in a transition period from a strictly coupled system built up over more than half a century to a more loosely coupled system.

Characteristics of a new system image of the Southwest Delta as a more loosely coupled system are the following:

- Each subsystem can develop such that combinations are possible with developments in other subsystems, but these combinations do not necessarily have to be implemented simultaneously.
- The various subsystems have relatively more freedom to develop, though within certain boundaries, so that they do not disturb the other subsystems. These boundaries must be clearly indicated by the formulation of clear-cut rules and parameters.
- When the development of one or more subsystems is hindered by one or more other subsystems, it could be investigated whether forms of synchronization are possible whereby a larger extent of freedom of action could again be created for all the subsystems individually.

Chapter 4

A futures perspective on the Southwest Delta

Building on the observations made in the retrospective analysis, changes in the future will also likely affect the delta's environment (e.g., changes in the climate and global economy) leading to major changes in one or more subsystems of the delta, and therefore also in the delta as a whole. This chapter uses "research by design" to test what the "adaptive capacity" of the delta might be if profound changes were to occur in, say, the climate or the global economy.

4.1 Introduction

Is it possible to develop meaningful future visions that can play a role in formulating adaptive plans for a complex system such as the Southwest Delta? Because of the major uncertainties surrounding future climate changes and future economic and demographic developments, it makes little sense to try to predict the future. Nonetheless, it is still important to explore insofar as possible what developments might be ahead for a region, and what their effects could be. On that basis, designers, planners, policymakers and stakeholders in the region can anticipate on possible developments.

Various different forecasting methods have been developed in recent decades to visualize possible developments in the future. These methods help to understand the main challenges perhaps ahead for a region and the uncertainties surrounding them (Dammers, Van 't Klooster, De Wit, Hilderink, Petersen & Tuinstra, 2013). Working with future visions can contribute to more future-proof planning and design, in other words, to plans and designs that take into account the different conditions that could possibly arise in the future.

Foresight studies have been applied for decades in the fields of spatial planning, water management, economics and others. Scenario development was first introduced in the Netherlands in the early 1970s, in response to the oil crisis and environmental crisis. Since then, foresight studies have been carried out for many purposes and on different scale levels and become an important part of the Dutch planning culture (Salewski, 2012). Some examples of key Dutch foresight studies are the "Netherlands Now as Design" (1987), "The Netherlands 2030" (1996), "Climate in the 21st Century" (KNMI, 2006), "Prosperity and the Living Environment" (CPB, MNP & RPB, 2006), the "Water Survey" (Deltares, 2008) and the "Delta Scenarios" for 2050 and 2100 (Deltares, PBL, KNMI, LEI & CPB, 2013).

Approaching the Southwest Delta as a complex adaptive system poses particular challenges for foresight studies. In this chapter we examine what those challenges are and how they can be addressed in carrying out foresight studies for a region such as the Southwest Delta.

4.2 Foresight studies: The challenges

Based on our representation of the delta as a complex adaptive system, the foresight study can be broken down into five steps. The first step is to choose the appropriate type of foresight study that does justice to the complexity and uncertainty of the delta environment. The second step is to investigate the interactions between the system, subsystems and the surrounding environment. The third step requires the past to be linked to the present and the future. The fourth step is the actual investigation of the uncertainty associated with future events and developments. The fifth step is to adequately articulate, quantify and envision the possible futures.

1. Choice of type of foresight study

The first step concerns choosing an appropriate type of foresight study that does justice to the complexity and uncertainty of the environment. Several methods are available for exploring the future (see Makridakis, Wheelwright and Hyndman, 1998; Scott Armstrong, 2001; Van der Duin, 2012). These can generally be categorized into three groups: projections, scenarios and speculations. Figure 4.1 depicts these graphically, and they are explained in more detail below.

A *projection* is based on extrapolation of a trend from the past to make the most accurate statement possible about the course of future developments. Uncertainty is expressed in terms of a confidence interval. The assumption made is that the future will be free of surprises: the possibility of discontinuities is not taken into account.

Projections are appropriate for exercises with a limited degree of complexity and in which there is little uncertainty about future developments. This may be because the development under study is influenced by just a few factors, because it proceeds uniformly or because the time horizon over which judgements are to be made is short or medium term (5–10 years).

Exploration of *scenarios* is based on knowledge and data about the past that are considered to be indicative of the different possible paths of future developments, based on a given set of conditions in the future (driving forces) (Dammers, Van den Born, Bruggeman & Van den Hurk, 2013). Usual practice is to develop several scenarios illustrating a range of different future conditions. Scenarios often relate to changes over a 10 to 50 year period. Scenario developers typically take a range of dynamics into account: in addition to incremental changes they also look at changes in the form of transitions. Scenarios are by far the most common approach to foresight studies applied in planning.

In *speculation*, futurologists formulate predictions and creative ideas about the future. Knowledge and data about the past play less of a role, or at least play less of a role in substantiating the statements. Futurologists often extrapolate particular developments to an extreme, trace new developments or explore radically different directions in which the future could materialize. Speculations are suitable for situations in which complexity and uncertainty are very large. This approach places particular emphasis on tipping points and other discontinuities.

Depending on the task at hand, all three forms of foresight studies can play a role in planning and design for a delta region. Nonetheless, it is important to make an informed choice of the type of foresight study to be conducted. For instance, a combination of approaches could be applied. Projections could be used for short-term inquiries, scenarios for medium- and long-term exercises and speculations to gain a glimpse of the very long term future.

For long-term adaptive planning for delta regions, scenario development is considered to be most suitable. Compared to projections, scenarios do better justice to the high degree of uncertainty surrounding the future of a CAS, as they explore multiple different development paths that may be taken over the course of time. Scenarios are also preferable over speculations because they are more firmly anchored in knowledge and insights about the past. This means they are better tailored to the particular characteristics and dynamics of the delta system and environment.

Speculations can constitute an important supplement to scenarios. This is because, due to the considerable complexity and uncertainty of the delta environment, it is important to have an eye for possible discontinuities, as well as key trend-like developments.

Within the framework of the Delta Programme, "delta scenarios" were created by Deltares, PBL, KNMI, LEI and CPB (2013), commissioned by the Netherlands Ministry of Infrastructure and Environment. The reason for developing the scenarios was the significant length of the planning and execution period required for the Delta Programme's physical investments, which aim at the period up to the year 2100. Over such a long time span, the programme cannot be certain of the physical and social developments it will face and have to take into consideration.

Four scenarios were defined based on two developments of key importance for water management: climate change and socio-economic development. Climate change affects, among other things, sea level rise and river discharges and hence the probability of flooding. Socio-economic development impacts, among other things, level of commercial and residential activity and expansion and hence the potential for flood damage. For both developments, extremes were determined: moderate and rapid climate change and socio-economic contraction and growth. These initial assumptions led to investigation of the scenarios PRESSURE, STEAM, CALM and WARM (see Figure 4.2).

The delta scenarios explore possible future developments in the system environment. As such, the scenarios examine factors such as rising sea levels and the upper and lower limits in which this might occur, globalization and the course it may follow over time, and global energy provision and how it might develop. Taken together, the scenarios sketch the range within which future developments are expected to happen. However, it cannot be ruled out that developments completely outside the indicated bandwidth will occur, such as a greater sea level rise.

In addition to the climatic and socio-economic changes that might occur, the delta scenarios also indicate possible developments in economic sectors such as ports, urbanization, agriculture, nature and energy and the way space is used in the Netherlands. Furthermore, they provide indications of what impacts changes in these areas might have in relation to flood threats and freshwater supply.

One of the ways the scenarios were used by the Delta Programme was to analyse future challenges and design possible, probable and preferable strategies by testing the strategies' applicability under different conditions. The delta scenarios relate to the Netherlands as a whole. However, regional

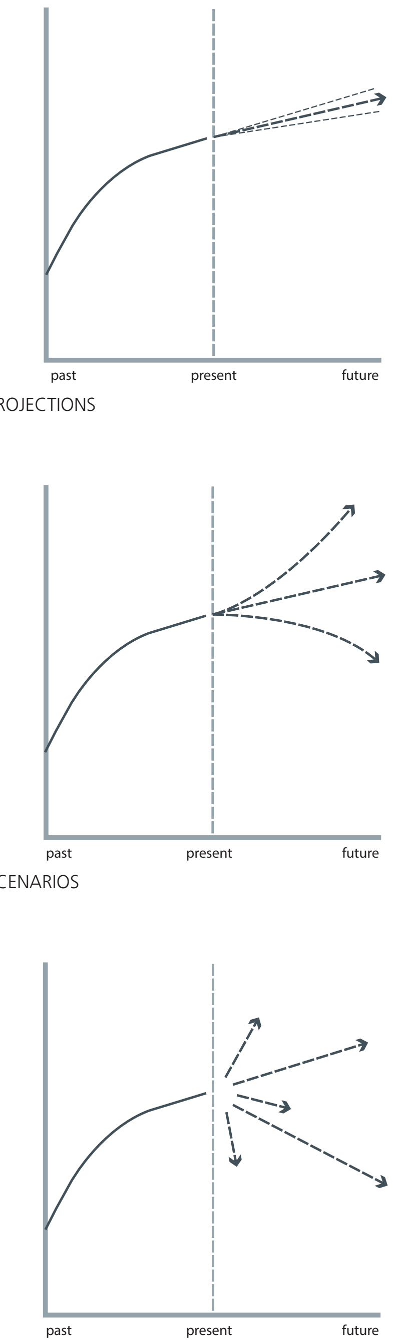


Figure 4.1 Projection, scenarios and speculation

Figure 4.2 Linking past, present and future

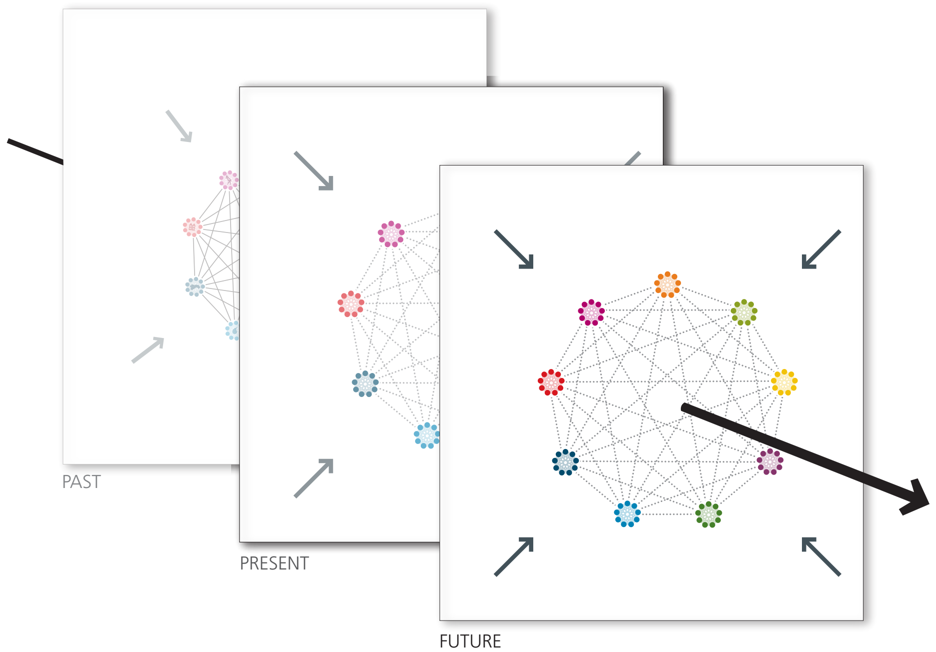
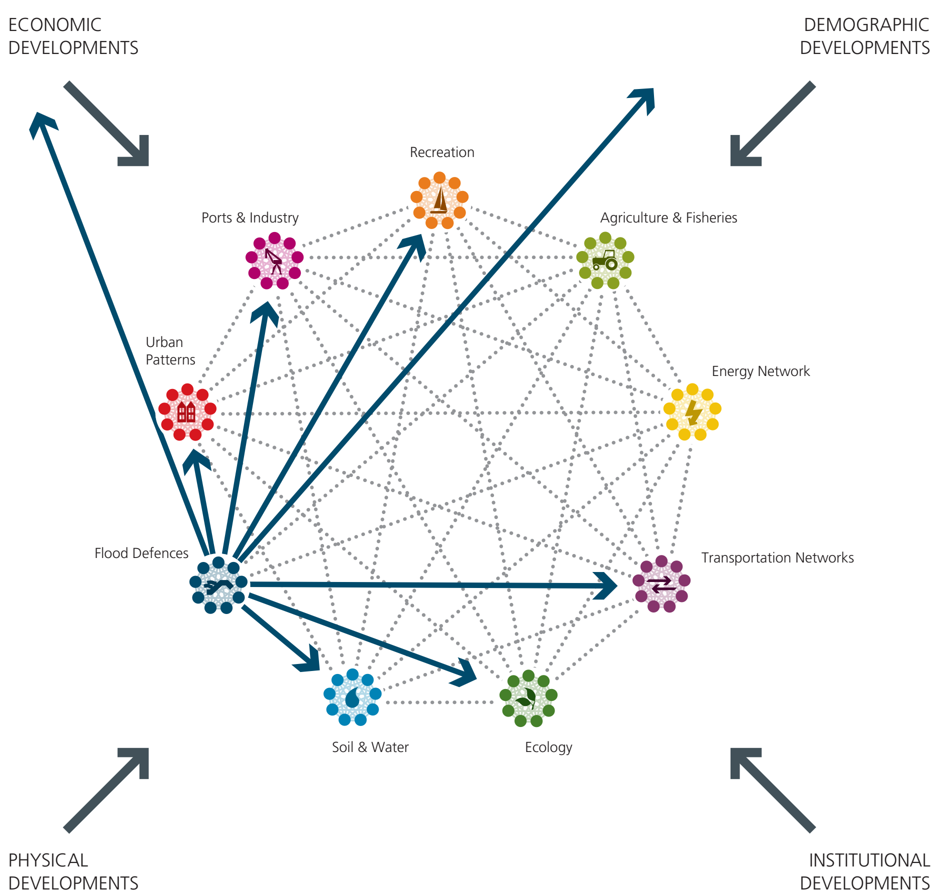


Figure 4.3 Interaction between environment, system and subsystems



translations were made of these national-level scenarios for a number of delta sub-programmes – including those for the Southwest Delta and for the Rhine-Drechtsteden area.

Because these delta scenarios were only recently developed and because they were elaborated for the Delta Programme and are being applied within it, we make frequent reference to these scenarios in discussing challenges facing the delta from the CAS perspective.

2. Exploring interactions between system, subsystems and the environment
Scenario studies often focus on exploring developments in a system's environment, such as climate change, demographic developments and shifts in institutional relationships. This applies to the delta scenarios too. The effects of these developments on the system of the delta are also brought into focus. This was done, for example, by spatially translating the delta scenarios for the different sub-regions. But the translations for the sub-regions remained abstract and lacked spatial specificity. This meant that the scenarios were difficult to translate into spatial planning tasks and they offered little guidance for designers. It was therefore important to elaborate the scenarios in more detail for specific regions and sectors. This is because the effects of developments in the environment could be quite different for the various different sub-regions and per sector.

In addition, it is important not to interpret relationships between the environment and system as merely one-way traffic. Two-way exchanges may also occur, with developments in the environment and changes in the system mutually influencing each other. This is characteristic of the open nature of complex adaptive systems. In the previous chapter we read, among other things, that key interventions in the delta region, such as the Delta Works, have major impacts not only on the future development of cities, ports, nature and other features of the region, but also on economic, demographic and urban development in the Netherlands as a whole. After all, much of the "Randstad" conurbation – which is the economic heartland of the Netherlands – lies in the Southwest Delta.

In the future, it is possible that these types of interventions in a particular subsystem could have far-reaching implications for the system as a whole and its surroundings. In this respect, for example, recent insights on the positive effects of saltwater and tidal dynamics on water quality could in time lead to new ecological and economic opportunities. Exploration of these types of prospects is important to form a full picture of the possible consequences of and challenges ahead for spatial planning and design.

3. Linking past, present and future
In exploring the possible course of future events, it is important to link possible future developments with the actual course of events in the past and the present (Van der Heijden, 1996). Looking back into the past enables us to understand the mechanisms at work in the environment, their impact on the system and subsystems and dynamics that can occur within this mix. The same is true for the influence of the subsystems on the system as a whole

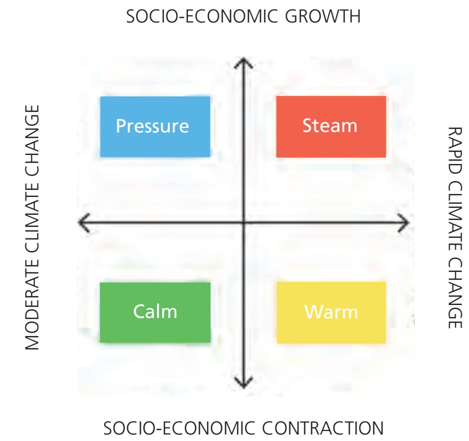


Figure 4.4 Delta scenarios

and on the influence of both the system and subsystems on the environment. This process produces greater insight into the nature of the changes on the horizon, for example, whether a process of change is incremental and path-dependent or instead displays tipping points indicative of a transition. In addition, a better understanding can be gained into the preconditions for developments to occur, what may cause them to change course and what may cause them to be displaced by new developments. These kinds of insights help in explorations of uncertainty and make uncertainty more manageable (which is different from reducing uncertainty).

Envisioning and analysing prospects for the future in the same way as in the retrospective analysis produces a coherent series of findings. As noted in Chapter 3, looking back quite a long way is recommended. If the future scenarios employ a time horizon of about a hundred years, then it is important to look back in time a number of hundred-year steps too, as was done in Chapter 3. This provides a sense of the changes that may or may not occur over such a period of time.

4. Exploring uncertainty about the future

Changes in the environment of a CAS often proceed at a steady rate, but as mentioned, discontinuities might also occur. These are not necessarily probable events, but they could nonetheless have major effects on subsystems or the system as a whole (Steinmüller & Steinmüller, 2004; Taleb, 2012). Exploring these events – also called "wildcards" or "black swans" – helps to increase our sensitivity to the variability that could occur in the environment (Smith & Dubois, 2010), and it helps us to gain a better grasp on adaptivity. Discontinuities can provide insight into new policy issues as well. They can help test the robustness and flexibility of a vision or package of policy measures, or they might add an increased sense of urgency for implementation of policy measures.

Many scenario studies explore steady developments, in other words trends, rather than changes in the form of trend breaks or unexpected events. This also applies to the delta scenarios, as each of the scenarios incorporates developments such as climate change, globalization and migration in a fairly uniform and orderly way. Some of the scenarios do incorporate a global energy transition, but other discontinuities receive little attention. The authors of the delta scenarios therefore also warn that more extreme situations may arise than those outlined in the scenarios. In the case of the Southwest Delta, these discontinuities may include a much greater and more rapid sea level rise than hitherto expected, a breakthrough in the cultivation of saline crops ending the dependence of agriculture on freshwater supplies and a merger of the commercial port activities of Antwerp, Rotterdam and Amsterdam. These scenarios therefore take on a speculative quality.

In this respect, changes that may occur in social and political debate should also be considered in scenario development. As such, an increased sense of environmental awareness may emerge as a result of a combination of economic recovery, the effects of climate change and a further decline in biodiversity, leading individuals, social organizations and companies to attach more value to nature and the environment and less to material wealth. It is important to also take these types of changes into account in scenarios and to use them in elaborating and substantiating the relationships between the environment, the system and subsystems.

5. Adequate articulation, quantification and visualization of possible futures

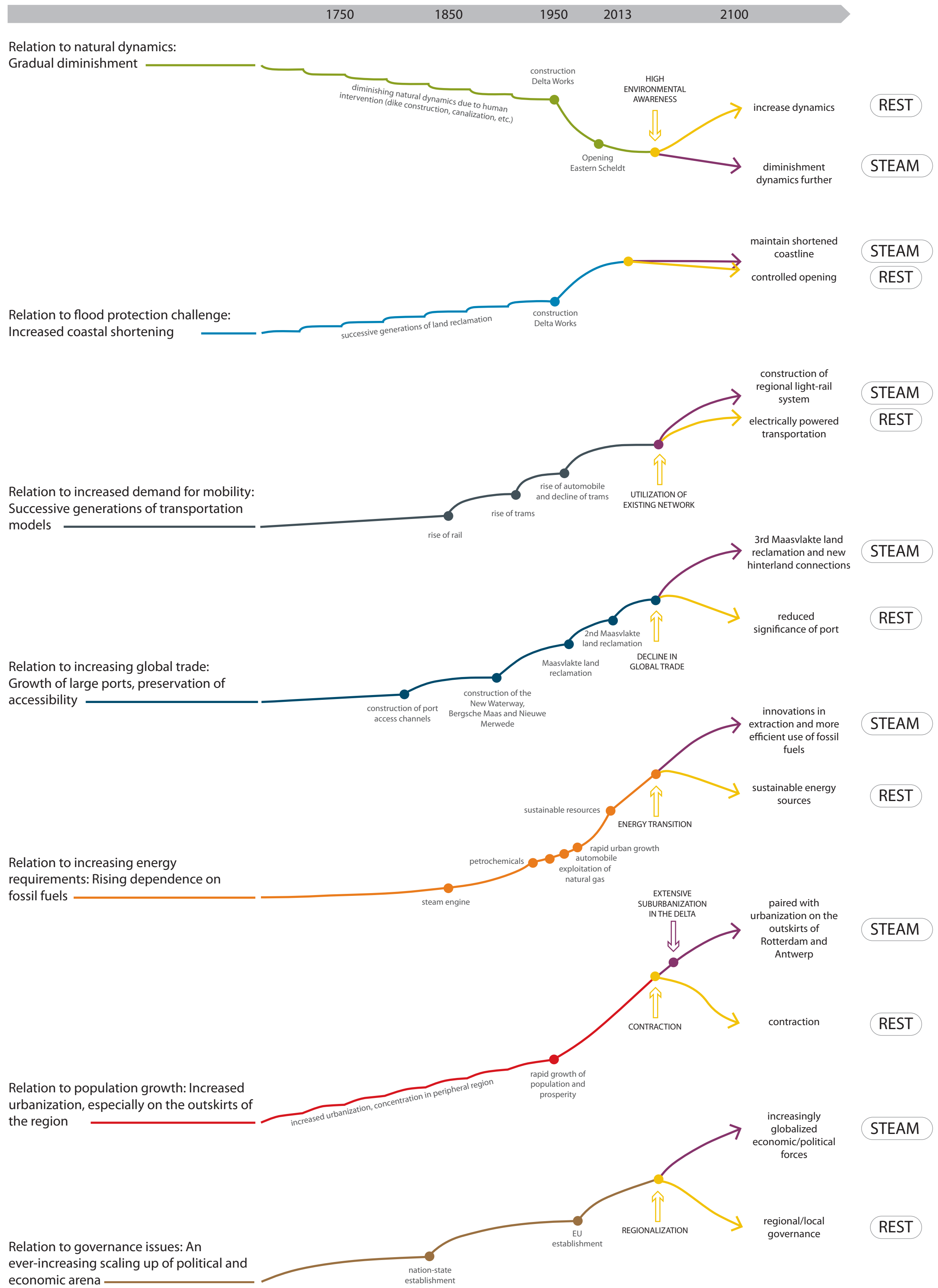
The actual adaptation of the system to its environment requires actors to be mobilized. After all, beyond just talk about adaptivity, plans also need to be implemented in practice. To help mobilize actors, the scenarios need to be articulated in such a way as to capture the public imagination and be perceived by actors as plausible. This in turn requires the scenarios to be quantified, articulated and envisioned in an even and balanced manner (Dammers, Van 't Klooster, De Wit et al., 2013).

Statistics and figures serve mainly to substantiate the scenarios, storylines are developed to impart the scenarios their meaning and images are created to visualize them. In many scenario studies, establishing quantitative support receives much of the attention. This trend has been fuelled by the increased emphasis on evidence-based planning (Davoudi, 2006). Development of the delta scenarios is no exception. For them, a number of different quantitative models were used, for example, to explore the effects of economic, demographic and other developments on regional and local land use (Rijken, Bouwman, Van Hinsberg, Van Bemmel, Van den Born, Polman, Lindenhof & Rijk, 2013).

The wording of scenarios is usually given ample attention (Dammers, Van den Born, Bruggeman et al., 2013). This is facilitated by the growing emphasis on strong storylines in planning (Hajer, Greys & Van' t Klooster, 2010). Thus, in the delta scenarios, too, due attention was devoted to the stories conveyed with each of the scenarios. This applies not only to the national delta scenarios, but also to the regional translation for the Rijnmond-Drechtsteden sub-programme (De Ruijter, Stolk & Alkema, 2011).

Visualization of the scenarios tends to receive less attention than justified. Maps showing the spatial effects of scenarios seldom provide any real insight into the regional differences that could occur. Moreover, artists' impressions often represent an exaggerated and not always well thought-out picture of the changes within the scenarios. In visualizing scenarios, it is important that enough regional and sector specificity be provided to guide designers and planners, without being so specific that visualizations can be construed as plans or a long-term vision. The aim ultimately is to illustrate a number of possible futures, not to present blueprints for the future.

Figure 4.5 Timelines: Past, present and future



4.3 Foresight studies: Approach

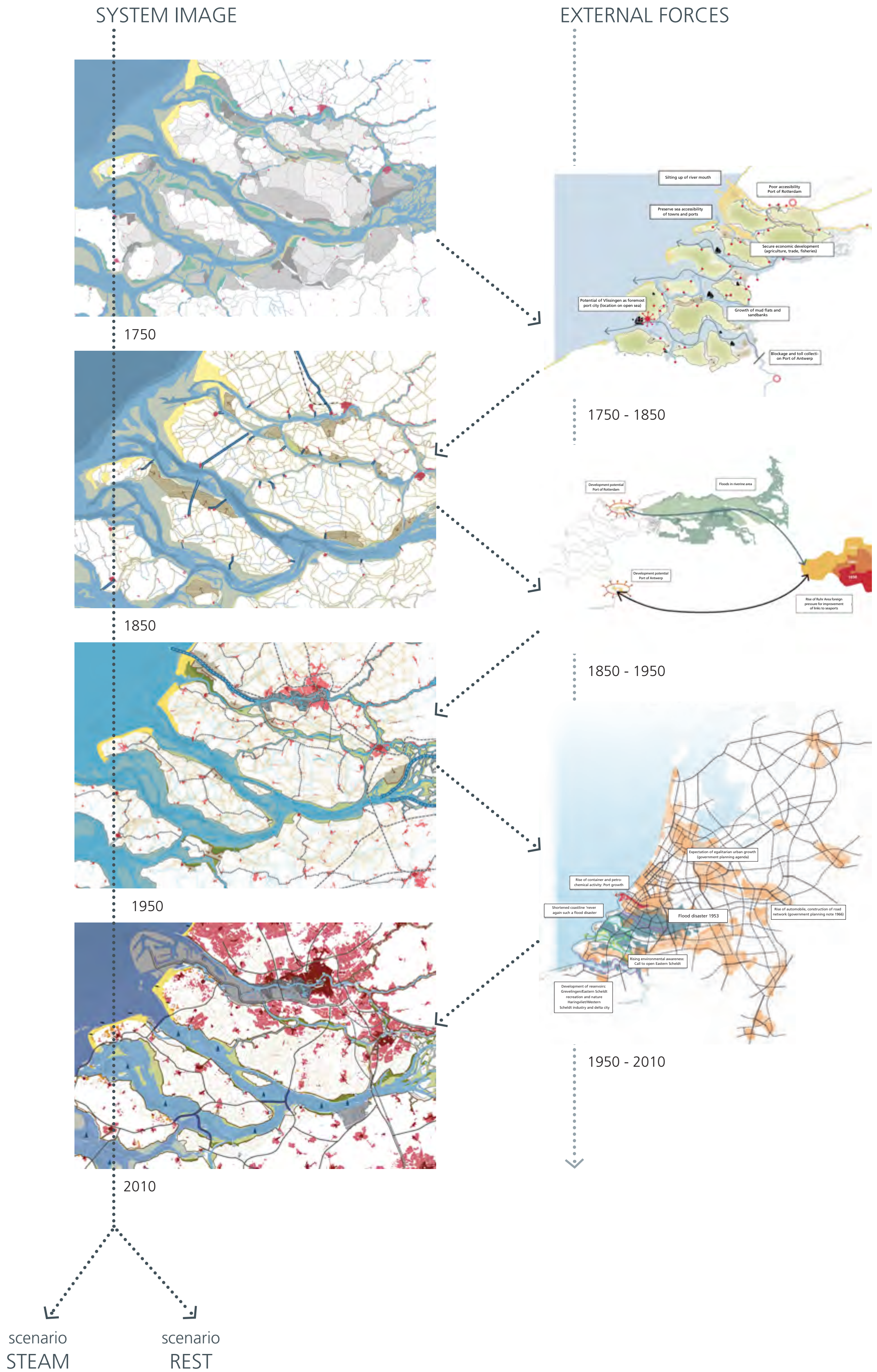
The retrospective analysis of the Southwest Delta investigated the interaction between the system and its environment by distinguishing between the external forces expected to act on the system and the results of these forces in the form of a spatial "system image". This same line of analysis can be extended into the future (see Figure 3.1). Visualization of the scenarios would thus consist of two main components: a depiction of the forces active in the external environment (the events and developments expected for the system and determining its future development) and a depiction of the future system image (the possible effects of the expected events and developments for the system and subsystems). By elaborating these two components in a cyclical process, the scenarios become increasingly regionally and sector specific.

The system image from the retrospective analysis provides the legend and visualization style for envisioning the future scenarios. This enables the scenario images to be placed into context more easily and produces a "visual language" that facilitates exploration of whether, in the future, a continuation or a break with developments of the past is expected.

Storylines from the delta scenarios were taken as the starting point for elaborating the future images. We focus here on the two scenarios that differ most and which therefore illustrate the bandwidth of the developments explored: "STEAM" and "REST". STEAM assumes strong economic growth and severe and rapid climate change. REST explores moderate economic growth and moderate climate change.

In addition to these storylines, a number of system mechanisms were elaborated stemming from the retrospective analysis of the Southwest Delta. These render the future scenarios more regionally and sector specific and anchor them better in past and present developments. According to the analysis, from about 1750 up to the present, development of the delta system has always been strongly driven by a particular set of mechanisms. Examples of these are reduced natural dynamics, increased dependence on fossil fuels and increased economic and political scale. These continuing developments will very likely continue to be decisive in the future as well, to a greater or lesser extent. They therefore need to be included in any future scenario development. They may continue into the future along the same lines as in the past, or a transition could occur. Figure 4.5 visualizes these mechanisms with a timeline that traces how the system has evolved along the lines of the STEAM and REST scenarios. Furthermore, for each of these two scenarios a social and political agenda is included that might become dominate. In fact, it is these agendas that will determine to a large extent how the system responds to external developments.

Finally, attention in this exercise is also given to the possibility of discontinuities. For the STEAM scenario, therefore, two variants were developed: one variant assumes more or less steady development taking place via small steps, and the other variant is based on occurrence of some wildcards, in which there is a transition. For the REST scenario only one variant was de-



veloped with a several discontinuities. Both approaches are useful in producing a more complete picture of the future in the face of uncertainty.

Elaboration of STEAM scenarios

The STEAM scenarios assume increased liberalization of the global market and expanding globalization. This offers large growth potential for ports and necessitates greater regional cooperation. The arena of political power is scaled up to the European level. At the same time, the EU is assumed to allow market mechanisms considerable sway. According to this scenario, population growth will be strong, and urban growth will be substantial too. Prosperity rises rapidly and with it the importance of maintaining an attractive business climate. New sources of fossil fuels are tapped, making an energy transition less urgent. Agriculture no longer receives EU subsidies and the sector's influence is diminished. The climate changes drastically and rapidly, which leads to greater challenges in the field of flood control and water hinder, as well as freshwater supply.

In this vision, there is robust growth of the ports of Rotterdam and Antwerp, in response to expanding global trade. Rotterdam expands seaward to remain accessible to larger vessels and begins to cooperate more closely with Antwerp and Moerdijk. The connections between ports and hinterland are improved by construction of new waterways, railways and pipelines. There is also strong urban growth, especially on the outskirts of the delta region between Rotterdam and Antwerp.

To satisfy the growing demand for freshwater, a new freshwater supply and disposal system is constructed. Sea level rises sharply, and river discharge extremes become more commonplace. A water storage reservoir is therefore constructed in the catchment area. The dikes are raised considerably higher for this purpose. Alongside the dikes and these freshwater supply and storage areas, suburban residential areas are built. The dikes are thus multifunctional zones. A regional light rail system is constructed to provide the suburban residential areas quick access to the city. The agricultural cultivation area diminishes. Nature's main function is recreation.

By adding a number of wildcards to the STEAM storyline, the bandwidth of possible developments widens. This is also reflected in a different status of the spatial system of the region. For illustrative purposes, three wildcards were added to the scenario. These were derived from a wildcard workshop held with master's degree students at Delft University of Technology:

1. In periods of drought, Germany uses most of the waters of the Rhine. Compounded by the rising sea level and increased salinity, this results in increasing shortages of freshwater in the region. More space for water storage is therefore required as well as additional supply from new water sources, such as the Alblasserwaard and Brabant Wall (overflow area).
2. International food scarcity becomes increasingly severe, resulting in a much greater importance of agriculture. The result is agricultural intensification, as well as increased areas of land under cultivation. Production is aimed at both export markets and private consumption. Together with in-

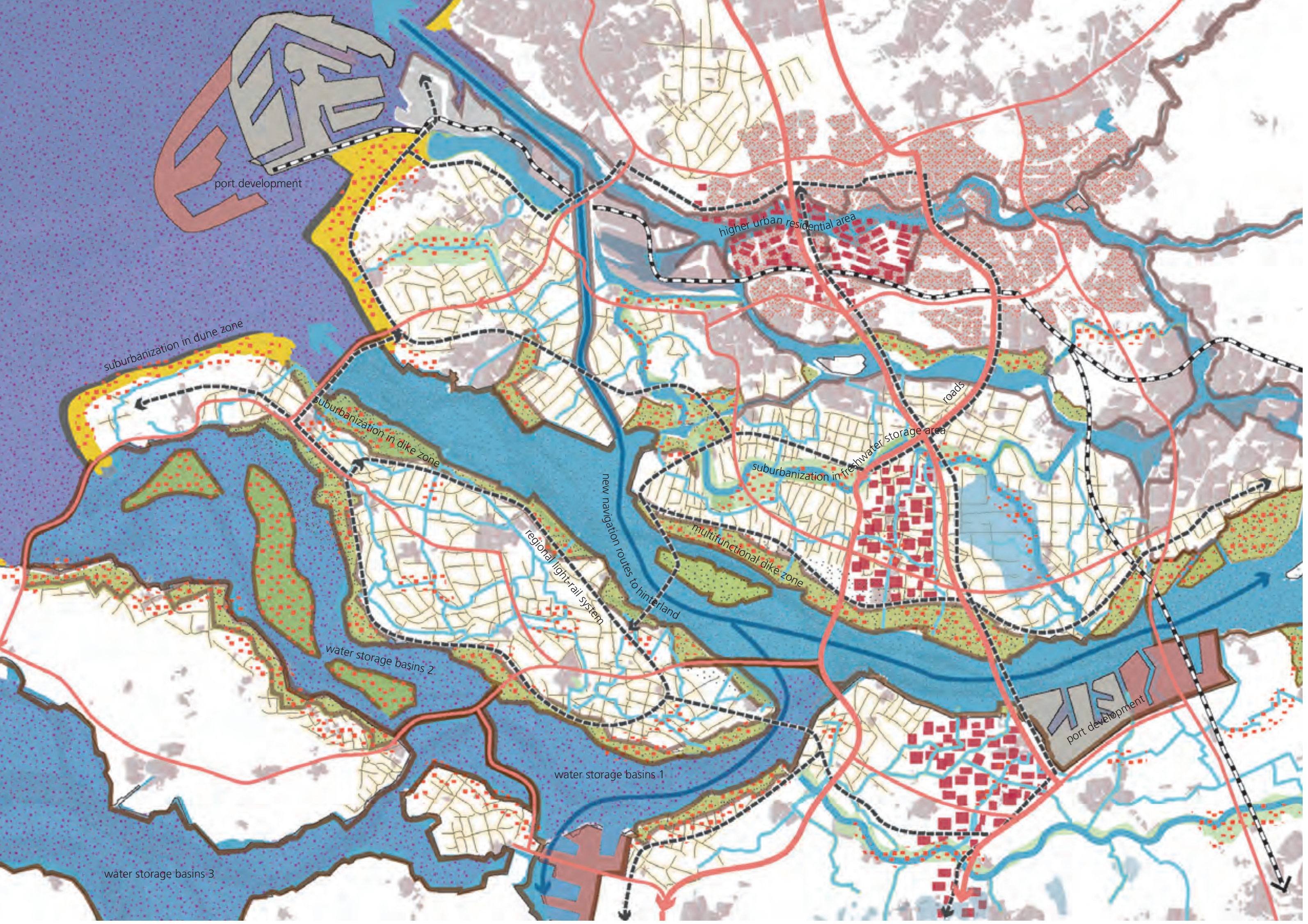
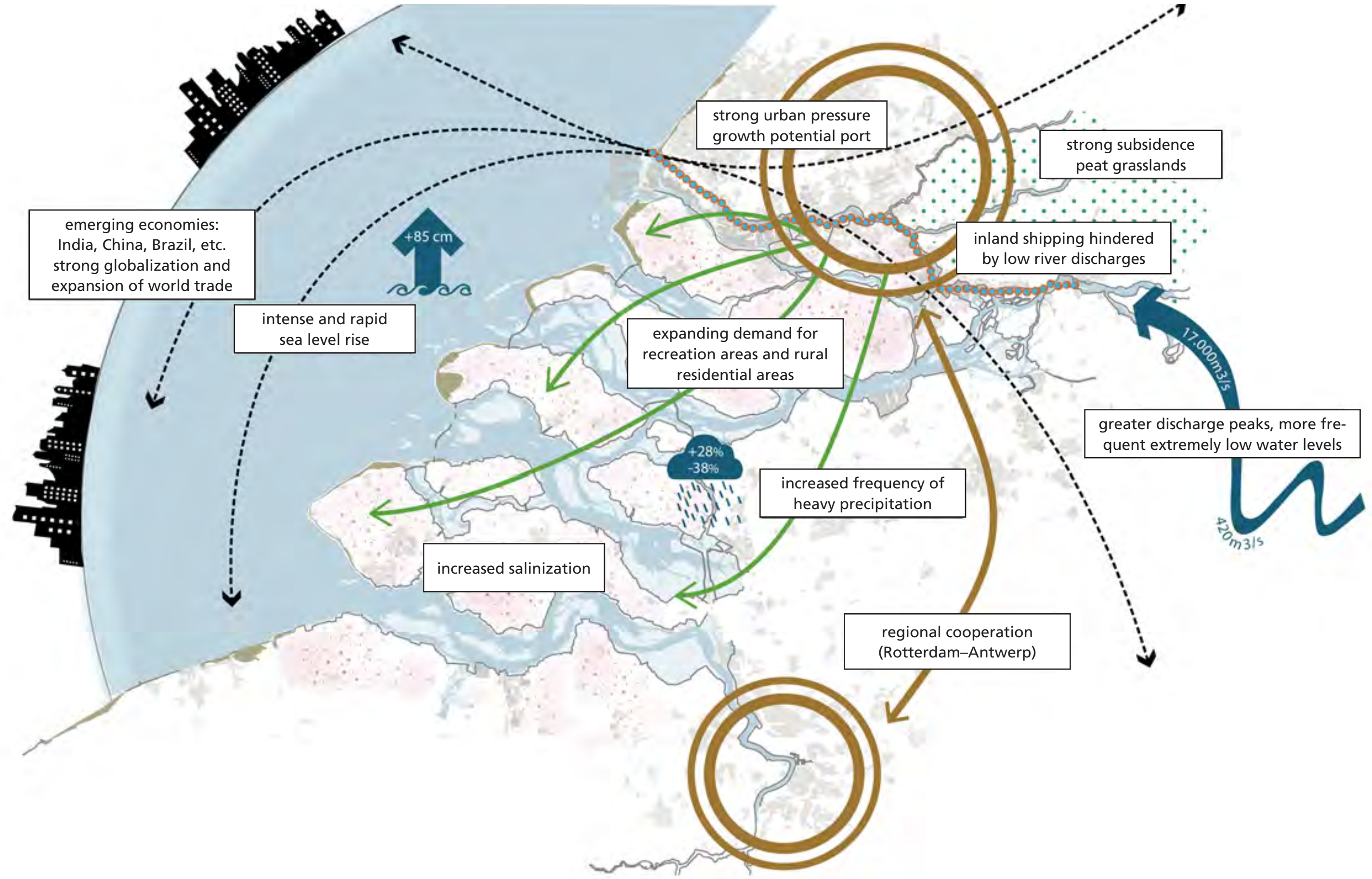


Figure 4.6 Future image: STEAM scenario



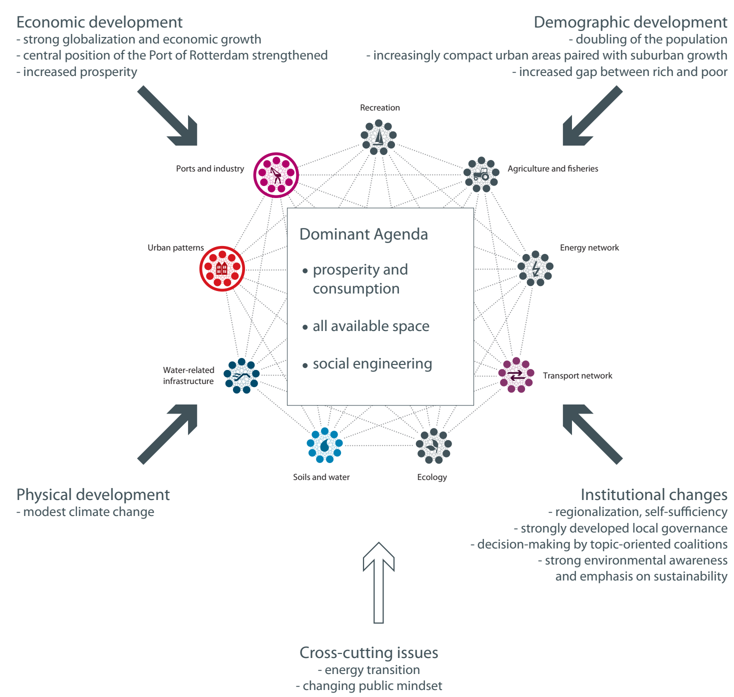


Figure 4.7 Visualization of the driving forces in the STEAM scenario

Figure 4.8 External forces and the relative dominance of subsystems in the STEAM scenario

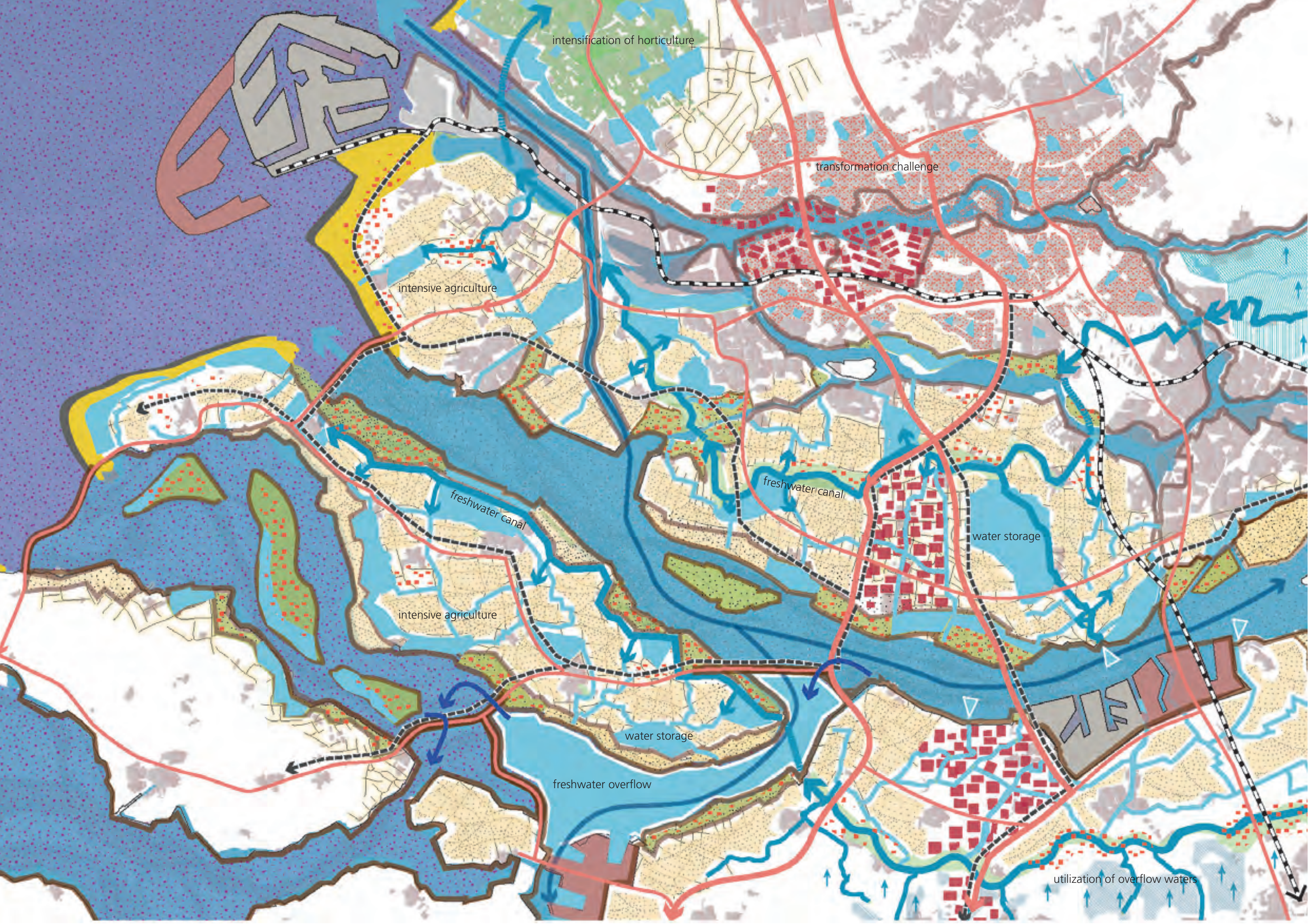


Figure 4.9 Future image: STEAM scenario with several wildcards

More water inflows and storage

More space for intensive agriculture

Transformation challenge for urban areas

creased urbanization and the need for recreation space and water storage areas, spatial pressure is heightened. In addition, the growing agricultural sector demands more freshwater.

3. Workers switch en masse to telecommuting. This poses a transformation challenge to the urbanized areas, as offices and business parks are left vacant and can be redeveloped and demand increases for residential work spaces. There is less pressure on transportation networks; frequency and severity of traffic jams are eased, and there is no need for a regional light rail system to be built.

Elaboration of REST scenarios

A major driving force in the REST scenarios is the changing direction of social and political debate: environmental awareness and the desire to be self-sufficient become priorities. This is manifest in an energy transition to sustainable sources and a strong shift towards regionalization. Climate change is modest, due to deployment of the energy transition, and therefore flood protection poses no major challenge. The population stabilizes and even contracts slightly. Economic growth is slow and consumption levels are low.

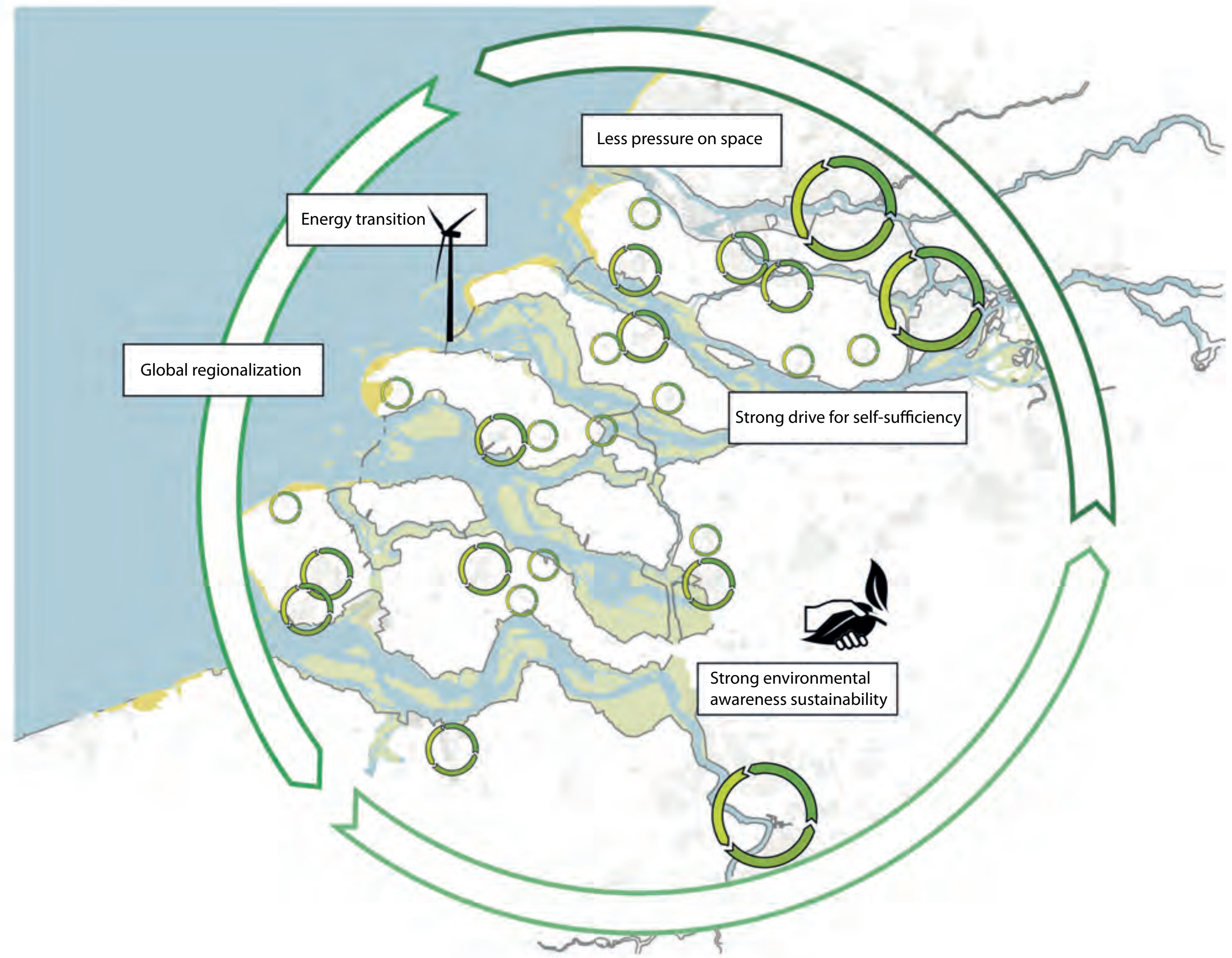
More space is available for nature in this scenario, as delta dynamics are given more freedom to follow their own course. To this end, sluices are opened and dams are re-engineered to allow water to flow through. The system becomes largely salt once again, meaning that the availability of freshwater is reduced. Some parts of the delta become brackish. The urban area shrinks and faces a transformation challenge. There is ample space for generating energy (wind, solar, tidal, biomass). There is a switch to electric modes of transportation, which make use of existing networks.

Characterization of STEAM and REST future images compared

In the STEAM scenario, multiple developments are expected to be on the horizon for the region, but the system itself develops mostly along lines of continuity with the past. In following this route, the dynamism of the system is further reduced, the present coastline is preserved, a new mode of transport is constructed, the system remains highly dependent on fossil fuels and the political and economic power arena continues to scale up. Besides the expanded urbanization on the outskirts of the delta (in conformance with developments of the past), greater suburbanization also occurs. Flood protection and freshwater supply both pose major challenges. Measures are implemented on the basis of technical considerations and the idea that the future can be engineered. Pressure on space is heightened, leading to development of multifunctional areas. The extent that various actors are capable of synchronizing developments is crucial in this scenario. The land-water transition zones face major challenges: flooding, suburbanization, recreation, infrastructure, water storage and others. Occurrence of a number of wildcards considerably increases the challenges facing the region.

In the REST scenario, many more transitions take place in the system. The transition to renewable energy is a major system leap, as is the re-establish-

Figure 4.10 Future image: REST scenario



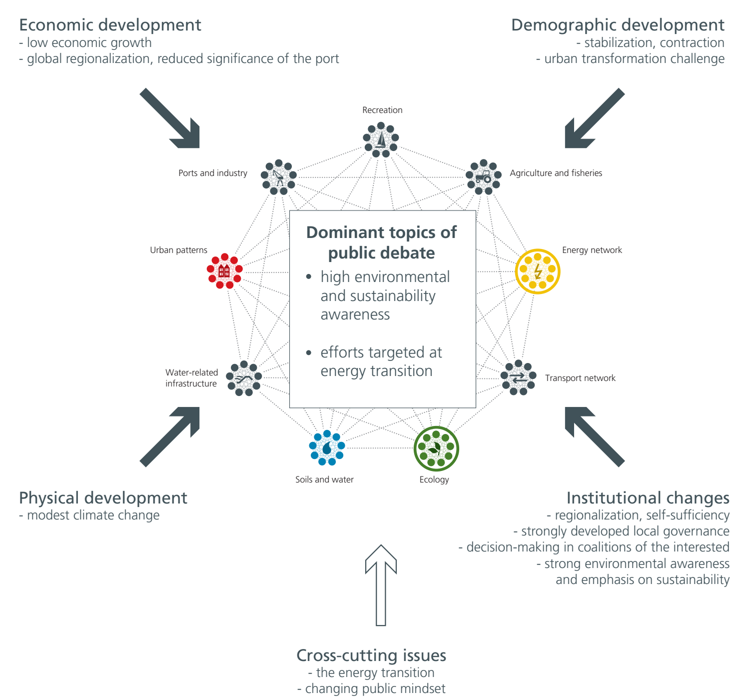


Figure 4.11 External forces and relative dominance of subsystems in the REST scenario
Figure 4.12 Visualization of the external forces in the REST scenario

Figure 4.13 Three categories of areas in the Southwest Delta according to different scenarios

Category 1:
Areas that show little or no change in either scenario, or where more or less the same challenges present themselves.

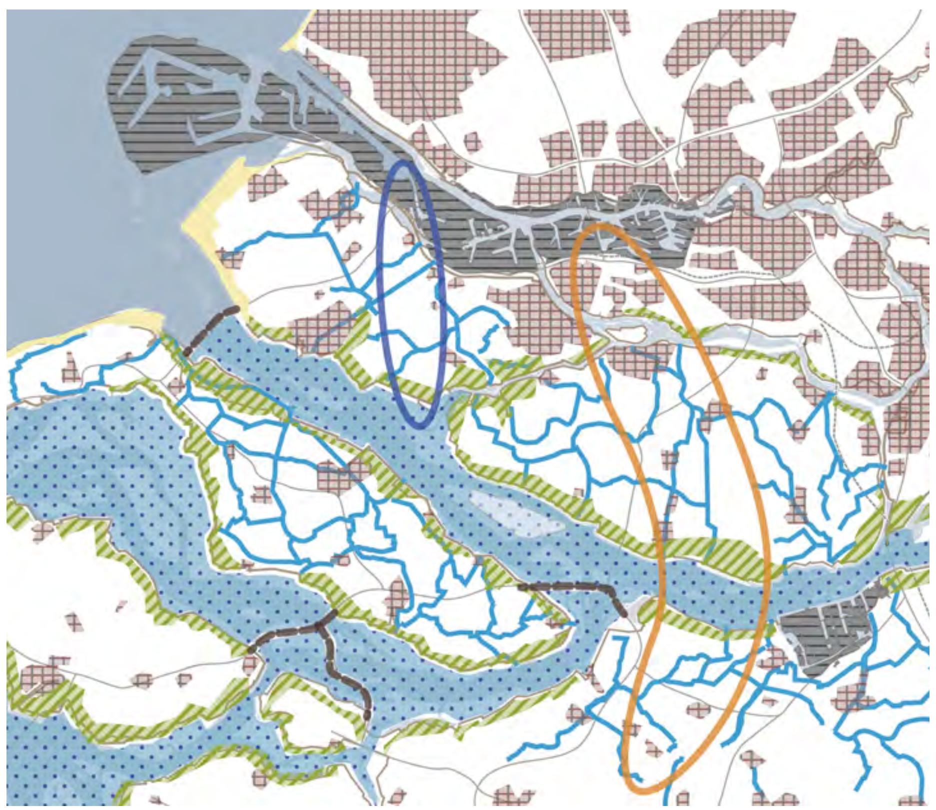
- Freshwater network

Category 2:
Areas that change in one scenario, but do not change in another scenario.

- A4 zone
- Channel zone Voorne-Puttenn

Category 3:
Areas that change in both scenarios, but in a different way and under the influence of different driving forces.

- Land–water transitions
- Overflow areas
- Urban areas
- Port area
- Large waterways



ment of dynamism in the delta system. Urbanization does not increase, and instead of continued scaling up regionalization plays a larger role. The main driving forces here are changes in social and political agendas. As a result, ecology comes to play a leading role, and interventions in the system are aimed at moving with the physical system. Land-water transition zones are also prominent in this scenario, but this time for developments related to sustainable energy and ecology: they are where the greatest opportunities lie.

Table 4.1 presents the primary driving forces in the STEAM and REST scenarios, indicating how each subsystem responds to the changing conditions.

Planning and design: Focus on critical areas

Both scenarios depict very different development opportunities for the Southwest Delta. This is especially true for the northern part: the Rotterdam-Drechtsteden sub-region. The question is how these different development possibilities might be used in planning practice to provide guidance for spatial planning and design strategies.

Scenarios based on CAS thinking explore both possible futures and futures that are deemed preferable. The driving forces in the environment represent developments that are considered possible. Policymakers in the delta must take these more or less as given. In this respect, they are not allowed to choose between the scenarios but instead have to take both scenarios into consideration. Interventions concern measures that policymakers themselves can institute, as they consider appropriate. In this sense, they do have some choices to make regarding the scenarios. Thus, scenarios based on CAS thinking provide not only insights into the events and developments that might occur in a region, but also offer an idea of what measures policymakers might institute in response to those developments – in other words, to adapt.

Comparison of map images illustrating the different scenarios provide several interesting insights. It does have to be kept in mind here that these are more indications than hard fact. Comparing the maps, we can distinguish three categories of areas in the region.

First, there are areas showing little or no change in either scenario, or where more or less the same challenges present themselves. An example of this is the freshwater networks. In both scenarios, there is a freshwater supply challenge: in the REST scenario because the overflow areas revert to brackish and the inlet points can no longer be used; in the STEAM scenario due to the rising demand for freshwater following intensive development. For these types of area similar types of interventions have to be undertaken in either scenario.

Second, there are areas that hardly change or do not change at all in one scenario, but do undergo considerable change in another scenario. This applies, for example, to the central area of the islands Voorne-Putten and Hoeksche Waard. In the REST scenario, little change is expected here. But if the STEAM scenario becomes reality, drastic interventions will be needed, such as a new shipping route through Voorne-Putten and an extension of the A4 expressway across Hoeksche Waard. That latter may be paired with urbanization in the heart of Hoeksche Waard. For these types of areas, it will be

	STEAM	REST
Driving forces	– Considerable and rapid climate change, substantial challenges regarding flood protection and freshwater supplies – Strong globalization and economic expansion – Increased growth of population and prosperity – Increased liberalization	– Modest and slow climate change – Regionalization and limited economic growth or contraction – Declining population – High environmental awareness
Soil and water	– Maintenance of shortened coastline – No added dynamism – Extra storage capacity for extreme river discharge in the Grevelingen, Volkerak and Eastern Scheldt overflow areas – Raise the flood barriers surrounding the overflow areas – Multifunctional flood barriers – Re-engineer embankments to allow water inflows for storage and other purposes – Construct new freshwater supply and storage system	– Maintenance of shortened coastline – Allowance of added dynamism in Haringvliet, Grevelingen and Volkerak, adaptation of coastal embankments – No requirement to raise the dikes – Salinization of the southern edge of Goeree-Overflakkee and Voorne Putten
Networks	– Construct new light-rail system – Upgrade hinterland connections with ports – Preserve energy supplies on the basis of fossil fuel sources	– Utilize existing infrastructure
Land use	– High urban development between Rotterdam and Antwerp – Strong suburbanization along the dikes and the freshwater network – Agriculture of little significance – Ecology in service to recreation outlets, park-type nature development – Continued expansion of the Port of Rotterdam	– Transformation of existing urban area – Ample space for energy generation – Ample space for nature

Table 4.1 STEAM and REST scenarios compared

important to consider the possibility that such interventions will be needed. Adaptation, in this context, means that no measures would be implemented that would block the interventions explored in the STEAM scenario.

Third, there are areas where changes are set to occur under both scenarios, but where the nature and extent of the changes differs per scenario. These include, in particular, the areas situated outside the dikes in urbanized regions, as well as the Rotterdam port area, and the edges of the islands along the large waterways, such as the Haringvliet, Volkerak and Grevelingen. In these places, new developments can be expected in both scenarios, but for each scenario the changes derive from different subsystems. The expectation of the STEAM scenario is that to ensure flood protection, major emphasis will have to be placed on reinforcement and raising the heights of the primary defences, on significantly increasing the storage capacity of the reservoirs or a combination of both. At the same time, greater pressure is expected on the peripheral areas for utilization for urban development and recreation. According to the REST scenario, these zones will mainly be considered attractive locations for establishing new forms of energy generation (wind energy) and as nature areas to promote re-establishment of the gradual transition between land and water.

These zones appear to play a crucial role in both scenarios, but in each scenario in a different way with a different programme and different demands with regard to spatial planning. This third category of areas may be labelled "critical areas". Precisely because they are set to play a crucial role in each scenario, though for each in another way, it will be important to develop a policy arrangement that guarantees maximum adaptivity in these areas: they will have to be able to be developed in either one of the directions of the scenarios.

An additional complicating factor is that scenarios do not develop in a linear fashion. Over the first 20 years, the REST scenario may seem to be transpiring, while later the STEAM scenario may come to pass or vice versa. An adaptive strategy for the "critical areas" means that an area could initially develop according to one scenario, and then relatively easily and at little cost to society be adapted to the demands of another scenario. This kind of adaptability requires special planning guidelines for the critical areas, with special restrictions on the use of space and special arrangements, or institutional measures, for management of these areas. We return to this in Chapter 8 which introduces an action perspective.

Chapter 5

Actor analysis in complex adaptive systems

An actor analysis for a complex adaptive system is aimed at exploring and mapping the different possible relationships and configurations among the actors from the various subsystems. Relations and intersections between actors are characterized in terms of synergy and competition and of interests and values that are either coherent or conflictive. An actor analysis conducted for the Southwest Delta revealed a number of dominant configurations.

5.1 Introduction

In any planning process it is essential to understand what actors might be active in the planning arena and process, what objectives they may have and what spatial planning challenges this may create (Innes and Booher, 1999). It is not unusual for a spatial planning process to begin as a rather unilateral design brief defined by a limited number of parties who represent only a fragment of the full complexity of reality, due to their focus on a particular spatial scale or certain subsystems (Lane, 2005). For example, an initial survey of the designs created for the Haringvliet area of the Southwest Delta demonstrates a "bias" towards higher scale level objectives and the longer term, with only very limited links to local-level agendas (Verkerk & Van Buuren, 2013). However, an actor analysis from a CAS point of view demands a more pluralistic and collaborative approach (Lane, 2005; Healy, 2003; Innes and Booher, 2004).

This chapter describes an actor analysis conducted from a complex adaptive systems perspective. The analysis takes the complexity of diverse time scales and subsystems as a given, and goes on from there to examine whether promising configurations of actors (synchronization) can be found for the Southwest Delta. As such, the actor analysis provides insight into which parties might be involved and activated to take certain promising designs a step further (mobilization). Furthermore, it advances stakeholders' understanding of the developments ahead for the delta and the challenges that may arise as a result (adaptation).

The purpose of this chapter is to describe how an actor analysis based on systems thinking can be implemented, and how such an analysis contributes to planning aimed at development of integrative spatial designs. Adoption of a CAS perspective means that consideration has to be given to the multitude of frames and system definitions applied by the various actors, each of which views the system from the perspective of their own scale level and subsystem.

5.2 Actor analysis from a CAS perspective

Actors in complex adaptive systems

Regions like the Southwest Delta are characterized by administrative and social complexity. A key feature of this complexity in the Southwest Delta is that every actor interprets and approaches the challenges facing the region from the vantage point of their own scale level, their own specific subsystem and with a focus on achieving their own particular values and ideas. As such, the national-level Delta Programme has focused mainly on ensuring the adequacy of flood defences and freshwater supplies (Delta Programme 2011). The Port of Rotterdam has concentrated primarily on long-term strategies for port development, in conjunction with environmental values (Port of Rotterdam, 2011; Vanelslander, Kuipers, Hintjens & Van der Horst, 2011). The World Wide Fund for Nature has developed a future image of an open and environmentally vital delta (WWF, 2010), though this objective is nonetheless somewhat at odds with the aims of local-level nature conservation organizations. In addition, we find numerous local and regional initiatives and spatial development plans. These are focused mainly on spatial development (housing construction and establishment of recreational areas), and efforts to advance these plans have often produced regional alliances and long-distance partnership for their implementation. Two examples of such alliances in the Southwest Delta are the inter-municipal partnership for development of the Voorne-Putten area and the cooperative alliance to guide developments in and around Hoeksche Waard.

While there is no shortage of ideas, plans and objectives for the region, every actor or coalition has its own field of vision and perspective on the problems and preferred solutions. Each actor, moreover, adheres to their own sector objectives (agriculture, ecology, infrastructure, water, etc.), timeframe (long, medium or short term) and scale level (local, regional, national or international). In an actor analysis conducted from a CAS perspective, this variety plays a pivotal role.

Conventional actor analyses

Conventional actor analysis is found in various disciplines and study domains. In the field of conflict resolution, for example, actor analyses are conducted to identify the concerns of the different actors in order to help engineer breakthroughs in intractable conflicts (Susskind & Cruikshank, 1987). Actor analysis has also emerged as a tool in business administration (Ackhoff, 1974; Mitroff, 1983), project management (Edelenbos & Klijn, 2009; Savage et al., 1991; Mitchell, Agle & Wood, 1997) and public administration (De Bruijn et al., 1998; Edelenbos, 2000; Koppenjan & Klijn, 2004).

Conventional actor analysis features a systematic mapping of the stakeholders in a project environment, alongside an examination of how proposed plans may affect these stakeholders' interests and what positions they take towards a particular proposal or plan: as a supporter, an opponent or a neutral observer (compare Ackhoff, 1974). The actor analysis provides information about how stakeholders' interests (Reed et al., 2009) should be incorporated in development and implementation of plans or policies. Conventional actor analyses are often supplemented by a "force field analysis" in which the constellation of driving and restraining forces among actors is analysed. This produces a network overview of interdependent relationships (Koppenjan & Klijn, 2004).

Actor analysis from a CAS perspective

An actor analysis conducted from a CAS perspective starts by examining how actors position themselves in different subsystems and in relation to other subsystems. This is followed by a survey of the plans, projects and initiatives that emerge from this web. Stakeholders' own views are explicitly tapped regarding how they relate to the different subsystems and whether their overall goal in these relations is to maintain existing features or rather to seek innovations in their relations with other subsystems. This reveals each actor's own understanding of the system: how do they perceive the arena in which they operate and what kind of development are they working towards? A picture is thus developed of how they ascribe substance and meaning to their own subsystem and to the system as a whole.

Another important element of an actor analysis from a CAS perspective is the mapping of actors' views about their own subsystem (and the system as a whole) in relation to other subsystems (and systems). This brings the *system boundaries* into focus (Van Meerkerk, Van Buuren & Edelenbos, 2013). Actors might, for example, conceive of boundaries in a very narrow sense, strictly defining their own subsystem and separating it from other subsystems, while emphasizing the problematic aspects of how the different subsystems' values and viewpoints relate to one another. They would then perceive primarily conflicts between their own subsystem and other subsystems. Or, actors might instead view system boundaries as more diffuse, perceiving their own subsystem to be connected to other subsystems. These actors would be likely to see potential synergies between their own subsystem and others, perceiving opportunities to link their own interests and values with those of other subsystems and integrating these opportunities into solution-oriented packages or programmes (Buijs & Edelenbos, 2012). The result of this mapping is an overview for each actor of the extent and nature of intersections between subsystems (Pel, 2014). These intersections might be strong, moderate or weak, and therefore are named "interferences" (competitive, conflicting) or "symbioses" (complementary, mutually beneficial) (Sandén & Hillman, 2011; Pel et al., 2013).

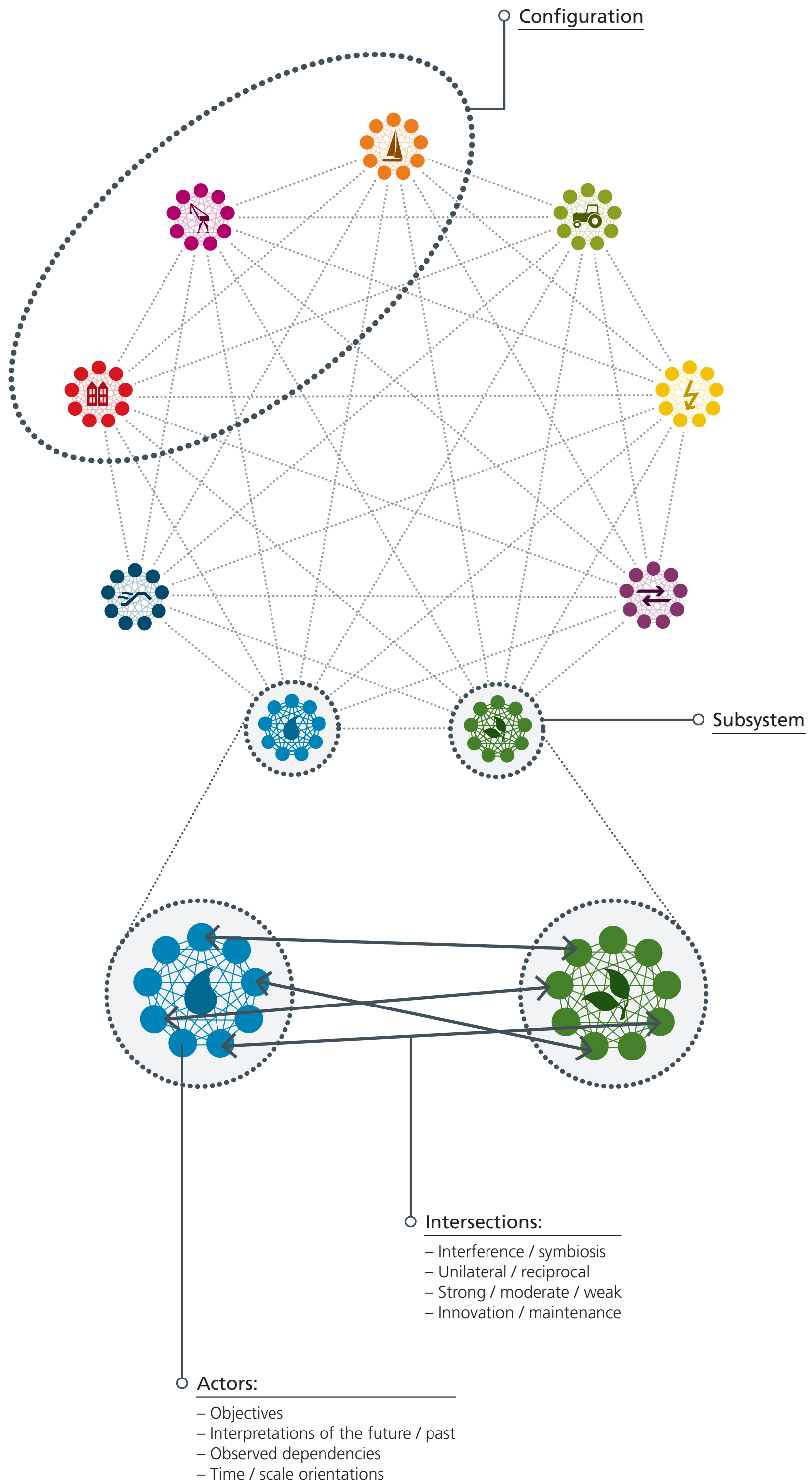
Moreover, this approach to actor analysis provides information about the clusters of subsystems that actors relatively frequently identify and describe in combination. For example, actors almost always speak of the agricultural subsystem in the same breath as the freshwater subsystem and the ecosystem subsystem. Such a cluster is referred to as a *configuration*: a set of highly cohesive subsystems in which the cohesion is mainly ascribed by actors in their thinking and acting on development of the delta.

In sum, an actor analysis conducted from a CAS perspective produces an overview of the whole spectrum of objectives and initiatives from the different subsystems. It also explores how actors from particular subsystems position their own plans in relation to other plans and how they relate to plans originating from other subsystems.

5.3 Methodical steps

An actor analysis conducted from a CAS perspective begins with a broad survey and finishes with a narrowing of results through selection and targeting. Figure 5.1 illustrates how our analysis zoomed in on the subsystems of the Southwest Delta. The subsystems are represented as networks of actors. Each actor has its own objectives, its own interpretations of past and future system developments and its own perceptions of mutual dependencies. Moreover, each is geared towards particular spatial-administrative scales and time horizons. Also evident from Figure 5.1 is that each subsystem itself is made up of a variety of actors, and that interrelationships exist among these as well.

Figure 5.1 Overview of actor analysis for the Southwest Delta



Thus, a particular type of actor, such as nature conservation organizations, is itself composed of a variety of actors. In the Southwest Delta these include the Dutch Nature Conservation Association (Natuurmonumenten), the Confederacy for the Environment (Milieufederatie) and the Society for Nature and the Environment (Stichting Natuur en Milieu). As such, the image that emerges is one of systems embedded within one another: a system of systems.

Between the subsystems, intersections can be identified. These may be numerous, reflecting the system-of-systems nature of complex adaptive systems. An actor analysis carried out from a CAS vantage point would therefore depict the delta as an assemblage of the large variety of interactions between subsystems. A step-by-step methodology for mapping and filtering this diversity of subsystems and interactions is briefly set out below, drawing on the actor analysis conducted for the Southwest Delta. The process involves four steps:

1. *Selection of sources and respondents.* In this step, an assortment of documents is consulted and analysed, including plans, advisory reports and visions. Furthermore, interviews are conducted with a variety of actors representing a range of organizational backgrounds and subsystems in the systems web. These interviews turned out to be the richest source of information for our actor analysis of the Southwest Delta. It is important, however, to interview not only the dominant actors, but also to include actors from emerging niches. This ensures that variety both between and within subsystems is expressed.
2. *Charting the diversity of values and viewpoints among the actors.* In this second step, for each of the actors identified, their own particular objectives are charted, as well as their interpretations of past and future developments in the subsystems and in the system as a whole, and the reciprocal dependencies they perceive. Their degree of focus on the different spatial and administrative scale levels is also explored, as well as their time horizons regarding challenges and objectives.
3. *Identification and categorization of intersections.* Relationships between subsystems are mapped in this step. Doing so, based on the standpoints catalogued in step 2, serves to identify a variety of intersections between the subsystems. These intersections help us to understand how the actors in the different subsystems relate to one another. The relationships are characterized in terms of competition (interference and discord) or synergy (symbiotic synchronization) between subsystems.
4. *Synthesis and elaboration of configurations.* The identification and categorization of intersections results in an as yet extensive matrix of interactions between our nine subsystems (see Figure 5.1). In this step, these intersections are merged and rationalized to arrive at a smaller number of configurations of coherent subsystems. These demonstrate that "everything is not connected to everything", but rather that some subsystems are strongly interwoven and others less so.

5.4 Intersection analysis

This section describes in more detail application of the first three steps of the methodology introduced above for the Southwest Delta. The outcomes generated by these steps (the fourth step) are covered in the section that follows.

Analysis of the subsystems (steps 1 and 2)

The subsystem analysis was done based on the first two steps: selection of sources and respondents and charting the diversity of values and viewpoints among the actors. In the Southwest Delta nine relevant subsystems were identified: "Ports & Industry", "Energy", "Agriculture & Fisheries", "Transportation & Shipping", "Ecosystems", "Soil & Water", "Flood Defences", "Urban Patterns" and "Recreation" (see Figure 5.1). These subsystems differ in character while also exhibiting internal diversity. To provide a sense of this diversity, three arbitrarily selected subsystems are described below: Ports & Industry, Flood Defences and Agriculture & Fisheries.[1]

– *Ports & Industry*

The Southwest Delta is an attractive location for ports and industry due to its deep waters, ample and easily accessible water for production and cooling, and good hinterland transportation and shipping connections. Such physical characteristics are highly valued by ports and industry, and enterprises in these sectors often make substantial on-site investments to further improve the local infrastructure.

Almost all parties involved in the Ports & Industry subsystem of the Southwest Delta are commercial parties active in harbour-related enterprises and industrial complexes. Most are entrepreneurs whose aim is to attract as many ships, businesses, freight and so on as possible. Beyond these actors, governments play an important role, as in most cases they are the majority shareholder in the port companies.

Two large commercial complexes are dominant in the Southwest Delta, namely the ports of Rotterdam and Antwerp. These complexes operate globally, are very influential and hold a leading position in governance of the Southwest Delta. In addition, there is a larger number of relatively small dependent players, including the ports of Vlissingen, Moerdijk, Terneuzen, Ghent and Zeebrugge. Given the context of global competition in which the ports of Rotterdam and Antwerp operate and try to maintain their market share, this is a crucial subsystem in the delta. Because of its huge economic significance, this subsystem is dominant compared to the other subsystems. Within the subsystem, a degree of competition can be observed, though recent initiatives have sought greater networking and cooperation.

– *Flood Defences*

Flood defences play an undeniable role in the spatial organization of the Southwest Delta. Dams, dikes, ditches, canals, waterways, locks and barriers have extensively transformed the landscape. This is particularly true of the flood barriers that make up the Delta Works. The transition from open estuaries to a delta defined by flood defences has spatially "fixed" the Southwest Delta, while also ensuring that there is always work to be done on the delta, such as combating the soil erosion that poses a constant threat to the dams and embankments. The flood defences are therefore significant from both an economic and a spatial perspective. Indeed, much of the economic and urban development in and around the delta is associated with or a product of water and the flood barriers.

The influence of the flood defence infrastructure goes beyond its dominance in the landscape; the actors in the Flood Defences subsystem also have autonomous and strong influence in the delta due to the overriding importance of their two nationally-mandated key tasks: flood protection and freshwater supply. This focus has been strengthened in recent years, as the Delta Programme has generated increased awareness of the challenges ahead in safeguarding the Dutch coast and maintaining adequate freshwater supplies – and accomplishing this in the face of climate change and in a context of reduced government budgets. Adding to these actors' position of power is their extensive knowledge, authority and resources. This applies to both public actors (e.g., national and provincial government agencies and water boards) and private actors (mainly academics and engineering and hydraulics companies). Nonetheless, this subsystem's focus on the two key tasks is being somewhat challenged by public demands for more optimal utilization of water's many functions, for instance, by integrating housing and recreation areas with flood barriers, preserving ecological values associated with water and maintaining high water quality.

This subsystem still has the role of setting the parameters within which the other subsystems may operate. However, the various initiatives under way aimed towards greater mixing of functions suggests that this role may change somewhat in the future.

– *Agriculture & Fisheries*

Agriculture & Fisheries has been a driving force in the "green-blue" heart of the Southwest Delta for centuries. The region's fertile clay soil makes it an appealing location for food production. This attractiveness has been enhanced in the northern part of the delta by the freshwater bodies created with construction of the Delta Works. Far less freshwater is available in the southern part of the delta, and the scale and intensity of agriculture here is therefore much less than in the northern region.

The parties in the Agriculture & Fisheries subsystem have traditionally enjoyed a strong position and substantial vested interests. Thus, a large and relatively reliable supply of freshwater to the farms in the northern delta is considered an inherent entitlement of the area. Farmers' land ownership further reinforces the influence of their position. Nonetheless, the economic importance and social status of the agricultural sector is eroding.

Farmers in the northern delta region are strong players in the global market, due to the favourable physical conditions of their farms and their immense capacity for innovation. They face many threats, however, such as salinization, plans to modify the way freshwater supplies are regulated

[1] The working paper by Van Buuren et al. (2014) provides detailed descriptions of all sectors.

and introduction of new EU-level regulatory measures. As a result, the main aim of the Agriculture & Fisheries subsystem is to maintain the Southwest Delta as a key region for food production. Among farmers in the delta, two predominant ideas have emerged regarding the best way to accomplish this goal. One idea, held mainly by farmers in the north, is to scale up production, to enable them to continue to produce competitively for the global market. The second idea, held mainly by farmers in the south, is oriented towards diversification – both within the sector (e.g., combining cultivation of different crops or agricultural activities) and beyond sector boundaries (combining agricultural activities with, e.g., recreation). The first position predominates among farmers in the northern part of the delta. This has meant that these areas have become the main battlefields in struggles for land between agriculture and other subsystems. The second perspective is stronger in the southern part of the delta, and new opportunities for synergy have emerged there as a result.

Intersections between subsystems (step 3)

The analysis of each of the subsystems on its own says little about the complexity and dynamism of the system as a whole. This is explicitly addressed in the third step of the methodology, examining intersections between the subsystems. Assessments are also made of the strength of dependencies, the character of interactions and the nature of the interrelationships.

– *Dependencies*
  First, dependencies between the subsystems are mapped (see Figure 5.2). Based on expert judgements and argumentation, dependencies are characterized as weak, moderate or strong and as unilateral or reciprocal. These categorizations are indicative rather than being firm differentiations.[2]
  When looking at the dependencies in the Southwest Delta, the dominance of the Ports & Industry and Transportation & Shipping subsystems is prominent. Many other subsystems are unilaterally dependent on these dominant subsystems. In addition, the Ecosystems and Recreation subsystems both appear to have a highly dependent relation to actors in other subsystems.
  These dominant and dependent positions were also evident in the concrete plans and projects reviewed. In these, Ecosystems and Recreation often appeared as "closing entries" or "desirable extras", while Ports & Industry and Transportation & Shipping imposed the boundaries within which other subsystems could carry out plans and projects. Thus, maintaining open connections to the ports (via the Western Scheldt and New Waterway) and maintaining the accessibility of the Rhine-Scheldt corridor were considered hard prerequisites for any plans and projects affecting these waters.

– *Interactions*
  Figures 5.2 through 5.5 reveal interactions in the Southwest Delta. These illustrations distinguish between weak, moderate and strong interactions and between interactions aimed at maintenance of the status quo of the system (see Figure 5.3) or stimulating system innovation (see Figure 5.4). Like the dependencies, these characterizations can be made via expert judgements and based on argumentation.
  Figure 5.3 presents those interactions in the Southwest Delta that are oriented towards maintenance of the current system. Here, a strongly synergetic interaction is found between the Flood Defences and Urban Patterns subsystems. A similar type of interaction is found between Flood Defences and Agriculture & Fisheries. In both cases, Flood Defences mainly facilitates existing functions. An analogous interaction is observed between the "red" functions: Transportation & Shipping, Urban Patterns and Ports & Industry.

[2] The strengths of the dependencies can be defined as follows:
- *Weak dependence: Dependence between the subsystems is site-specific or case-specific; in particular cases, Subsystem A creates opportunities for or raises barriers to Subsystem B;*
- *Moderate dependence: Dependence between the subsystems is structural; Subsystem A in many cases requires efforts from Subsystem B;*
- *Strong dependence: Dependence between the subsystems is unavoidable; Subsystem A has a direct impact on Subsystem B.*

5.5 Analysis of configurations

The previous section traced the first three steps of the methodology, illustrating them with empirical examples. This section discusses the configurations that emerge based on these steps for the Southwest Delta. Analysing the intersections between the subsystems we find that some relationships between subsystems are highly influential in steering many actors in the delta, while others appear to be relevant to only a few actors or to none at all. Furthermore, the intersections are often found to also be linked to one another. As noted, such a set of mutually coherent intersections is labelled a *configuration*. This section describes the most notable configurations found in the Southwest Delta, for purposes of illustration. These configurations were identified by taking the strongest intersections between the subsystems.

Configurations are dynamic coherences, as they consist of both interfering and symbiotic relationships. Such a set of intersections may sometimes exhibit predominantly symbiotic relationships between subsystems, while other times its relationships are mostly interferential in nature. In the former case, the primary task is to develop and capitalize on the symbiosis observed; in the latter case, new solutions have to be found to reduce interference and overcome conflicts. Figure 5.5 presents four configurations used as examples in our further discussion. The first of these configurations is formed by the interactions between Flood Defences, Agriculture & Fisheries, Soil & Water and Ecosystems, and can be discussed under the heading "Dynamic Equilibrium in the Natural System".

– *"Dynamic Equilibrium in the Natural System" Configuration: Soil & Water, Flood Defences, Ecosystems and Agriculture & Fisheries*
  From the analysis, it appears that a change has taken place over the past decade in debates regarding the Southwest Delta. Much of the emphasis has shifted to the question of how to deal with the negative effects of the Delta Works, especially problems associated with managing sedimentation dynamics and water quality. Re-establishing estuarine dynamics, either partially or completely, could offer a solution to these challenges, while at the same time boosting the quality of the natural environment and enhancing opportunities for recreation and fishing. This, moreover, corresponds

Figure 5.2 Dependencies in the Southwest Delta

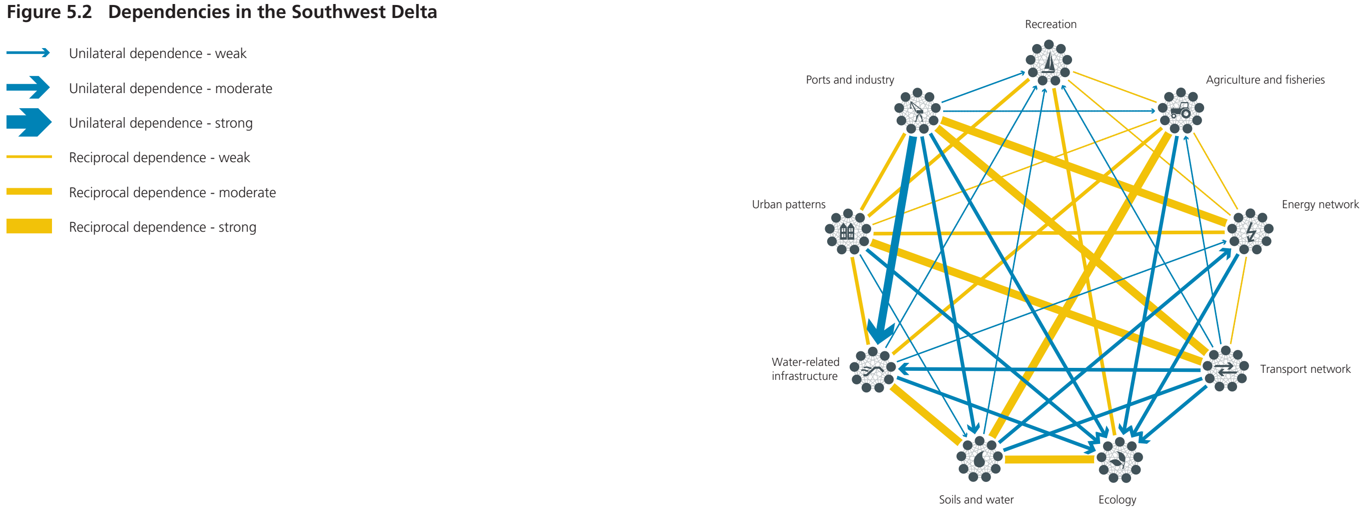


Figure 5.3 Interactions in the Southwest Delta oriented towards system maintenance

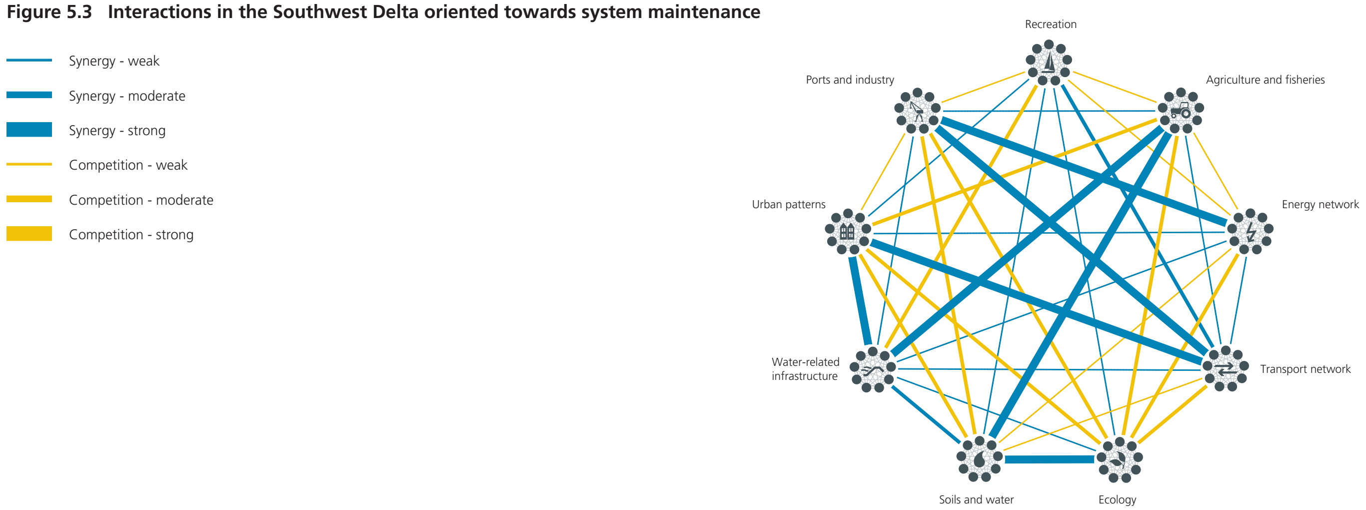


Figure 5.4 Interactions in the Southwest Delta oriented towards system innovation

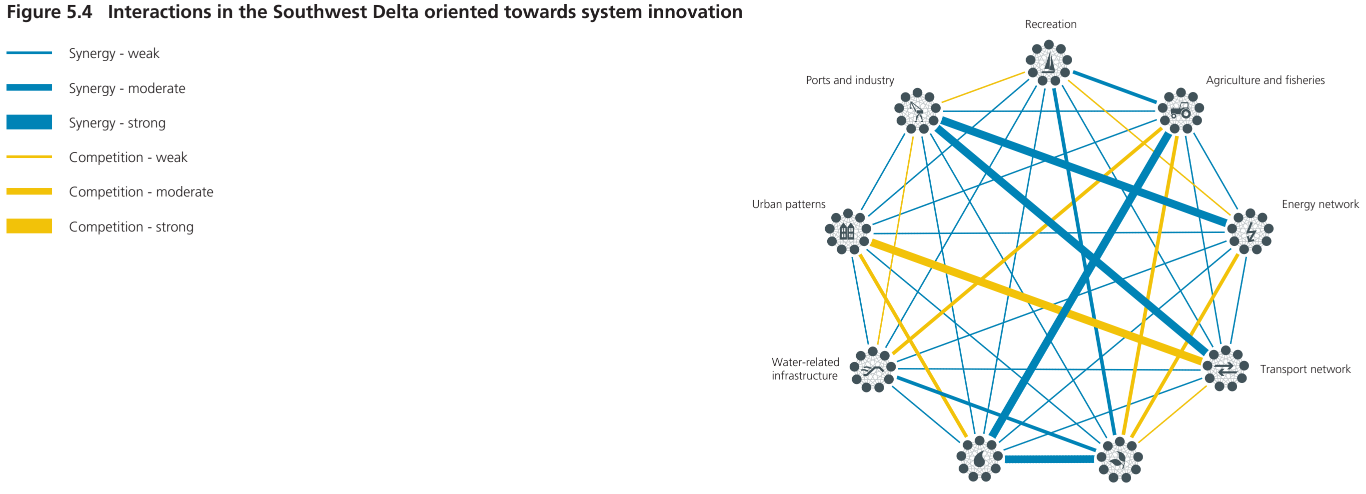
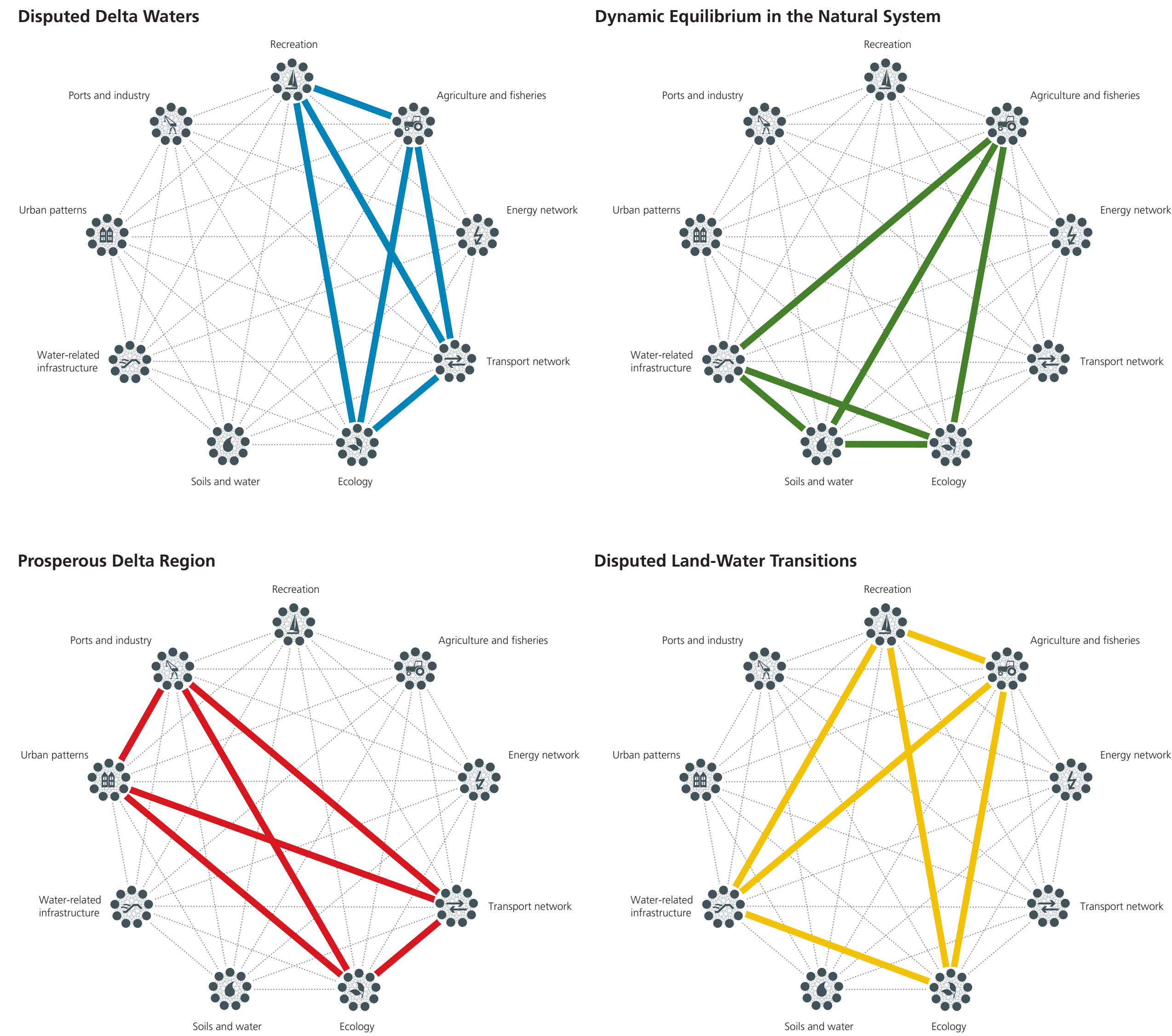


Figure 5.5 Examples of configurations in the Southwest Delta



with the aim of rendering the natural system more robust in the face of a changing climate. Salinization of the Volkerak-Zoom lake, reducing tidal movement in the Grevelingen inlet and partially opening the Haringvliet sluices are all examples of measures that reflect this new perspective on the delta, which is increasingly on the agendas of the collective regional governments and is being elaborated in numerous projects. The analysis also reveals that this configuration comes at a price, especially in terms of the supply of freshwater for agriculture. Stakeholders consider this interference to be of extremely high importance. The strong relationship between large-scale agriculture (oriented towards maintenance of the current system) and the Flood Defences subsystem makes this configuration particularly controversial.

In ongoing debates, such as that regarding the opening of the sluices and expansion of the area devoted to nature, the interference between a new dynamic equilibrium in the delta and the vested interests of classic agriculture are in strong evidence. In addition, there is also tension between regional objectives and national priorities. Objectives within the region require adjustments to be made in the management of flood barriers, but considering national priorities and prevailing views regarding the key tasks, there seems to be little reason for national actors to help bear the costs of these adjustments.

– *“Disputed Delta Waters” Configuration: Transportation & Shipping, Recreation, Ecosystems, Agriculture & Fisheries*

The delta waters are intensively utilized. They are used not only for cargo shipping, but also for recreation and fishing (for shellfish and seafood). Moreover, use of the waters is being restricted to meet nature conservation requirements. Each type of user has its own demands for the water, and any time one user expands its activities this quickly poses limitations on the activities of other users. For example, if more area is used for mussel seed capture (Agriculture & Fisheries), this automatically means that less space is available for sailing and pleasure boats (Recreation) and for inland shipping (Transportation & Shipping). The activities of the different users of the delta waters are therefore at odds with one another.

With increased demands for space, the number of potential conflicts rises. These potential interferences require spatial solutions, and even more, new arrangements for better aligning the different types of usage. Joint envisioning for the different delta waters is an important step towards achieving a greater consensus about the functions of the waters and how these could be strengthened. The “Prospects for Grevelingen” programme (Zicht op de Grevelinge) is an example of such a joint envisioning exercise.

– *“Prosperous Delta Region” Configuration: Ports & Industry, Transportation & Shipping, Energy Networks and Urban Patterns*

This configuration is primarily focused on strengthening the economy while also ensuring that the delta area remains a pleasant place to live. In the configuration, nationally and internationally significant economic development are strengthened, such as cross-border transportation networks between the Netherlands, Belgium and Germany and cooperation between the ports of Rotterdam and Antwerp. At the same time, there is recognition of the dependence between the ability to attract well-qualified employees for these economically vibrant sectors and provision of an attractive living environment. Economic development objectives are therefore often combined with strengthened local and regional government initiatives to improve the living environment.

One point of concern is the relationship between the “green-blue” values of the delta and port- and industry-related development in cities such as Moerdijk, Vlissingen and Terneuzen. In this regard, the stark contrast between the red “horseshoe” and the green-blue “heart” of the delta is perceived as both a blessing and a potential risk: a blessing because of the spatial values that have been preserved in the heart, but with the risk that continued economic development could lead to further shrinkage and loss of amenities in that same heart.

– *“Disputed Land-Water Transitions” Configuration: Flood Defences, Ecosystems, Recreation and Agriculture & Fisheries*

Many actors expressed frustration that transitions between land and water in the Southwest Delta offered little opportunity for shared usage and enhanced spatial quality. They pointed out that many chances were available in this regard involving nature, recreation and housing, but that these were not being utilized because there was no urgency to take action and also because the infrastructure manager was not eager to allow such forms of shared use. The opportunities mentioned varied in form and magnitude. Some related to the potential for commercial development of areas alongside shipping canals, enabling towns to establish stronger links with open water. Others involved nature areas combined with recreational usage. The national government and energy companies are exploring the potential for generating sustainable energy on the outskirts of the larger delta waters, for example, by constructing wind turbines. Nonetheless, major obstacles remain to experimentation on the boundaries between land and water, such as the land uses that are currently dominant (often agriculture) and the widespread socio-cultural perception of water as a threat that should be kept at a safe distance.

In the Southwest Delta, the concept of “innovative dikes” is receiving increasing attention. The desire to do more with dikes is being voiced with rising frequency and manifest in experiments with “Building with Nature” and other ideas for multifunctional dikes. Water managers, too, seem increasingly willing to think along these lines, though numerous procedural and institutional barriers remain. Here, again, the room for manoeuvre available is a sole function of the concrete priority that water managers apply to the task.

5.6 Functions of an actor analysis

Our actor analysis reveals which spatial issues dominate the debate in the Southwest Delta. At the same time, the configurations will be given different accents at different scale levels and different locations. The scale at which the configurations are drawn is important, because it also determines the scale at which the spatial design has significance. In this regard, alignment and interaction with the plan analysis are important. This is because the plan analysis has a clearer focus on the area of application (see Chapter 6). Although the actor analysis draws a picture of the *spatial* configurations of the subsystems, in doing so, it primarily reveals how subsystems relate to one another in terms of institutions and the objectives of the actors involved. Links between some (clusters of) subsystems seem to offer considerable spatial-functional potential, while these subsystems are highly disconnected institutionally, and therefore difficult to synchronize. Spatial configurations then become mainly an administrative puzzle, in which finding appropriate governance arrangements to better coordinate functions or to equalize benefits and costs is key. Conversely, subsystems may be easily forged into a configuration in terms of institutional arrangements, but nonetheless be spatially and functionally incompatible. In such cases, there may be institutional will, but no functional way.

Such actor analyses, based on a CAS perspective, perform three functions in design and planning processes: (1) broadly exploring the challenges, (2) assessing the feasibility of spatial designs and (3) mapping emerging configurations.

Exploring challenges

A primary function of our actor analysis was to broadly explore the challenges facing the region of the Southwest Delta. In an urbanized delta such as this, it is important that the challenges not be defined unilaterally by a narrow group of academics and policymakers. Indeed, from a CAS perspective, the planning brief has to do justice to the complexity of the system that the plan is to serve. Mapping out the configurations helps fulfil this requirement. The configurations ultimately reveal which subsystems work together and between which subsystems interference exists or may occur. In addition, it exposes the (combinations of) synergies and conflicts at play between subsystems. In doing so, the actor analysis helps us to understand which challenges facing a region can be addressed through design. Via the methodical steps, challenges can be identified not only by researchers, but also by the parties active in the region or by a combination of both. This last approach is taken in DENVIS, a methodology for joint envisioning on the delta, in which researchers present the results of the actor analysis and the participants choose which challenges they take up, how these are defined and how they are dealt with. The actor analysis therefore contributes to the creation of designs that are aligned with what the parties in the delta region perceive as core qualities to be preserved, while also incorporating the desires held for innovation in the region.

Feasibility of design

The stakeholder analysis can also play an important role in providing feedback on spatial designs that have already been developed. This feedback offers information on the feasibility of the designs, for example, by making clear how the interests emerging from other subsystems are affected. It also contains information about the opportunities available for refining designs or for broadening them. The actor analysis presented here indeed points towards potential synergies between subsystems and opportunities for mobilizing actors. Conversely, the analysis also indicates possible conflicts that may arise with other subsystems and possible resistance of particular actors, which will require new solutions or compensation for any damages experienced. When an actor analysis is used to assess the feasibility of a design, its steps are carried out in reverse: starting from the configurations implicated in the design, via the intersections underlying the configurations towards independent synergies and synergies that contain intersections.

Emerging configurations

Finally, it should be noted that the actor analysis, though based on the interactions currently dominant between subsystems, could also be used to signal emerging configurations, to further explore them and even to mobilize them. In our case of the Southwest Delta, this could include for example the emerging alliance between the WWF and the Port of Rotterdam. The WWF developed a vision for the Haringvliet called “With Open Arms”, in which interconnections between river and sea are once again restored. The Port of Rotterdam supports that vision. Figures 5.2, 5.3, 5.4 and 5.5, furthermore, suggest the potential of exploring relations between the subsystems that are currently present but not yet dominant or that receive too little emphasis at the current time. The diagrams could then be used to mobilize unexpected encounters between actors from the subsystems to advance potentially attractive configurations. This is the way that the actor analysis is applied within the DENVIS methodology (see Chapter 7).

5.7 Conclusions and reflections

This chapter demonstrated that an actor analysis based on a CAS perspective provides a broad overview of the relationships between the subsystems that were identified in the Southwest Delta. Such an analyses yields results that further the quest to develop integrative spatial designs that mobilize actors within a region. The actor analysis offers insights on how actors define their subsystems and how this creates particular configurations of subsystems. Use of intersections to map configurations in which a number of characteristic synergies or even conflicts are central, can help guide design and planning processes onto a promising path. The analysis provides insights on how subsystems are synchronized (synergy or conflict) and on which actors need to be mobilized to bring promising configurations a step further. This process leads to designs that link different sectors, scales and time horizons, and are therefore more integrative.

The stakeholder analysis can also be used to detect emergent actor constellations and the associated configurations (synchronization) and to develop them further (mobilization). In this regard, the methodology also offers insights into changes that may occur within the configurations. The conflictive and synergistic relationships between (parts of) subsystems are neither static nor given. They are subject to change and can (to some extent) be deliberately influenced. Repeatedly carrying out an actor analysis (producing snapshots through time) can yield new insights that are relevant for the further development of configurations and for designs that are richer and more feasible. Particularly helpful in this respect are insights into the changes under way within and between subsystems, such as the parties aimed at maintaining the system's status quo and those focused more on innovation.

Ultimately, the goal is concretization of the configurations identified. To maximize the usefulness of the results, it is important that the configurations be sufficiently specific, so that policymakers and stakeholders can actually get down to work with them. This mainly requires adequate development and refinement of the fourth step of the analysis. It also requires interaction and integration with the plan analysis, which is the subject of the next chapter.

Chapter 6

Analysis of spatial plans as a contribution to planning in complex systems

Over the past fifteen years, a large number of designs have been developed for the region surrounding the Haringvliet. These make abundantly clear that there are multiple different possibilities for the region's future development. Further analysis of the possible consequences of these designs for the various subsystems provides us a glimpse into the area's spatial and social potential.

6.1 Introduction

The Haringvliet and surroundings has long been a topic of debate, design and planning. After it became clear that the goals of the 1950s and 1960s, to establish large-scale industry and urbanization here, would not be realized, various parties took the initiative to develop new proposals for the region's future. These proposals typically reflect the interests and objectives of just one or a few subsystems, while largely neglecting to consider how the interests and objectives of other subsystems would be affected.

This does not mean that all these proposals are irrelevant and can be written off. The reverse is true, as these plans offer a valuable overview of the different possibilities for the region and the different particular interests that the proposals have tried to accommodate.

This chapter contends that before any new regional development gets underway, it is important to carefully analyse the recent planning and design history of an area and literally to map it out. All the design initiatives of the recent past, taken together, can be considered important preliminary work already done and, furthermore, with which many of the actors in the region are already familiar.

This chapter describes a methodology for conducting a plan analysis that relies on complex adaptive systems thinking. By analysing multiple designs, the correlations between the design solutions proposed in the different plans are revealed and can be better understood. This knowledge provides actors in a planning process a wider overview of all the spatial options for achieving their own objectives and of how their own objectives relate to those of others. The analysis of the designs distinguishes between spatial interventions and spatial effects. An intervention in the subsystem “Soil & Water”, for example, will have effects on other subsystems, such as “Ecosystems”, “Agriculture & Fisheries”, “Flood Defences”, “Ports & Industry” and “Urban Patterns”.

6.2 Methodical steps

This spatial plan analysis sets out to find interaction between planning problems and elements from the multiple planning proposals that have been developed by different actors, using a variety of different scale levels and time horizons. The goal is not to identify any one final best solution to a planning problem, but rather to map out a broad pallet of possible solutions and draw correlations between potential solutions. A precise analysis of spatial designs according to subsystems demonstrates that the issues facing certain subsystems can be resolved in conjunction with one another. At the same time, it becomes clear which solutions are impossible to combine and which have a neutral relationship with one another.

The spatial plan analysis comprises four steps: (1) selection of design proposals, (2) decomposition of design proposals, (3) overview of interventions per subsystem and (4) recomposition.

6.3 Selection of design proposals (step 1)

The region has over the past fifteen years (1997–2012) been the subject of a variety of design events, competitions and commissions. The first important vision for the region, after annulment of the plan for large-scale industrialization and urbanization, was published by the World Wide Fund for Nature (WWF) in 1997. The WWF called for the Haringvliet sluices to be opened and new land-water transition gradients realized along the shores of the Haringvliet (WWF, 1997). In the years that followed, the WWF elaborated this plan in greater detail in a number of stages (WWF, 2008; 2010). In 1999–2000, the Rotterdam Art Foundation organized an Architecture International Rotterdam (AIR) planning event called "Rotterdam Southbound", which examined the topic of the future spatial development of the Hoeksche Waard (a river island in the delta). Eight design teams (four Dutch, four foreign) were invited to develop a vision for the Hoeksche Waard (Cusveller & De Volder, 1999). The attention generated by this event produced a widespread appreciation of the Hoeksche Waard as an area possessing unique landscape qualities, ultimately leading the Dutch government to declare the Hoeksche Waard a protected landscape.

In 2008, the Eo Wijers Foundation organized a design competition focused on "Delta Port", the area between Dordrecht and Rotterdam. Many of the submissions explicitly incorporated the Haringvliet and its surroundings.

Finally, from 2011 to 2012 the Delta Programme invited a number of designers to reflect on the entire Rhine-Meuse delta region. This yielded six design studies which related to different parts of the Rhine-Meuse delta and were exhibited at the 2012 International Architecture Biennale Rotterdam (IABR) (De Greef, 2012).

The triggers for all of these design proposals can be found in specific subissues, or subsystems. The proposals developed at the initiative of WWF were targeted mainly towards improving conditions for characteristic delta ecosystems. The proposals developed in the framework of AIR Rotterdam and the Eo Wijers competition mainly explored the theme of possible new urbanization patterns. The designs created in the context of the Delta Programme and IABR 2012 had the goal of exploring the spatial development possibilities associated with a particular solution to the water management issue.

For our plan analysis, the decision was made to first select, out of all these designs, seven integrated design proposals, based on the expectation that because of their integrated nature these would cover as many subsystems as possible and that interactions between different design solutions would be their starting points. The design studies chosen were the following: "Open Arms!" (WWF, 2008), "Open Haringvliet!" (WWF, 2010), "The Great Delta Hem" (International Architecture Biennale Rotterdam: Bosch Slabbers, 2012), "The Rhine-Meuse Delta as a Whole" (International Architecture Biennale Rotterdam: H + N + S, 2012), "Blue Blood" (Eo Wijers competition 2008: Kuiper-Compagnons, 2009), "Turning Tide" (Eo Wijers competition 2008: DHV, Enno Zuidema, 2009) and "The Golden Delta" (Architecture International Rotterdam Bindels, Gietema, Hartzema & Bell, 1999).

This chapter examines two of these designs, which on the surface seem to represent very different perspectives on the area's future river discharge regime. Investigation of these two designs, therefore, should enable us to explore the extent that possible solutions to the water management issue in the future have critical significance for other subsystems.

"The Great Delta Hem" design proposal was commissioned by the Delta Programme, in collaboration with the International Architecture Biennale Rotterdam. The goal of this design study was to investigate what spatial development options were possible assuming maintenance of the current river discharge regime, in which the New Meuse and the New Waterway continue to play an important role. The main change foreseen for the future regarding river discharge concerns the possible need to increase the water storage capacity of the Haringvliet. To this end, "The Great Delta Hem" plan investigates two variants: (1) raising the Haringvliet flood barrier and (2) expanding temporary water storage capacity by developing an overflow zone alongside the Haringvliet. An essential characteristic of "The Great Delta Hem" plan is that the end-result envisioned represents a culmination of a process that can be accomplished in many small steps.

The "Blue Blood" design proposal was an entry for the 2008 Eo Wijers competition, and won second prize that year. The Eo Wijers Foundation has aimed, since 1985, to stimulate spatial design at a supra-local level, and it encourages visionary spatial planning. The starting point for this design was the necessity and feasibility of radically changing river flows and discharge distribution in the region.

Analysing these particular proposals will provide greater insight into the possible consequences for spatial development of these very different solutions to the river discharge distribution issue.

6.4 Decomposition of the individual design proposals (step 2)

The various measures contained in the design studies were decomposed according to our nine subsystems (see Chapter 5). In the analysis, a distinction was made between a spatial intervention, such as the relocation of a dike, and spatial effects, such as, for example, more space for water storage or creation of new, ecologically valuable foreshores. The different interventions are presented using similar outlines below.

Design proposal: The Great Delta Hem
Author: Bosch Slabbers, 2012 (Delta Programme/IABR)
Term: Medium to long (2100)
Area: Haringvliet–Hollands Diep

In the framework of the International Architecture Biennale Rotterdam 2012, Bosch Slabbers carried out design-oriented research on the Haringvliet–Hollands Diep–Biesbosch region. The central question was how can we employ the strategy "continuation along the present course" (*business as usual*) to solve problems related to flood safety, while at the same time making the area as attractive and adaptive as possible with added value for the landscape, nature and the economy, among others? The plan sketches a vision of how the region might look in 2100.

The most important intervention proposed in relation to the water system is to increase the water storage capacity of the Haringvliet. To do this, two variants were studied: (1) raised and reinforced flood barriers and (2) increasing the Haringvliet's temporary water storage capacity by making the shore zone suitable for overflow storage. This second variant builds on initiatives already under way in the context of the "Delta Nature" project, in which the banks of the Hollands Diep and Haringvliet are designated as nature conservation zones and provisions are made for more gradual transitions between open water and the polder landscape.

"The Great Delta Hem" plan combines both of these ideas with the additional aim of developing the southern ends of the islands of Hoeksche Waard and Voorne-Putten into an attractive "front yard" for Rotterdam offering new forms of housing and new opportunities for recreation. Private parties are active investors in this landscape, where the delta's presence is tangible everywhere, and land and water appear perfectly interwoven. A continuous belt of nature extends all the way from the mouth of the delta inland to the Biesbosch Nature Park, an expanse that is also referred to as "from seals to beavers", signifying the variation in wildlife found from the delta mouth to the tidal forests inland. The main ingredients of the plan's envisioned end-result are the following:

- development of an island/archipelago in the mouth of the delta, therefore creating a large brackish water environment;
- development of saltmarshes and mud flats, thereby extending the intertidal environment;
- increasing inflows to the Biesbosch;
- development of "The Great Delta Hem";
- strengthening links between the cities and water, or in design terms, between "Coolsingel and Tiengemeten".

Intervention 1: Development of an island/archipelago in the mouth of the delta (subsystem: Soil & Water)
Effect 1: Retain freshwater (subsystem: Soil & Water)
Development of an island archipelago in the mouth of the delta would ensure that fresh river water is retained there longer. In addition, salt penetration would be reduced to 35%, meaning that the dam could be left partly open more often and for longer periods without the salt tongue extending beyond the river Spui.

Intervention 2: Partial opening of the Haringvliet dam (subsystem: Flood Defences)
Effect 2: Fuller estuarine dynamics (subsystem: Ecosystems)
Partially opening the Haringvliet dam combined with enlargement of the delta mouth would offer opportunities for development of nature areas of particular value in the European context, with a progression from freshwater via brackish to saltwater (providing for nature compensation in the longer term). In the Haringvliet, saltmarshes and mud flats could develop, expanding the brackish and freshwater intertidal environment. Flows to the Biesbosch would be increased, and an extension of the freshwater tidal area would be achieved with development of tidal forests in the Biesbosch.

Intervention 3: Expansion of the deltaic creek system (subsystem: Flood Defences)
Effect 3: Improved water system (subsystem: Soil & Water)
By extending the deltaic creek system inland of the dikes, the water management in the area would be improved (providing a local freshwater buffer for agriculture and local water storage).

Intervention 4: Raising the dikes (subsystem: Flood Defences)
The dikes with insufficient height north of the Haringvliet and Hollands Diep would be fortified and raised. Increased dike height would mean that the dike would also have to be widened, creating a higher-level plateau. To reinforce the dikes, various local raw materials would be used. Thus, three types of dikes would be created: dune dikes, marsh dikes and Biesbos dikes.
Effect 4a: Multifunctional dike (subsystems: Urban Patterns, Recreation and Ecosystems)
A variety of plans could be implemented on the plateau at the top of the widened dike (e.g., housing, commercial activities, recreation), creating opportunities for strengthening the links between existing urban areas and the water. As such, these zones could develop into a bustling "front yard" for the City of Rotterdam.

Intervention 5: Moving back the dike (subsystem: Flood Defences)
The current primary flood barrier north of the Haringvliet and Hollands Diep would be moved more than 25 km inland, and the existing barrier lowered to such a height that it would be flooded on a regular basis.
Effect 5a: Multifunctional zone (subsystems: Urban Patterns, Recreation, Ecosystems and Agriculture & Fisheries)
The polder inland of the lowered dike would accommodate various plans (e.g., housing, commercial activities, recreation, nature, agriculture). As above, this would create opportunities for strengthening links between existing urban areas and the water. Again, this zone could develop into a bustling "front yard" for the City of Rotterdam.
Effect 4b/5b: Increased water storage capacity of the Haringvliet (subsystem: Soil & Water)
Both raising and relocating the dikes would increase the water storage surface area of the Haringvliet and Hollands Diep.

Intervention 6: Construction of additional transportation links (Subsystem: Traffic & Transportation)
Comfortable and attractively designed transportation links would interweave the City of Rotterdam with the delta.
Effect 6: Bustling "front yard" for the City of Rotterdam (subsystems: Urban Patterns and Recreation)

Construction of new transportation links, together with implementation of dike reinforcement measures, would make it possible for the Delta Hem to develop into a bustling "front yard" for Rotterdam by 2100. This could lead to increased demand for new forms of housing and recreation (e.g., second homes), growth of marinas or development of new ports for pleasure crafts, and establishment of leisure resort complexes.

Design Proposal: Blue Blood
Author: KuiperCompagnons, 2009 (Eo Wijers competition, second prize)
Term: Medium to long (2100)
Area: Haringvliet–Hollands Diep/New Meuse–New Waterway

To guarantee flood protection in the coming centuries, a new "CO2 dike" would be built north of the Haringvliet. The dimensioning of the dike (height times width) would be inversely proportional to the speed at which emissions of polluting gases are reduced. The "CO2 dike" would combine a number of dike rings and have a safety standard of 1:infinity. Construction of the breach-free "CO2 dike" would safeguard the Randstad conurbation (composed of the Netherland's four largest metropolitan areas) from the threat of flooding. The dike would be built along the northern shores of the Haringvliet, Merwede and Waal rivers, and extend from the coast to higher land. In the event of extremely high river discharges, water would be channelled to sea south of Rotterdam. A series of tunnels would be built into the dike. These would accommodate a variety of transportation flows, relieving some of the pressure on the current inner-city transportation networks while also offering additional space for new purposes. The current road network would be converted into a lower-speed (80 km per hour) network of urban boulevards. Clusters would be developed along these "green" city boulevards to accommodate urban functions. Within the new secure dike ring, freshwater buffers would be retained in a peat meadow zone, providing sufficient clean water for the region during periods of drought. Outside the dike, upstream waters would be drawn from the river for use as drinking water. Along the banks of the "CO2 dike", there would be opportunities for new developments, and on the seaward side of this large and secure dike, a water-rich environment would be established. The three cities would be integrated into one urban metropolis (KuiperCompagnons, 2009).

Intervention 1: Construction of "CO2 dike" (subsystems: Flood Defences and Traffic & Transport)
The new "CO2 dike" would comprise a number of dike rings along the northern boundary of the Waal river. The new flood barrier would be accomplished largely by raising and reinforcing existing dikes. The new dike would also provide space for a highway for freight transportation.
Effect 1a: New flood protection system (subsystem: Soil & Water)
The new "CO2 dike" would serve as a super dike ring for the Randstad conurbation and protect it from the threat of flooding. The current dikes could continue to function as oversized partition dikes.

Effect 1b: Stimulus for new nature (subsystem: Ecosystems)
The "CO2 dike" would create a sharp division between the robust nature areas outside the dikes and the controlled urbanized areas within it. The Biesbosch would extend all the way to the coast, creating the largest nature conservation area in the Netherlands. The Hollands Diep and Haringvliet would be transformed into a vast freshwater tidal estuary.
Effect 1c: Relieve existing transport infrastructure and construct new links (subsystem: Traffic & Transportation)
The new freight highway would provide relief to the current inner-city transportation networks. The current motorway network would be transformed into a lower-speed (80 km per hour) system of urban boulevards. The A4 expressway would be linked to the A29 via a junction and connect Amsterdam, Schiphol, Elsmere, the Westland region, the Port of Rotterdam and Antwerp. There would then be no need for the A4 to cut through the Middle Delftland city park.
Effect 1d: Relocation of ports (subsystem: Ports & Industry)
Port activities would be pushed further westward. The waterline would then be freed up for housing.
Effect 1e: New conditions for urban environments (subsystem: Urban Patterns)
The dike would integrate the cities of the Rijnmond-Drechtsteden region. Existing cities could strengthen their connections with the water, and opportunities would be created for new developments along the waterline. Old port areas could be transformed into residential areas (Rotterdam/Drechtoevers). Clusters would be developed along the 80-km boulevards to accommodate urban functions. Inside the super dike there would be space for a 15-km long strip for commercial activities and businesses.
Effect 1f: New recreation (subsystem: Recreation)
Along the rivers space would be provided for marinas, second homes and new communities. A network of cycle paths and ferries would make the fields accessible to visitors.

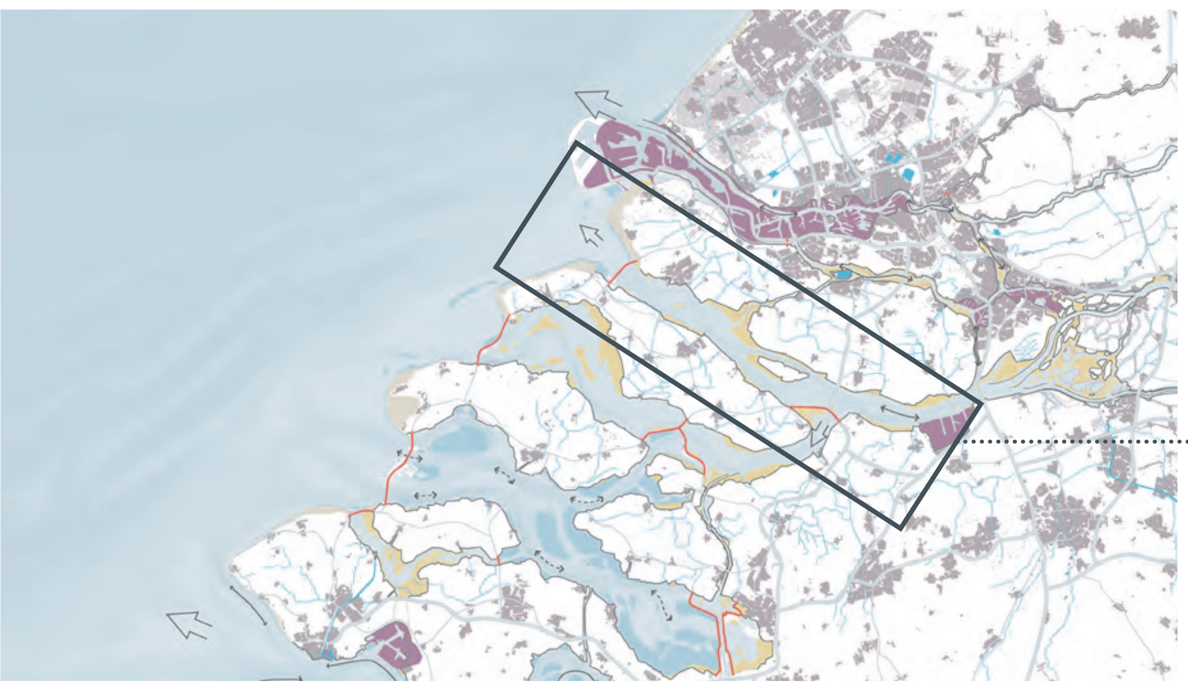
Intervention 2: Construction of high dams and locks (subsystem: Flood Defences)
In the Lower Merwede, the Dordtsche Kil, the Wantij and the Spui new flood barriers would be constructed. Locks would be built into the new super dike.
Effect 2: New routing for river discharge (subsystem: Soil & Water)
Due to the new flood barrier and the new "CO2 dike", it would become possible to divert the bulk of river discharge south of the new barrier. During high sea levels, water could be buffered in the Haringvliet and Grevelingen. In the event of a permanently high sea level, the "CO2 dike" would be permanently closed off with locks.

Intervention 3: Construction of new water connections (subsystem: Traffic & Transportation)
In the area behind the super dike, new water connections would be established linking urban centres with one another and with the surrounding landscapes. Using simple means, dammed up waters could be branched out again into rivers, resulting in expansion of the water network.

Figure 6.1 Methodical steps

STEP 1	STEP 2	STEP 3	STEP 4
Choice of location + Selection of design proposals	Decomposition of individual design proposals	Overview of interventions per subsystem based on the seven design proposals + Overview of interventions per subsystem based on the design proposals AND sectoral plans	Recomposition: Correlations between multiple design proposals

Figure 6.2 Location chosen for study



STEP 1: CHOICE OF LOCATION + SELECTION OF DESIGN PROPOSALS

Figure 6.3 "The Great Delta Hem"
(Bosch Slabbers, 2012)

Figure 6.4 "Turning Tide"
(DHV, Enno Zuidema Stedebouw, 2009)

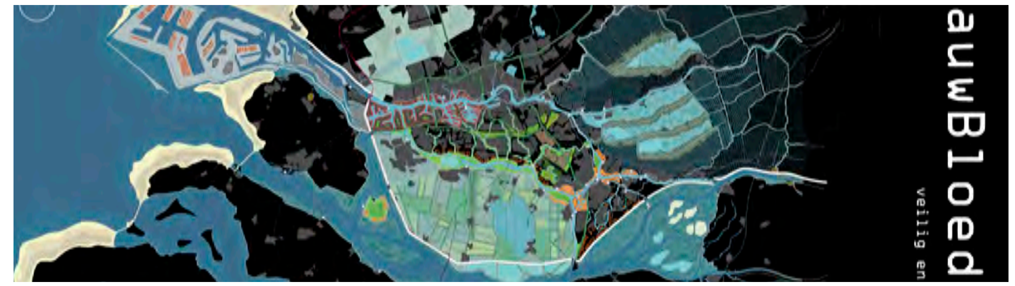


Figure 6.5 "Blue Blood"
(KuiperCompagnons, 2008)

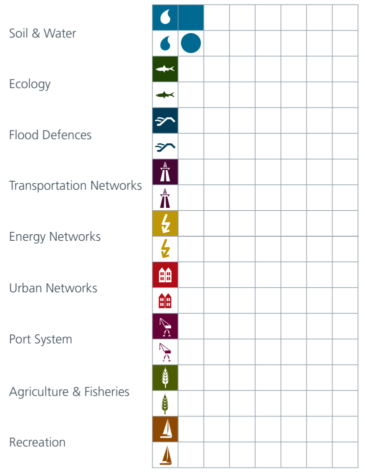
Figure 6.6 "Rijn-Meuse Delta as a Whole"
(H+N+S Landschapsarchitecten, 2012)

Figure 6.7 "Open Arms"
(WNF, 2008)

Figure 6.8 "The Golden Delta"
(Bindels, Gietema, Hartzema, Klok, 1999)

STEP 2: DECOMPOSITION OF INDIVIDUAL DESIGN PROPOSALS – EXAMPLE: "THE GREAT DELTA HEM"

INTERVENTION 1



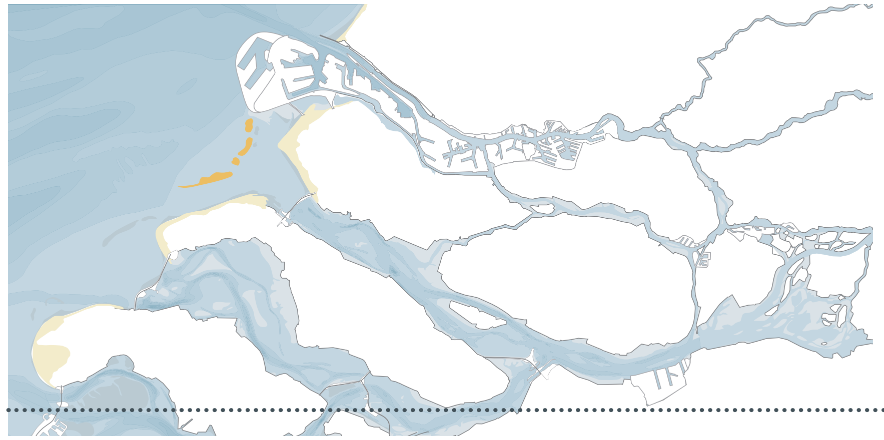


Figure 6.9 Development of an island/archipelago in the mouth of the delta. Subsystem: Soil & Water

EFFECT 1

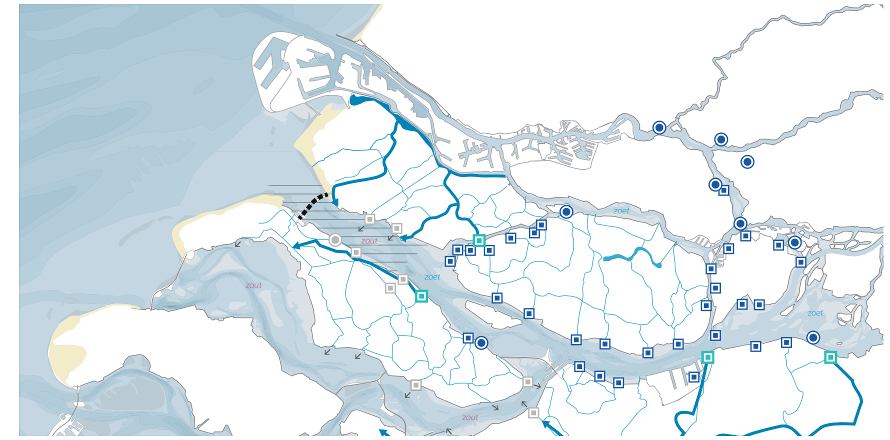
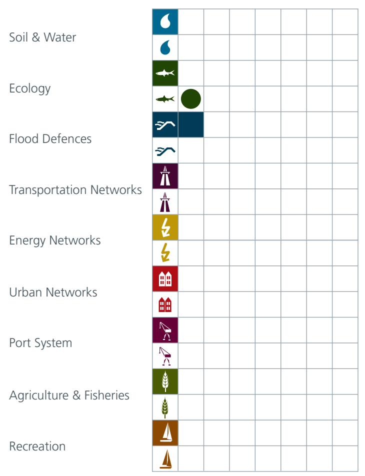


Figure 6.10 Retain freshwater. Subsystem: Soil & Water

■ = intervention
● = effect

INTERVENTION 2



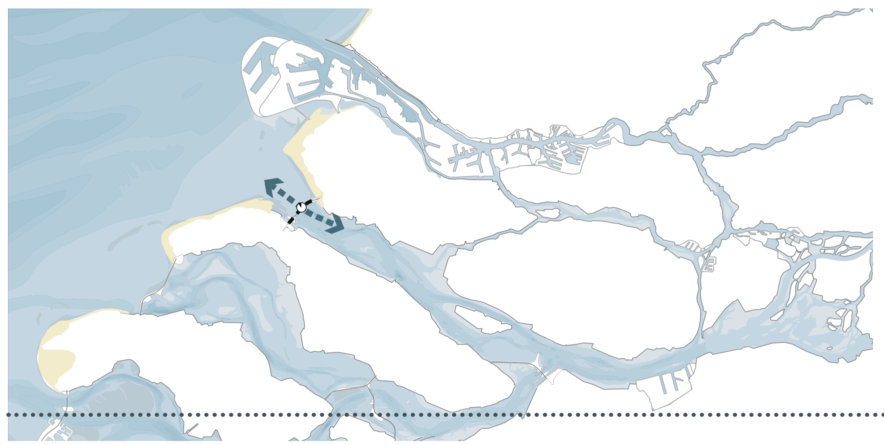


Figure 6.11 Partial opening of the Haringvliet dam. Subsystem: Flood Defences

EFFECT 2

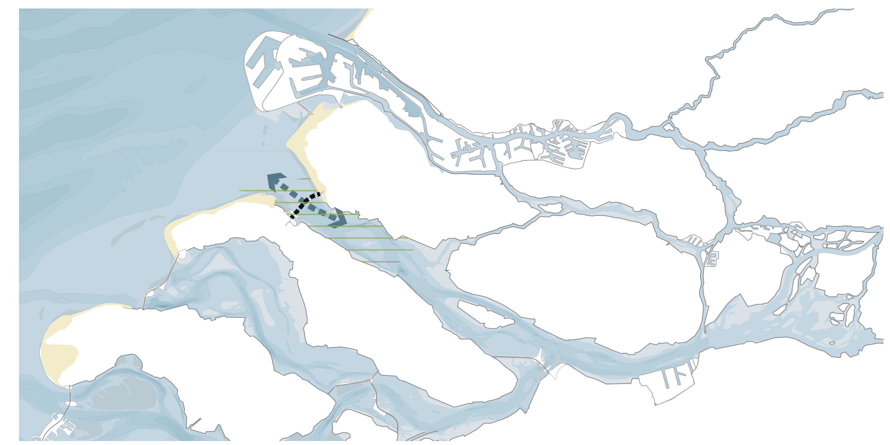
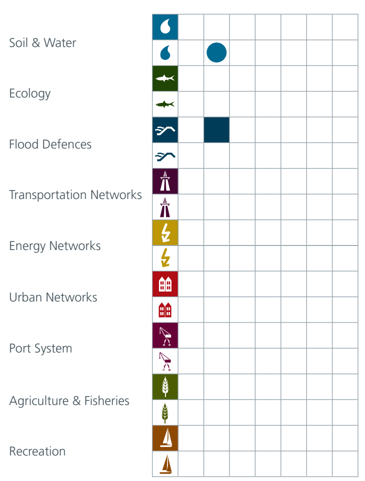


Figure 6.12 Fuller estuarine dynamics. Subsystem: Ecology

INTERVENTION 3



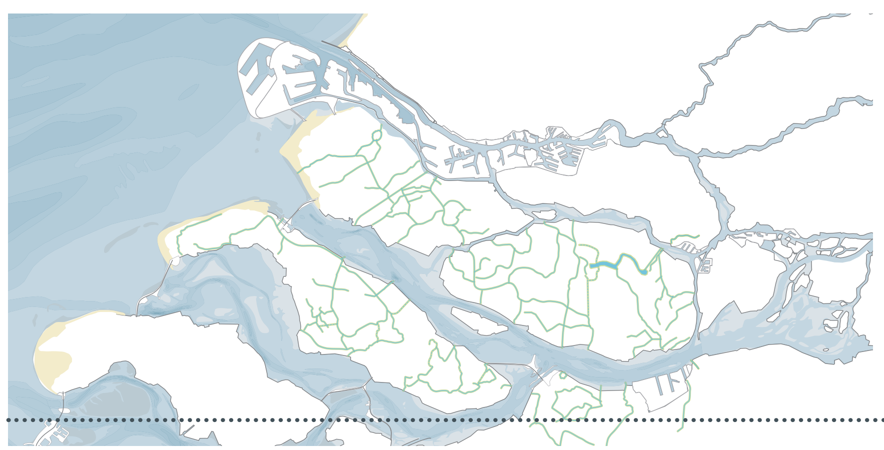


Figure 6.13 Expansion of the deltaic creek system. Subsystem: Flood Defences

EFFECT 3

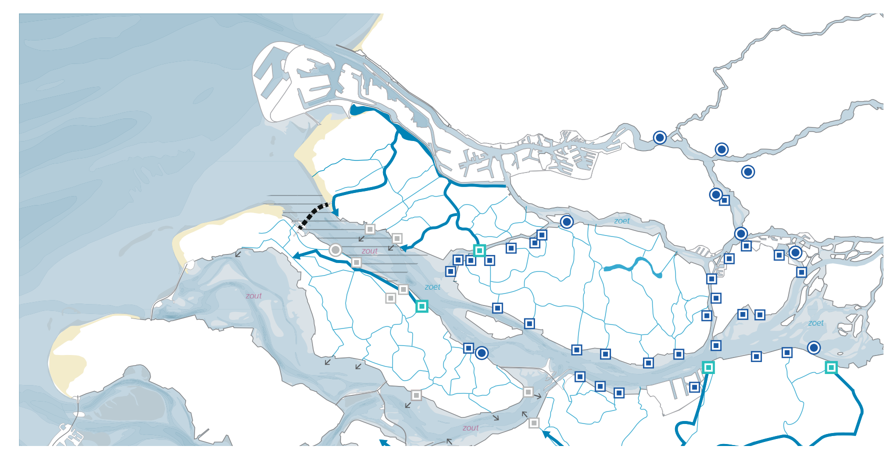
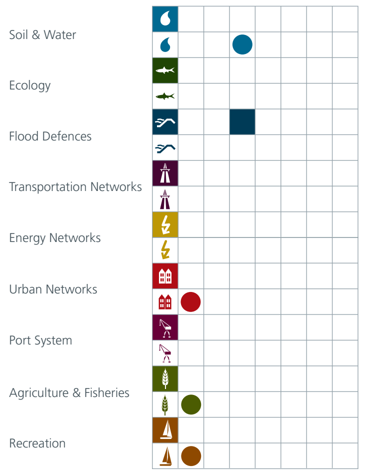


Figure 6.14 Improved water system. Subsystem: Soil & Water

INTERVENTION 4



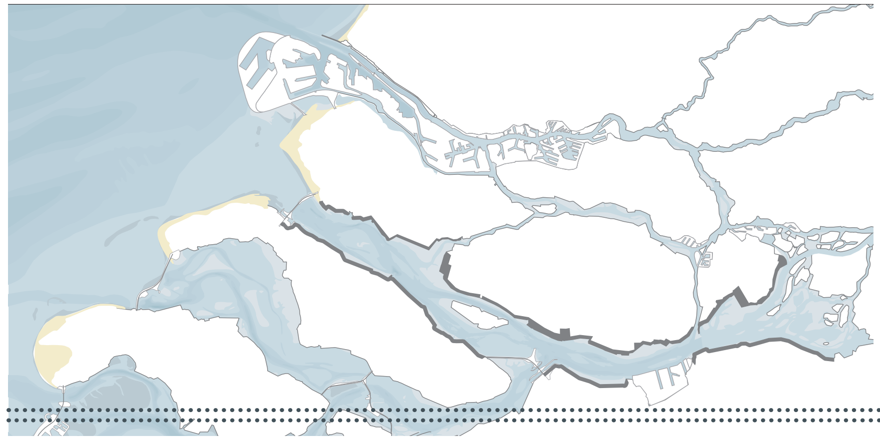


Figure 6.15 Raising the dikes. Subsystem: Flood Defences

EFFECT 4A

Figure 6.16 Multifunctional dike. Subsystems: Urban Networks, Recreation, Ecosystems

EFFECT 4B / 5B

Figure 6.17 Increased water storage capacity of the Haringvliet. Subsystem: Soil & Water

INTERVENTION 5

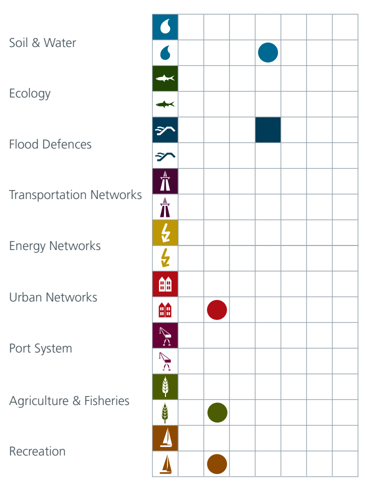


Figure 6.18 Moving back the dike. Subsystem: Flood Defences

EFFECT 5A

Figure 6.19 Multifunctional zone. Subsystems: Urban Networks, Recreation, Ecosystems, Agriculture & Fisheries

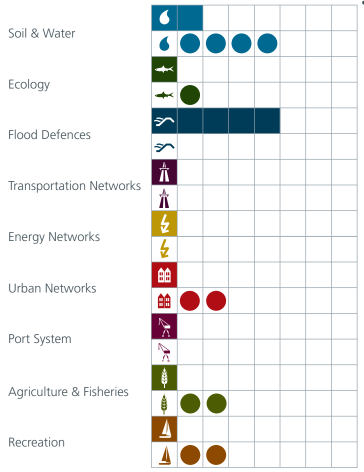


Figure 6.20 Overview of interventions and effects "The Great Delta Hem"

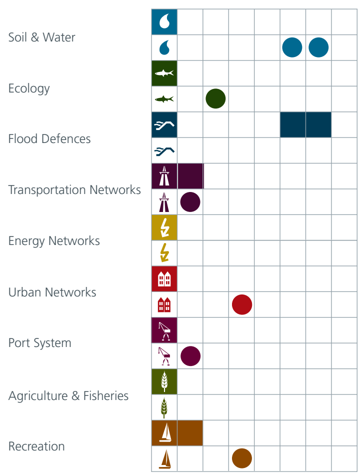


Figure 6.21 Overview of interventions and effects "Blue Blood"

Overview of interventions and effects – design proposal 3

Overview of interventions and effects – design proposal 4

Overview of interventions and effects – design proposal 5

Overview of interventions and effects – design proposal 6

Overview of interventions and effects – design proposal 7

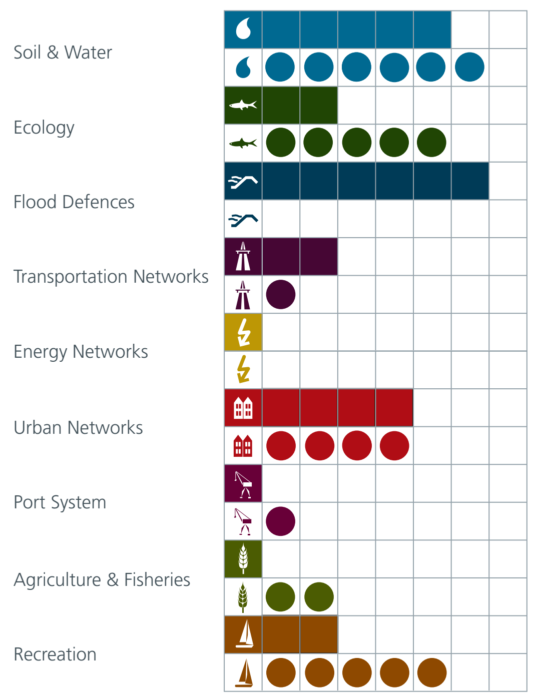


Figure 6.22 Overview of design solutions based on seven design proposals

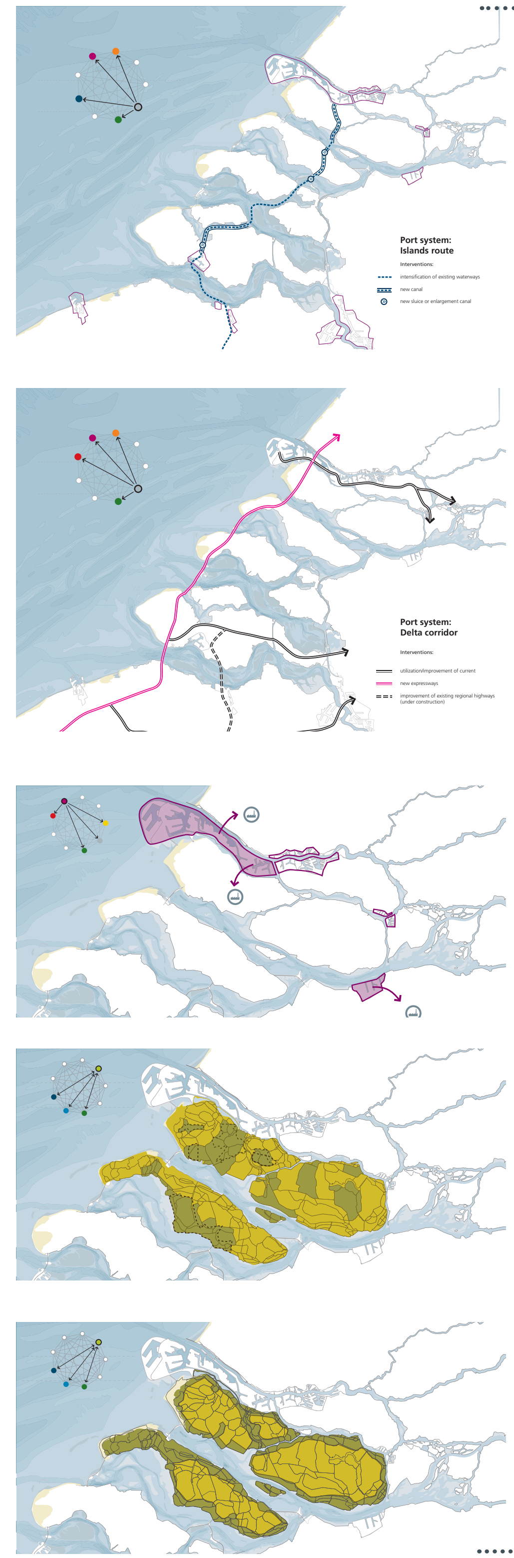


Figure 6.23 Supplementary sectoral plans

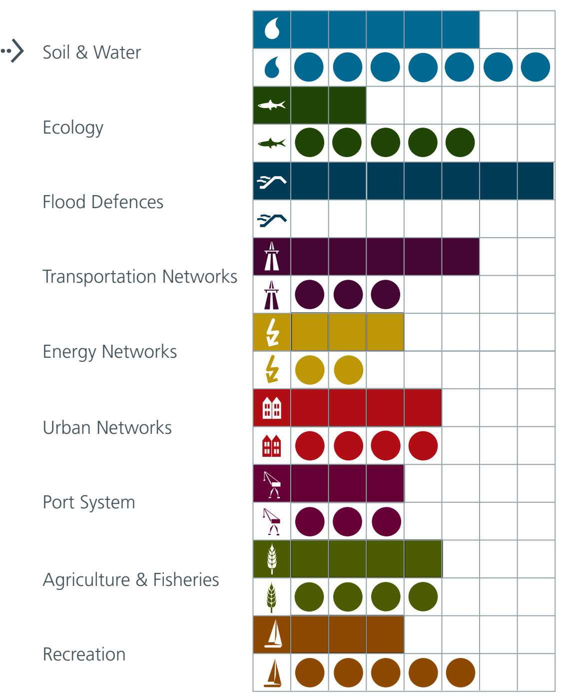


Figure 6.24 Overview of design solutions based on seven design proposals and supplementary sectoral plans

Effect 3: Greater cohesion between Drechtsteden and its surroundings (subsystem: Urban Patterns)
The new water connections would ensure greater cohesion between Drechtsteden and the surrounding landscape.

Intervention 4: Construction of new freshwater buffers and higher water levels (subsystem: Soil & Water)
Within the new dike ring east of Rotterdam, new freshwater buffers would be established on suitable polders, and the water level of drainage ditches would be raised.
Effect 4: New freshwater system (subsystem: Soil & Water)
New freshwater buffers would provide the region with sufficient clean water reserves during periods of drought. In the areas between waterways, marsh forests could grow, helping to purify freshwater and reduce evaporation. Outside the dike ring, upstream water would be drawn out of the river for drinking water supply.

6.5 Overview of interventions per subsystem (step 3)

The next step in the analysis was to list the various interventions and effects in an overview. Interventions found in multiple design proposals were included in the listing only once. From this overview it became evident that a number of the subsystems had not been addressed in the seven design proposals investigated, such as the freshwater system, the port system and agriculture. Consequently, a series of additional planning documents, many of them sector-specific, were analysed to gain as broad an understanding as possible of the different spatial interventions conceivable for these subsystems. The relevant planning documents were selected in consultation with the researchers involved in the actor analysis (Chapter 5), as they had acquired a thorough knowledge of plans for the region. Among the plans examined in this step were, for example, "Port Vision Rotterdam", "MIRT Antwerp-Rotterdam" (a multi-year national planning document concerning infrastructure, spatial development and transport), and plans for the Goeree-Overflakkee freshwater system. These were, again, decomposed according to interventions in and effects on the different subsystems.

6.6 Recomposition: Correlations between multiple design proposals (step 4)

As the final step of the spatial plan analysis, correlations between the interventions and effects from the different planning proposals were examined. Since the design proposals were developed with different planning problems and actors in mind, this part of the analysis also reveals synergies as well as areas of conflict and neutral relationships between the interventions and effects across the various plans. First, the overview indicates for each intervention, according to the original design proposal, which other interventions in other subsystems correlate with it. This relates back to the analysis of the individual plans done in the decomposition step. These correlations are synergistic in nature, since each of the design proposals is in principle internally consistent. Then an assessment is made of whether and how an intervention from one design proposal harmonizes or conflicts with interventions from other design proposals. This last step reveals the potential for conflictive or neutral relationships among the interventions and effects of the different plans. This step of the analysis was performed based on the expert judgements of a group of four experienced designers.

As noted, the two designs examined are very different from one another. The main differences can be summarized as follows:
- Gradual transition versus sharp division. "The Great Delta Hem" plan advocates restoration of gradual transitions between open water and inhabited lands, while "Blue Blood" opts for a radical dividing line between the new and urbanized lands within the dike and an outer-dike zone where water and nature are left more or less free and unrestricted.
- Gradual construction versus one "grand project". The new contours of the two delta islands (Hoeksche Waard and Voorne-Putten) could be developed gradually, bit by bit. It is also quite conceivable that new dune areas could appear here and there, or new land-water transition zones, as is currently the case. Both of these features (dune areas and "wet" land-water transitions) could even be implemented in conjunction with and alongside one another. However, implementation of the "Blue Blood" CO2 dike is a large-scale and complex undertaking that can only be done as a single project. This would continue in the tradition of other large infrastructure works in the Netherlands, such as the Afsluitdijk (a major integrated dam and motorway project constructed between 1927 and 1932) and the Delta Works (a series of dams and barriers protecting the south-western conurbation from flooding). Ultimately, the situation envisioned by Blue Blood with its "grand project" could also be achieved with the gradualist approach of The Great Delta Hem; in the case of The Great Delta Hem, a situation might similarly be achieved in which the New Waterway no longer plays a significant role in river water discharge, an additional storm surge barrier or lock would be built in the New Waterway, and the Port of Rotterdam would be entirely concentrated in the Europort and Maasvlakte 1 and 2 areas outside the dikes.

The overview of interventions and effects was compiled into a digital (web-based) application that linked each measure with the underlying sources of information and made that information directly accessible. Within the IPDD project, the overview of interventions was used as part of the DENVIS process to stimulate discussions among stakeholders about synchronization of interests and to mobilize new actors in the planning process (see Chapter 7).
The result of the spatial plan analysis was a broad pallet of interventions and

effects for the Haringvliet and its surroundings. The overview reveals that some goals could be achieved in a variety of ways. To illustrate, two examples are presented below based on the spatial plan analysis for the Haringvliet and surroundings.

Ecosystems

Construction of the Haringvliet dam transformed the Haringvliet from an estuary into a freshwater basin. Moreover, construction of high dikes at the edges of the Haringvliet greatly reduced the connection between open water and nature in the polders. Both of these measures resulted in a sharp depletion of the ecosystem in and around the Haringvliet. Successive visions published by the WWF therefore propose a gradual opening of the sluices in the Haringvliet, to enable estuarine dynamics to be restored. This is expected to result in a healthy, dynamic ecosystem. This proposal has encountered strong resistance from farmers in the area, who fear increased saltwater intrusion. The spatial plan analysis has demonstrated that there are alternative solutions to this problem. IABR design proposals, for example, indicate that moving back the dikes or creating a wet, inter-dike zone could also produce new, healthy ecological systems in the Haringvliet. The area of conflict associated with increasing saline intrusion is not a direct issue in these interventions, and potential synergies can be found, for example, with provision of extra water storage capacity or recreational opportunities. Moreover, a gradual opening of the Haringvliet sluices and a re-engineering of the land-water transitions are not mutually exclusive.

The radical option of an open Haringvliet serving as the main mouth of the entire river system creates very different conditions for flora and fauna species than the option of maintaining the situation as it is now.

Agriculture & Fisheries

Agriculture is an economic and spatial mainstay of the area. Salinization calls for a response that will enable agriculture to maintain its vitality as an economic sector into the future. The solution most often heard is to permanently guarantee sufficient freshwater so that current agricultural practices can be continued. Our analysis of the design proposals and supplementary planning documents suggests that a more nuanced, site-specific approach is possible. The pallet of possible solutions includes, for example, large-scale industrial agriculture, regional (specialty goods) production, saltwater crops and greenhouse horticulture. Each of these solutions can be combined with a specific type of water system. Moreover, each of these different types agriculture will bring different relationships with other subsystems, such as Soil & Water, Energy and Recreation.

Our overview also demonstrates that choices made in the Soil & Water subsystem affect many of the other subsystems. This subsystem can be characterized from a spatial planning perspective as a dominant subsystem. A crucial question for future spatial development of the delta concerns the choice between maintaining the current distribution of river discharge or changing

the discharge distribution, making the Haringvliet the main outlet and reducing discharge via the New Meuse/New Waterway, either gradually or at once. These two options are illustrated in figures 6.25 and 6.26. The choice of one variant or the other would be operationalized through interventions affecting the Flood Defences subsystem. After all, it is this subsystem that controls the discharge flow direction. The choice of discharge distribution therefore implies interventions in the Flood Defences subsystem, affecting a variety of other subsystems in turn. Below is a brief description of the interconnections between these various interventions.

Figure 6.25 Optimization of current river discharge distribution

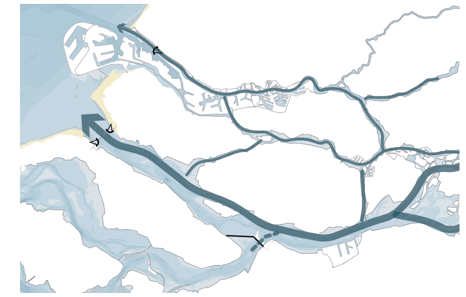


Figure 6.26 Most river discharge via the Haringvliet

Flood Defences

If the choice is made to maintain the current discharge distribution, the water storage capacity of the Haringvliet will have to be increased to accommodate the expected higher peak flows in the future. To achieve this increase in storage capacity, various interventions are conceivable:

a. increase dike heights along the Haringvliet;
b. move back the dikes;
c. develop an “inter-dike zone” between the current primary flood barrier and the older flood barriers that now run in more or less parallel lines within the diked area (this zone could provide additional water storage capacity, e.g., in Overdiepse polder, only in extreme situations; the inter-dike zone could also serve as a Multilayer Safety Zone);
d. same as c, but with inclusion of more polders within the dikes;
e. linking the Volkerak and Grevelingen for water storage purposes;
f. combinations of e with a through d.

Urban Patterns

The different options for discharge distribution have implications for the ability to develop both existing urban areas, inside as well as outside the dikes, and new urban development plans. Directly on and nearby the Haringvliet, the different variants for the water system offer different possibilities (and also limitations) for a range of urban qualities: The “super dike” notion creates opportunities for housing in (artificial) dunes; the idea of an “inter-dike zone” creates opportunities for recovering lost relationships between the various villages and urban centres with open water (e.g., in Goedereede, Middelharnis and Numansdorp). Furthermore, the possible development of new modes of housing in the overflow zone could be investigated.

The developments possible for Rotterdam and Drechtsteden are highly dependent on the division of roles between the New Waterway and Haringvliet. For the different variants that include a new branch of the Haringvliet, the consequences for Rotterdam and Drechtsteden will therefore need to be continually examined.

Ports & Industry

The choice regarding the water system also implies a choice between maintaining the current unrestricted access to all ports in Rijnmond and Drechtsteden, or instead instituting a differentiation between unlimited access ports and ports that are not directly accessible either during high water events (when a storm surge barrier is closed) or permanently (due to locks).

Agriculture & Fisheries

The options for river discharge distribution also have consequences for agriculture. Will the choice be made to abandon salinization in the New Waterway (important for the Westland region) or instead to maintain the freshwater inflows from the Haringvliet?

The dominance of the Soil & Water subsystem in the area under study might seem to be obvious, since it is a delta region. Yet this finding is largely driven by our selection of the designs analysed, in which water management was a central theme. The actor analysis found that other subsystems are also powerful forces steering the functioning of the delta, such as the port system and the agricultural sector.

6.7 Conclusions of spatial plan analysis based on complex adaptive systems

The analysis of different plans for the Haringvliet and surroundings demonstrates that the treatment of the edges of the delta islands will be particularly important, as contradictions between the interests of the various groupings are especially observed here, and conflicts therefore seem particularly likely to arise. At the same time, the analysis also revealed that opportunities exist for combining interests and synergy.

Using the spatial plan analysis, design proposals from the recent past were drawn on to play a productive role for new regional development. The analysis of the design proposals demonstrates the relationships between solutions in the various subsystems and shows that for some planning problems multiple solutions are possible. This systematic, side-by-side presentation of different design solutions provides the relevant actors in a planning process a view of solutions that may not have been on their radar before. This newfound understanding can contribute to a more rapid synchronization of elements of solutions. Moreover, this knowledge can lead to the conclusion that it is very worthwhile to mobilize actors who had not as yet been involved in the planning process.

Chapter 7

Envisioning for a complex delta

A specialized approach is needed to consolidate a large amount of information and a wide spectrum of different interests into a single, broadly supported strategy for spatial development. Using digital geo-information, such an approach can be achieved in a relatively short period of time. For the Southwest Delta, this led to development of the "Delta Envisioning Support System" (DENVIS).

7.1 Introduction

How can the lessons of the previous chapters be integrated to develop an overall vision of the future that can then be assured of the support of the many people and parties involved?

To this end, a method was developed for establishing a free environment or *"soft space"* which would help designers, scientists, policymakers and stakeholders from the Southwest Delta to develop a shared vision of the region's future. As discussed in Chapter 2, a soft space is an informal forum in which a variety of groups are brought together to identify challenges for a delta region or subregion, to discuss objectives, to explore options and to build relationships. The Delta Envisioning Support System or "DENVIS" is made up of a collage of interrelated social, design and GIS techniques that are employed to support and to stimulate envisioning by actors within the region. All these techniques contribute to integrate the insights on the region gained in the previous steps of the adaptive planning approach.

With DENVIS, the aim is to facilitate development of adaptive, synchronizing and mobilizing visions of the future. *"Adaptive"* means that the visions take sufficient account of the uncertainties associated with many developments foreseen for the region. *"Synchronizing"* means that the visions seek to align the various aspirations and objectives for land use in the region. *"Mobilizing"* refers to the visions' capacity to stimulate regional policymakers and stakeholders to action, encouraging them to take steps to achieve the visions in actual practice. To do this DENVIS builds on experiences gained with comparable methods in the past, such as decision support, serious gaming and design studios, incorporating some elements of these methods as well.

7.2 A history of decision support systems

Decision support, serious gaming and design studios have been employed to support planning for a number of decades now, though the specific methods applied have evolved over time, in line with other changes in planning practices. The first generation of decision support systems was developed in the 1950s and 1960s and emphasized physical systems that evolved in predictable ways. This was consistent with the then-prevailing notion that physical reality was definable and could be engineered to suit any conceivable purpose. In the 1970s and 1980s, emphasis shifted to stimulating and supporting interactions between participants in planning processes. The methods used during this period aimed in particular at encouraging knowledge-sharing among participants in planning processes and reflection on the outcomes of decisions. The methods developed in the 1990s and 2000s brought about a transition to collaborative action and collaborative design.

By this time, experience had shown that for complex tasks it was useful for policymakers to work together in design development, for example, in a design studio. A model thus emerged of collaborative design as a reflexive process (De Jonge, 2009). This is methodology of design-oriented negotiations, which in addition to developing a concrete plan, promotes meaningful changes in participants' ways of thinking. Thus, a new dimension was added: stimulating a reframing while also producing a concrete design result based on shared knowledge.

Methods for stimulating knowledge-sharing have evolved rapidly in recent years. These methods make increasing use of geo-information in combination with decision support systems. Because spatial issues are addressed in planning activities for delta regions, a shared foundation of knowledge based on geographic components is particularly important here (Bregt, 1999). Geo-information systems offer a way to present large amounts of information about a delta in an organized manner that is intuitive and easily accessible to users, resulting in a level playing field among participants with regard to knowledge.

For complex decision tasks, "serious games" have been developed. These are simulations in which participants take part in trial runs of decision processes. The games offer a safe environment in which players can practise taking decisions, while also experiencing the consequences of their decisions and responding to unexpected and undesired outcomes. As such, the players become part of the system, which results in highly interactive and informative relationships both among the players and between players and the physical environment (Van Bilsen, Bekebrede & Mayer, 2010). When playing serious games, participants can feel more at liberty to seek solutions outside the usual avenues, and they learn to cope with complexity. Because the decision exercise is a game, participants experience more freedom to experiment than in real-world planning, and interactions with other players may offer new insights on how they might approach their own role in relation to others. After completion of the game, the players reflect on the results and their experiences. They can then apply these experiences in their regular planning activities.

Over the years, serious games have become increasingly sophisticated, as they have been continually adapted to the changing requirements of decision support (Mayer, 2009). The current generation of serious games is designed to address very complex systems while also enabling players to take future developments into consideration. Some games, for example, are designed to be played based on a variety of different future scenarios. Game leaders then invite participants to take their decisions bearing in mind a specific set of circumstances, dictated by whichever scenario is in play. The effects of decisions taken are then computed and visualized using models.

For the Southwest Delta, too, planners have experimented with serious games. The SimPort-MV2 simulation game was developed for use in strategy development and project management for a large infrastructure project called the Second Maasvlakte (MV2) (involving land reclamation for expanded port activities). The game was played by several teams and in a number of successive rounds. The players provided their inputs via computer, and all decisions were immediately (virtually) implemented and made visible for all players. This particular game was designed to provide insights into the consequences of decisions rather than to find any single "best solution".

Similar methods have been and are being applied within the Delta Programme. For example, workshops have been organized to translate national scenarios for delta development into regional scenarios for the "Rijnmond-Drechtsteden" and "Rivers" sub-programmes, and the Southwest Delta sub-programme did this by organizing an atelier. For the "Coast" sub-programme, the Coastal Quality Atelier developed an approach involving a series of workshops held at various locations within the coastal zone (Coastal Quality Atelier, 2013; Brand, Kersten, Pot & Warmerdam, 2014). Participants at these events represented a range of design organizations, government agencies, NGOs and research institutes. They were given the opportunity to contribute all kinds of ideas. During the workshops, the ideas were visualized using sketched maps. The Rijnmond-Drechtsteden sub-programme (2014) also held meetings on the theme "opportunities and the market". These generated a wide range of ideas on innovations related to flood defences and land-use planning in the region. Furthermore, design studios were organized during the Fifth International Architecture Biennale Rotterdam "Making City" conference. These studios brought together design organizations with various policymakers and other stakeholders as participants in a process of "research by design" to explore the long-term sustainability of the existing flood protection strategy (Boeijenga, Gerretsen & Wieringa, 2013).

DENVIS builds on such practices, but also brings in several new elements. An added value of DENVIS compared to the Delta Programme scenario workshops is that DENVIS participants do more than just discuss ideas: they are also encouraged to use their imagination, which stimulates creativity. Moreover, DENVIS meetings employ a wider variety of inputs than just a limited number of scenarios for the future. A retrospective analysis is also included, as well as an actor analysis and plan analysis. This means that participants are better informed. Compared to the Southwest Delta atelier, DENVIS has the advantage of producing more integrated and better visualized future scenarios for the area (see Chapter 4). Unlike the design studios, DENVIS does not limit itself to exploring continuation of the current strategy for flood protection, but also investigates alternatives based on the objectives of a whole spectrum of organizations and groups in the region. Finally, compared to the other methods discussed above, DENVIS has the advantage of offering support via GIDS. This makes relevant geographic information about the area available to planning participants in an intuitive way, and aids the participants in building up (their contributions to) the design step by step.

7.3 Structure of DENVIS

DENVIS was developed as a means of implementing the soft space concept. As noted earlier, "soft space" is a free environment in which different stakeholders active in design, governance and knowledge come together to identify the challenges facing a delta region or subregion, to discuss their own objectives for the region, to build relationships and the like. A soft space can be established by organizing a series of meetings, preferably held someplace away from the offices of the participating organizations, though within the region being addressed. An external location also stimulates participants to distance

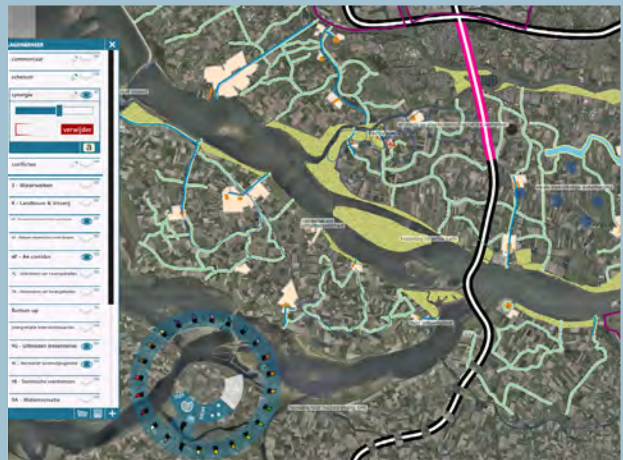


Figure 7.1 Working with intervention maps and drawing overlays on the map table

MAP TABLE

The map table is a touch screen in table form (also called a touch table) made available for the participants to use. At the DENVIS meetings, a map table was used which gave participants access to two types of maps.

1. iMaps provided geographic information on the study area and its surroundings. For each sector, one base map was created which summarized the most relevant information. Underlying each base map was a set of maps presenting relevant geo-data in an intuitive manner and making it digitally accessible.
2. Intervention maps were derived from the current designs and plans that had been proposed for the region, therefore depicting the various different objectives for the area, as well as indicating where there may be synergies or perhaps even conflicts. The intervention maps were also classified by sector and designed for compatibility with the iMaps.

In addition to the digital maps provided via the map table, paper maps were also made available to participants, both wall maps (for participants to consult) and hard copies placed on the tables (to sketch on). Users could therefore overlay several digital maps, combine map layers and then sketch on them (see Figure 7.1).

Use of the touch table required some basic instruction. During the DENVIS meetings, facilitators were available to help participants navigate through the map table. Designers assisted participants in the collaborative design process by visualizing and integrating their ideas on the digital and/or paper maps. They then discussed the results with the participants, afterwards adapting the designs if necessary.

By presenting the region layer by layer, each time showing what was happening in each layer and how it related to the other layers, the participants gradually gained a more in-depth understanding of what was taking place in the region, both as a whole and at different locations within it. In addition, the maps provided a focal point for the generation of ideas, because the area was always visible. Furthermore, because the ideas contributed were recorded on a map, the participants felt that their ideas were really being taken on board. Moreover, the visualization enabled the participants to see whether their ideas fit well together or conflicted with one another instead. Added to this, the visualization stimulated creativity, because it prompted the participants to start thinking not only in words but also in images. An equally important aspect was that the participants developed a shared vision via the map, through which they constructed a "storyline" about the region together. Finally, the visualization exercise enhanced participants' affinity with the region. Because the participants were given a tool to imagine the region in concrete terms, a common commitment emerged to find solutions for the area.

themselves from their day-to-day activities and mindset, and reduces the chance that the proceedings will be dominated by any one of the organizations represented. A meeting location within the region conveys the idea of "here is where it's all happening", said one DENVIS participant. The DENVIS workshops referred to in this chapter focused on the region surrounding the Haringvliet and Hollands Diep and were held in the nearby town of Willemstad.

To successfully integrate aspects of design, governance and knowledge, a process has to be implemented within the soft space that stimulates unexpected encounters, shared understanding and joint design.

Unexpected encounters. Face-to-face meetings with a diversity of people involved in design, governance and knowledge activities in the region will produce unexpected encounters. By bringing together people involved in these different types of activities, a variety of perspectives can be considered and combined, and participants will be challenged to adapt and enrich their views on the delta and the challenges facing the region. Regarding governance, this is a task of more than just government employees; it should involve the business community, civil society organizations and citizen groups as well. To collect knowledge relevant to the delta, universities will be involved as well as planning agencies, consulting firms and other centres of expertise. The design element will bring in designers from urban planning agencies, engineering firms and (landscape) architects. Furthermore, participants will need to be drawn from a variety of other sectors that play or might be able to play a key role in the region. Thus, the DENVIS meetings for the Southwest Delta brought in participants from the Dutch Public Works Department (Rijkswaterstaat), municipalities, the Rotterdam Port Authority, the World Wide Fund for Nature (WWF), the agricultural sector, the recreation industry and a landscape planning organization, among others. External actors also took part, including people knowledgeable about delta regions abroad. They had alternative views and ideas to contribute about the challenges facing the delta and the region's future.

Shared understanding. By exchanging and reflecting on different kinds of knowledge about the delta during the meetings, participants can dispel any distrust they may initially have of one another's expertise and develop a shared foundation of knowledge. The DENVIS methodology devotes extensive attention to this, with presentations of the findings of the historical analysis, future outlooks, the actor analysis and the plan analysis. Via "map tables" these findings are made as available and easily accessible to participants as possible (see Box 7.1). To avoid information overload, the inputs must be provided in a controlled manner. Thus, the results of the analyses are brought into the workshops step by step, each at the appropriate time. Participants are then always given opportunity to, among themselves, select, discuss and process the results that they consider to be important. To ensure that trust is maintained, communication should always be in the form of two-way exchanges: if one participant can convince the others that a different analysis provides a better picture of the area, then the group can decide amongst itself to use those results instead.

Joint design. The shared foundation of knowledge established throughout the process can provide the starting point for participants to discuss their objectives for the area. They also examine together whether those objectives do justice to the region's core qualities and whether they take sufficient consideration of the challenges facing it. Furthermore, the shared foundation of knowledge gives participants a basis for exploring where their objectives are mutually reinforcing (synergy) and where goals might clash (conflict) (see Chapter 2). They also generate ideas together about how objectives might be achieved and conflicts overcome. Finally, participants apply their conclusions to create a shared vision of the desired development of the region.

To ensure that participants are provided sufficient intellectual space during the workshops, it is important for the group to agree on a number of ground rules, for example, that all ideas are welcome, that participants may request others to explain their ideas but they cannot criticize, that ideas must be expressed briefly or that they imagine that participants who might generally be least heard are the first to speak. These rules increase participants' active contributions, enhance mutual trust and stimulate "a flow of ideas" (Dammers et al., 2013).

7.4 Implementation of DENVIS

DENVIS is implemented by organising two meetings within a timeframe of a few weeks. At the meetings, participants are given opportunity to take part in several successive rounds during which unexpected encounters occur, shared understanding develops and joint designing takes place. Each round is introduced by the game leaders, and appropriate inputs and facilitation are provided. DENVIS consists of six rounds:

1. Formulation of core qualities and challenges
2. Identification of objectives, synergies and conflicts
3. Vision development
4. Vision refinement
5. Consideration of governance arrangements
6. Presentation and evaluation

Over the course of these rounds, the participants are given the opportunity to get to know one another, to familiarize themselves with the region and developments influencing the region, and to create one or more shared visions of the region's future. The section below discusses these six rounds in more detail and also examines relevant aspects of preparing the meeting and processing the results.

Preparation

Organizing the workshops requires extensive and thoughtful preparation. This applies to the choice of the focus region, the spatial analysis of it that is done as an input to the workshops, the selection of participants, the choice of workshop location and the design of the process to be followed during the meetings. In the case examined here, choosing a subsection of the delta as the area of interest gave more focus to the work done during the meetings, and made the work more tangible and comprehensible. The IPDD team chose to apply the DENVIS methodology to the region surrounding the Haringvliet. After all, as discussed in Chapters 3, 4 and 6, the Haringvliet is a key area with respect to both river water discharge in the coming years and the future economic and urban development of the metropolis of Rotterdam. It is possible that the Haringvliet will be given a much larger role in the temporary storage and discharge of river water. At the same time, increased pressure is likely to be exerted on this subregion by economic and urban development and shipping and transportation activities. According to the two future outlooks elaborated in Chapter 4 (section 4.3) changes in the Haringvliet are certain to occur. But the nature of the changes foreseen differs depending on which future outlook is being considered.

In addition to *possible* long-term developments, a large number of planning initiatives are currently under consideration for the Haringvliet and Hollands Diep region. These propose new projects associated with nature, recreation and property development. Around the Haringvliet, thus, a pertinent question is how to prevent *possible* long-term, larger-scale developments from getting in the way of the more localized, often smaller-scale planning initiatives under consideration, and vice versa.

The analyses – which were performed for the delta region as a whole – had to be elaborated for the study area and tailored to it. This applied both to the retrospective analysis and the future outlooks, as well as to the actor analysis and the plan analysis. This was done by selecting among the analyses those considered most important for the study area. In addition, the results of these analyses had to be processed in such a way that they could be included on the map tables.

Regarding participant selection, the aspects mentioned above played a role, but potential participants' affinity with the workshops was also important. To gain participants' interest, the game leaders approached candidates personally and discussed with them the benefits of taking part in the exercise.

A further key part of the preparations was designing the process that would take place during the meetings. Not only did the rounds to be played during the workshops have to be prepared, roles and tasks also had to be delegated among facilitators, participants, game designers and map table support staff.

The successive rounds were played by two teams. Working with two teams instead of one has numerous advantages. For example, it allows more people to participate, a greater number and diversity of ideas are produced, and because the teams compete with each other, creativity is stimulated.

Round 1. Formulation of core qualities and challenges: Dynamic land-water relations

The purpose of this round was for the participants to gain insight into the core qualities of the region and the challenges facing it, and for them to reach consensus on these. A core quality encapsulates the essence of the identity and function of an area from the perspective of the participants. A challenge is a problem or task that, according to the participants, the region is or will be facing. The input for this round was a presentation of the results of the retrospective analysis (see Chapter 3). This emphasized the conditions the study area had experienced in the past and the transitions that have occurred in and around it.

After the presentation, the participants were instructed to identify core qualities and challenges, and then to select the most important ones. While they were doing this, the participants could consult the map table to call up geographical information about the study area and the sectors and industries active there.

The main core quality identified, on which large consensus emerged, was the dynamic relationship between land and water. There is a "slow dynamic" of changing relationships between land and water spanning centuries (due to climate change, fluctuating sedimentation patterns and progressive land reclamation) and a "fast dynamic" of changing river water levels and the alternation of rainy and dry periods. The spatial expressions of these different dynamics are evident everywhere in the landscape, in the outlines of the islands with their dikes, mud flats and bands of willow; in the many interior dikes; and in the remnants of coastal inlets. These dynamics and the spatial structures associated with them were identified by all parties as the key core quality of the area: they are decisive for the fertility of the land, for the landscape's unique spatial characteristics and for the many opportunities for ports and shipping – for both recreation and commerce. At the same time, the dynamic relationship between land and water has always been a major problem for the region, due to the frequent flooding and water damage experienced. A major objective of all those concerned was to reduce the flood risk to a minimum in the future. The main challenge is to create enabling conditions for development of the positive aspects of this core quality (land fertility, the unique spatial characteristics and use of water for recreation and commercial shipping), insofar as possible, limiting the negative aspects (flood) to an absolute minimum.

Round 2. Identification of objectives, synergies and conflicts

The goal of the second round was for participants to identify their objectives in the region, to gain an understanding of the objectives of the other participants and to share these amongst themselves. As input for this round, participants received a presentation of the results of the actor analysis (see Chapter 5). This included the most important relationships found between policymakers from the different industries and sectors active in the region.

Participants first specified their own objectives, with a primary question being what bottlenecks and opportunities they felt, from their own perspective, were important to tackle. Afterwards participants identified potential synergies between objectives and any conflicts that they perceived. To help them in this quest, the facilitators provided them, via the map table, intervention maps for all the relevant industries and sectors. These maps were derived from the plan analysis (see Chapter 6). Using the intervention maps, participants could systematically explore where opportunities for synergy could be found and where conflicts were likely to arise. The designers sketched the outcomes of this round on paper, and the game facilitators ensured that the results were digitally "recorded" and saved.

With the approximately 20 participants, two teams were formed. Team I was made up mainly of parties and individuals involved in various local initiatives. Most of these initiatives concerned locations on the outskirts of the Haringvliet – because these areas presented the best opportunities, not only for development of new nature zones and recreational areas but also for connecting existing urban centres with open water (or restoring such connections where they have been lost). Participants observed that these initiatives often got stuck due to the fragmented approach of municipal planning. This had affected numerous proposals, such as plans for the restoration of locks and port channels, nature development, housing construction and water recreation, among which meaningful coordination was often lacking. The team quickly came up with the idea that seeking possible relationships between the projects could ensure greater synergy, coherence and support for the various projects, which should enable the projects to be accomplished more easily. Moreover, with greater synergy, coherence and support, a whole might be achieved greater than the sum of its parts.

Team II was made up mainly of participants representing the Delta Programme and the agricultural sector. This team wanted to investigate the possible consequences of and new conditions created by opening the Haringvliet sluices further and allowing a larger portion of the river water to be discharged through the Haringvliet. This would result in greater tidal movement in the Haringvliet, and its waters would also become to a large extent brackish. Because tidal movement would be reduced in the Spui and Dordtse Kil rivers, the substantial erosion occurring here, and the corresponding risk of unstable dikes, could be brought to a halt.

Round 3. Vision development: Spatial concepts

The objective of the third round was for participants to jointly develop a vision of the future development of the area. As input for this round, the participants were given a presentation on future outlooks (see Chapter 4). This presentation gave them insight into the key social and physical developments that may affect the region and the challenges that these might pose for the area. Examples are the possible rise in sea level and the challenges this entails in terms of flood defences and salinization of agricultural lands. In communicating the future outlooks, it is important that they are elaborated in sufficiently specific terms for the region under study, using words, images and statistics (see section 4.3).

The vision of the region's future builds on the core qualities, the challenges and the objectives identified earlier. Participants came up with ideas for the future vision and discussed these with each other. The discussion leaders ensured that the game's ground rules were observed (see section 7.3). In addition, they encouraged participants to break free of entrenched thought patterns and practices, for example, by first letting them brainstorm existing ideas and then continuing on from there to probe for new ideas, in light of the future outlooks presented. The facilitators provided, via the map tables, geo-information both at participants' request and at their own initiative. Ideas for the vision could be sketched either on paper or on the map table. In the latter case, designers and/or participants could sketch on the intervention maps.

Team I came up with the idea to identify a "spatial envelope" for a zone on the outskirts of the Haringvliet and institute a governance arrangement for it. The envelope would offer development space for recreation, housing and nature as well as opportunities for strengthening the relationship between existing residential areas and the waters of the Haringvliet and maintaining the level of municipal services. The governance arrangement proposed was a "Regional Land-Water Fund for the Haringvliet", which could be managed by the most relevant policymakers and stakeholders. Depending on the nature of the proposals submitted and on the enthusiasm for them, the Fund and with it the envelope could be further developed step by step.

Team II elaborated a vision involving the gradual opening of the Haringvliet sluices in a series of steps, during which the parties involved would continually respond to the observed reduction of erosion and the effects of the sluice opening on nature and the freshwater supply. If continued opening of the sluices is observed to have positive effects on the environment and water quality, while posing few problems for the area's farmers, the sluices may be opened a bit further.

If this turns out to be the case, then another planning regime and another water management plan are possible. Storage of freshwater in ditches, creeks and the soil can then be increased. Cultivation of saline crops for food and energy production could reduce farmers' dependence on freshwater. Precision agriculture could also play an important role, as GPS-controlled applications of water and nutrients can enable farmers to very efficiently manage the freshwater available. Because this requires rectangular plots, the unused edges can be employed for purposes of nature, landscape and small-scale water storage.

Along the periphery of the Haringvliet, there are opportunities for energy generation. For example, wind turbine development has been proposed on the southern edge of the Hoeksche Waard (a delta island), tidal energy generation is possible at the Haringvliet dam and biomass energy can be produced on farmlands. This vision further considers the transitions between land and water to offer valuable opportunities for development of recreational zones and housing. New developments in this zone bring opportunities to strengthen the relationship between the existing urban areas and the Haringvliet. Revenues earned from initiatives such as those in the field of energy generation could be reinvested in the region via a regional fund, for example, to benefit nature and the landscape. In this way, a "green" business model would be created.

Round 4. Vision refinement

The objective of the fourth round was to further elaborate the visions and gather supporting materials. The main input for this round was qualitative feedback provided by an expert panel. The feedback related to the extent that the visions took a number of aspects into account: (1) the uncertainty surrounding the evolution of developments set to affect the region in the future (adaptive); (2) the influence of the various sectors and industries on one another (synchronizing); and (3) the extent to which the visions were administratively and socially feasible (mobilizing). That last aspect refers not so much to support (passive involvement), but rather to commitment (active involvement).

Based on the feedback, the participants further refined and justified their visions. The game leaders asked them to do so considering different time scales, different geographical scales and the differing values and viewpoints among actors. The approach taken in this fourth round was very similar to that of the third round.

Round 5. Consideration of governance arrangements

The aim of this round was, in addition to developing the substantive future visions of the region under study (design), to also develop process-oriented visions (of governance arrangements) to achieve the visions developed. The input for this round was a short presentation about potential new governance arrangements that could be employed, such as a public-private trading company or tradable development rights. With the substantive vision in mind, the participants brainstormed on the measures that should be taken to achieve the vision, the organizational forms that would therefore be required, the organizations and groups that could play an active role and so on. The participants began by generating as many ideas as possible for governance arrangements, and then selecting those that they considered most promising and that they could imagine themselves playing a role in, individually or as an organization.

The most concrete option came from Team I: the regional fund already mentioned in which the various parties form an alliance to jointly bear the costs and share the benefits of developing the zone on the outskirts of the Haringvliet.

Round 6. Presentation and evaluation

In the final round, the participants presented their results, the game leaders looked back with the participants on the workshops and they looked forward to possible follow-up activities. During this round, each team had the opportunity to share their results with the other team and with the expert panel. Both the participants and the experts responded to the results presented and made suggestions for further adjustments and refinement. This was done according to the CAS concepts of *adaptivity, synchronization* and *mobilization*.

In addition, the game leaders, participants and facilitators together evaluated the process followed in the meetings. In doing so, they examined both the

Figure 7.2 Identifying objectives, synergies and conflicts

Figure 7.3 Contributing ideas for envisioning

Figure 7.4 Regional vision: Sustainable media

- Freshwater canal
- Strengthen creek system (water storage, ecology and recreation)
- Decision on sluice opening
- Large-scale nourishments
- Outside dike zone
- Inter-dike zone (recreation, housing, energy)
- Search area for wind turbine development
- Tidal power station
- Quality improvement port areas
- Recreation water route
- Commercial shipping route
- Enhancement of town-water relationship
- New residential environments
- Collaboration ports (Rotterdam, Moerdijk)
- Reallocation agriculture (saline, small-scale, regular, GPS)

Figure 7.5 Governance arrangement

- Regional fund Haringvliet
- Local initiatives

Figure 7.6 Regional vision: Freshwater supply

- Freshwater buffering (low-lying polders and streams)
- Freshwater canal
- Freshwater inflow from the Biesbosch National Park
- pd Water level-controlled drainage
- Large-scale nourishments
- Outside dike zone
- Inter-dike zone (multi-level safety)
- Saline agriculture

Figure 7.7 Water perspective

- Decision on sluice opening
- Inflow of saltwater
- Inflow of freshwater via Lek River

overall structure and the individual rounds. They also discussed and listed key points that should be retained and ideas for improvements.

The workshop ended with a discussion of possible follow-up. This was done by discussing as a group opportunities and potentials for cooperation, for example, via a Community of Research and Practice (CORP). A CORP usually lasts several years and is characterized by interpersonal contacts among participants alternated with communication via Internet (see section 2.6). Through a CORP, participants of the meetings can discuss the further development of the visions and the steps to be taken towards the implementation of the vision, while also involving other relevant policymakers and stakeholders with an interest in the area or a desire to be involved. In this way, a CORP can stimulate collaborative action.

Processing the results

As usual with workshop or atelier-like events, the DENVIS meetings for the Southwest Delta produced fairly global results, and some outcomes were riper than others (Dammers et al., 2013). For optimum results, it is therefore important to process and elaborate the results after completion of the meetings. In this case, several designers were called upon to edit the substantive visions, and several policy researchers did the same for the more process-oriented results. The products of this adaptation were subsequently presented to a number of participants for review. The following section describes and illustrates the outcomes achieved by the DENVIS meetings. Chapter 8 is devoted to the action perspective in the delta that was developed based in part on these results.

7.5 In conclusion: Results of DENVIS

The participants at the meetings perceived the dual focus on both a substantive and a process-oriented vision of the region as important and innovative. The substantive designs were made more feasible and practical by the attention devoted to governance arrangements. As such, the participants worked on "plans that work".

How can the visions be evaluated in terms of adaptation, synchronization and mobilization? The vision developed by team I can be labelled adaptive, as it establishes a spatial framework in which initiatives are bundled. Initiatives will be undertaken or further developed in response to or in anticipation of events such as sea level rise and changes in land uses and freshwater supply. The vision can thus be adapted to changing circumstances. A question remains, however, regarding the link between the initiatives and the long-term challenges facing the region. The vision developed by team II is adaptive in one sense, but not in another. This vision embodies a long-term perspective on the area. By gradually opening the Haringvliet sluices wider in a step-by-step procedure, changes will occur over time in the freshwater supply that will make other types of nature and recreation activities possible. These changes can be continually adjusted or even halted. But this advantage is offset by the single-track

line of reasoning employed: the shifting of the freshwater inlet. If the inlet is not moved, then the other components of this vision lose their meaning.
In terms of adaptivity, it may be interesting to look at a combination of both visions. What would happen if team I's "envelope" of short-term initiatives is linked with the long-term vision of team II? The idea to combine both views is discussed further in Chapter 8, in which an action perspective towards a robust adaptive framework is discussed.

Team I's vision also contributes to synchronization, because the grouping of initiatives in a spatial envelope promotes alignment of interests and sectors. Yet at the same time, the space allowed for diverse local initiatives carries a risk that one initiative may be realized to the detriment of another. The administrators of the regional fund would be responsible for ensuring that this does not happen. Team II's vision similarly contributes to synchronization, because in gradually opening the Haringvliet sluices and changing the water discharge, consideration must be given to the risk of further salinization of agricultural lands. It is precisely for this reason that the sluices are to be opened gradually, step by step. In addition, the team explored, for example, what (precision) agriculture might mean for nature and the landscape. Other aspects, such as patterns of urbanization, shipping and transport networks and energy networks were not considered.

The extent that team I's vision contributes to the mobilization of policymakers and stakeholders in the region is dependent on various factors. Some of these are the character of the initiatives that are developed, the enthusiasm – or perhaps resistance – these initiatives invoke and the extent that the regional fund has sufficient resources to support them. Team II's vision could have a mobilizing effect because, first, it offers a long-term perspective and, second, it assumes an implementation process that proceeds gradually, step by step. The long-term perspective could inspire enthusiasm among policymakers and stakeholders in the region, while possible resistance to the vision could be counteracted by the vision's gradual implementation and monitoring of its effects.

Figuur 7.8 Presentation and discussion of results

The DENVIS meetings contributed in various ways to the integration of design, governance and knowledge. To begin with, the composition of the teams promoted integration. After all, policymakers and stakeholders worked under the guidance of a facilitator collaboratively with designers and experts in the field of geo-information. In addition, the limited size of the teams promoted integration. This is because it encouraged intensive and personal contacts and exchanges of ideas, in which all participants took active part. It is important that all relevant sectors be represented in the teams. Furthermore, the process used promoted integration. Indeed, the participants were explicitly instructed to develop substantive visions on the desired conditions of the region (designing), combined with process-oriented visions (governance arrangements) and supported by geo-information. Furthermore, the techniques employed contributed to integration. The map tables were particularly effective here because in addition to making relevant geographic information available, they also offered participants the opportunity to sketch. Despite the contributions of DENVIS, there are opportunities for developing the methodology further.

Though DENVIS added value on a number of aspects, there is still scope for enhancement of the approach. For example, more attention could be paid to attracting (potential) participants to take part in the meetings. Indeed, participation from a variety of sectors is crucial for the meetings' success. Interest could be heightened by clearly communicating the DENVIS goals and methodology and by emphasizing the benefits of taking part for those involved in the meetings. In addition, the meetings could be spread out more over time, for example, with a half day devoted to each round, and the rounds organized over a period of several months. This would not only allow the participants more time for each round, but also contribute more to a process of collective learning (Dammers & Hajer, 2011). In such a way, DENVIS would also form an easier stepping stone to a Community of Research and Practice (CORP).

Further, improvements could be made in working with the map table, for example, by providing quantitative feedback on the participants' designs. Quantitative feedback would enable participants to see at a glance how their design scores on particular criteria and to revise their plans accordingly on the spot. This would require development of an interface (dashboard) that quantifies the main effects of virtual interventions in the region under study. Moreover, the visualization of the region via the map tables could be further developed. This might be done by using the map tables to display not only different maps of the region, but also photographs of the conditions at different locations. This would enable participants to more concretely imagine the issues at stake in various places within the region.

As noted in the introduction, DENVIS was tested within the IPDD, and the methodology will be further developed in one or more subsequent projects. This will offer more frequent opportunities for organizing a "soft space" in which diverse policymakers and stakeholders establish a common understanding of a region and jointly develop a vision of the area for the future. It will also offer opportunities to realize the aforementioned improvements of the method.

Chapter 8

An action perspective for the delta

How can an action perspective be formulated for a complex adaptive system like a delta? This chapter addresses this question in both spatial and governance terms. The spatial dimension is elaborated in the form of a Robust Adaptive Framework (RAF). The corresponding governance dimension is elaborated in the form of adaptive delta governance. The action perspective discussed here specifically targets land-water transitions in the Southwest Delta.

8.1 Introduction

An action perspective translates the objectives formulated in a vision into concrete actions geared towards implementation. This enables solutions to multiple components of a planning problem to be synchronized and mobilizes relevant actors to take action. This is a major challenge in spatial planning processes. Interests at the local level and short-term objectives are often difficult to reconcile with objectives at higher scale levels, which often apply a longer-term time horizon. A crucial aspect of an effective action perspective is therefore that the spatial vision be anchored in appropriate governance arrangements.

An action perspective for complex adaptive systems should contribute to both the robustness and the adaptive capacity of a region. Robustness concerns safeguarding the basic interests of a region and its actors over the long term. Adaptivity relates to the system's ability to respond flexibly to unforeseen changes. Robustness of the region is the goal, while adaptivity is the means to ensure fulfilment of that goal over the long term.

Formulation of an action perspective is preceded by the steps of conceptualization and envisioning. The previous chapters introduced the main building blocks of these steps for our action perspective concerning land-water transitions. These were the retrospective analysis (Chapter 3), the study of possible futures for the system (Chapter 4), the actor analysis (Chapter 5) and the plan analysis (Chapter 6). These building blocks will furthermore be placed in their national and international context in the next chapter (Chapter 9).

8.2 Spatial dimension

Based on these building blocks, a framework for spatial development in the Southwest Delta was created that can be characterized as both robust and adaptive. This "Robust Adaptive Framework" (RAF) builds to a considerable extent on the conceptual framework underlying the Room for the River programme (Sijmons, 1991). At the same time, the RAF constitutes an important addition to that conceptual framework.

Room for the River

A central principle of our conceptual framework is that subsystems with the slowest and at the same time also the most determinative dynamics should be guaranteed space over the very long term. In the case of the "Room for the River" programme, this meant securing adequate space over the long term for peak river discharges and new nature development. Peak discharges increase at a very slow pace, but the plans being made to accommodate these is a fundamental aspect of land-use planning in the entire riverine region.

Currently the rivers can safely handle peak discharges of 15,000 m^3 per second (measured at Lobith); the "Room for the River" programme assumes that by 2050 peak discharges of 18,000 m^3 per second will be reached and have to be planned for. To adjust river capacities to accommodate these increased flows, riverbeds are being widened and flood bypasses and retention basins built. With these measures, parallel contributions are also being made to a second low-dynamic system component: the ecosystem. New gradual land-water transitions are being created that provide important habitat areas for numerous plants and animals. Essential for achievement of this goal is the infrastructure of the Flood Defences subsystem: (new or relocated) dikes, ditches and dams, which must be sufficiently robust to ensure that the rivers get the space they need, that biodiversity can increase and at the same time that the land protected by the dikes remains dry and safe far into the future. This hydraulic infrastructure in fact forms the essence of the robustness framework of the Room for the River programme. In identifying the main characteristics of the Room for the River framework, sufficient allowance had to be left for adaptation to local conditions. Where cities are situated along the rivers in particular, but also in various rural areas, substantial efforts had to be made to formulate the framework in such a way that local initiatives for new developments or preservation of houses and farms could be accommodated – with improvement of spatial quality in the riverine region as a key consideration in all of this (Room for the River Quality Team, 2012). River guidelines were published setting out a number of rules of thumb for ensuring robustness and spatial quality in implementing the framework, while also providing leeway for flexible responses to specific local needs and conditions (Rijkswaterstaat, HKV Lijn in Water, Arcadis & Met Andere Woorden, 2007).

The Room for the River programme framework can be considered to some extent adaptive, because it can be adjusted to various local conditions not foreseen at the time the framework was adopted.

Uncertainty in the Southwest Delta

In application of this approach to a region like the Southwest Delta, however, there is a further complicating factor. The high-water level and water quality in the estuaries, where the rivers and sea meet, are highly uncertain. This is true for the riverine area as well: the peak discharge of the rivers, though conservatively calculated at 18,000 m^3 per second, remains an approximation which could still be adjusted in the near future and perhaps ultimately estimated at a higher level (Kok & Hoekstra, 2008). The same uncertainty applies to sea level rise in the future. The latest IPCC report employs a bandwidth of possible sea level rises up to 2100 ranging from some 55 cm to 130 cm (IPCC, 2014).

These two uncertainties converge in the delta region. Moreover, another uncertainty has to be added to these: the possibility that current estuary closures, such as the Haringvliet dam, might be opened, which would lead to changes in the ecosystem. Yet another uncertain factor is the frequency of use and reliability of the Europort barrier (made up of the Maeslant and Hartel storm surge barriers). Closure of these barriers has major impacts, for example, on water levels in and around the Haringvliet.

The worst case scenario for the delta region is a prolonged period of peak river discharge combined with sustained storm tides at sea, meaning that river waters could not be discharged into the sea and would have to be stored within the delta region for an extended period. As a result, the delta region could experience extremely high water levels in the future, beyond those levels for which the existing hydraulic infrastructure system was designed. The exact height of future water levels that could result from this combination of circumstances cannot be determined with certainty. This means that the planning framework for the delta will have to be designed as adaptive not only with regard to local development initiatives in the short term, but also with respect to the water-retention capacity of the estuaries in the longer term. Furthermore, the system must be adaptive in relation to possible modification of the freshwater-saltwater balance in the river mouths, and the possible development of gradual transitions between open water and land.

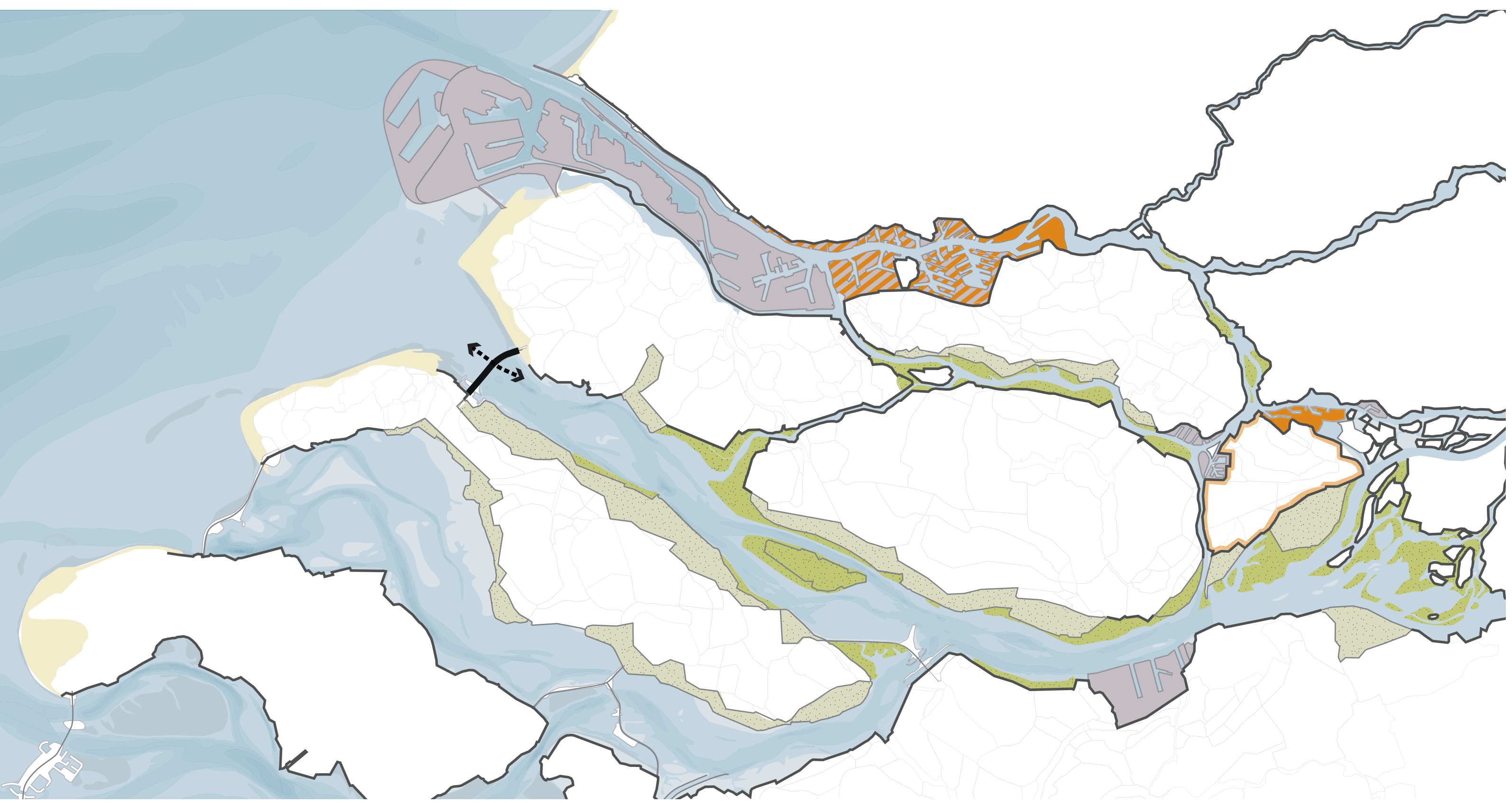
The framework required for a region like the Southwest Delta therefore should not only allow adaptivity regarding regional developments in the relatively short term, as in the Room for the River programme, but it must also be adaptive itself, in the sense that it can be adjusted as new insights emerge on possible water levels.

Room for the River is a 10-year programme (2005–2015) with links to current local development initiatives and anticipating on possible changes up to the year 2050. The Southwest Delta requires a framework that can be adjusted to accommodate developments beyond 2050, that can be combined with new local and regional development initiatives, and that can respond to the still uncertain and unknown changes in water levels up to 2100. It not only has to meet robustness requirements similar to those of Room for the River, but again, it also must be adaptive itself.

Towards a Robust Adaptive Framework

Findings from the building block analyses indicate that the various land-water transitions play a particularly important role as a central hub of a Robust Adaptive Framework (RAF) for the Southwest Delta (Figure 8.1 and Figure 8.2). They offer the opportunity to make use of a structure that has evolved over centuries and to give that structure new significance. They were also found to offer a key focal point for the various actors. These zones “between dikes” are ideally suited for water-related regional development. Landowners, municipal governments and water boards could decide in joint consultations to make the area between the dikes wetter. At the same time, the zone as a whole could respond adaptively in multiple ways to the water situation as it evolves in the future: by raising the current primary flood barrier, by raising and reinforcing the current secondary flood barrier, by designating the inter-dike zone as a temporary water storage area, or by some combination of these option. Figure 8.3 elaborates in more detail on how these zones could contribute to increase the water storage capacity of the Haringvliet and Hollands Diep. A number of design options are possible for the inter-dike zones (Figure 8.3):

Figure 8.1 The Robust Adaptive Framework (RAF), composed of outer-dike nature areas, inter-dike zones, harbour areas outside the dikes and outer-dike urban areas



- The water in the inter-dike zone could be connected with the outer dike waters via a culvert only (as was done in the "Tureluur" plan for nature restoration on the island of Schouwen in Zeeland).
- A coupure with a sluice could be added to the primary barrier. This would offer the potential to build new marinas behind the main flood barrier. These marinas would be accessible from open water under normal circumstances, but the sluice could be closed in the event of extremely high waters. This situation in fact is already found in the region, for example, in the ports at Numansdorp, Middelharnis, Ooltgensplaat and Oude Tonge.
- The older secondary barrier could be reinforced and "promoted" to primary barrier. This situation is also already present, for example, in the Crezee polder along the river North.
- Like the inter-dike zones along the Haringvliet and Hollands Diep, the zones outside the dikes in urban areas of Rotterdam and in the surrounding municipalities could be considered part of the RAF. These outer-dike zones have been heightened via nourishments (varying from 3.5 m to 6 m above sea level) and contribute to protection of the hinterland beyond. To increase the safety of the outer-dike zones themselves, multiple options that could be considered within the parameters set by the Rijnmond-Drechtsteden delta sub-programme, such as large-scale nourishments, adaptive building (e.g., floating buildings) and construction of a new main barrier on the seaward side. The choice preferred between these three options could differ per development location.
- Summarizing, the Rijnmond-Drechtsteden region can be said for the most part, especially where lands outside the dikes and between the dikes have been raised, to have a solid framework that is robust from a flood safety point of view, and that is also adaptive in the sense that the framework allows flexibility for various types of land use and can be adapted in multiple ways to future changes in water levels.

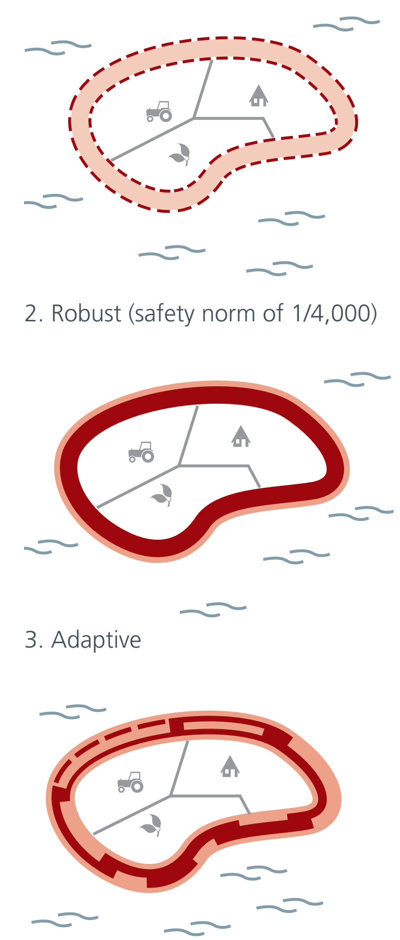


Figure 8.2 RAF – concept

8.3 Governance dimension

The action perspective has, in addition to the spatial dimension, a governance dimension. Adaptive delta governance is an approach and means to bring uncertainties about future socio-economic and climatic developments to bear, transparently and interactively, in decision-making on spatial developments in the delta. In this respect, the concept of adaptive delta *governance* differs from the concept of adaptive delta *management* used in the Delta Programme. "Management" assumes a hierarchical relationship, in which a central and higher-ranking actor takes the decisions on adaptive measures and development paths. The concept of "governance" instead implies that decision-making takes place in consensus and cooperation, with the various actors having more or less horizontal relationships with one another and reaching decisions about adaptive measures consensually and collaboratively. Choices, for example, about the adaptive development paths to take, are not made by a higher-level actor (e.g., the Delta Commissioner), but are a product of an interactive

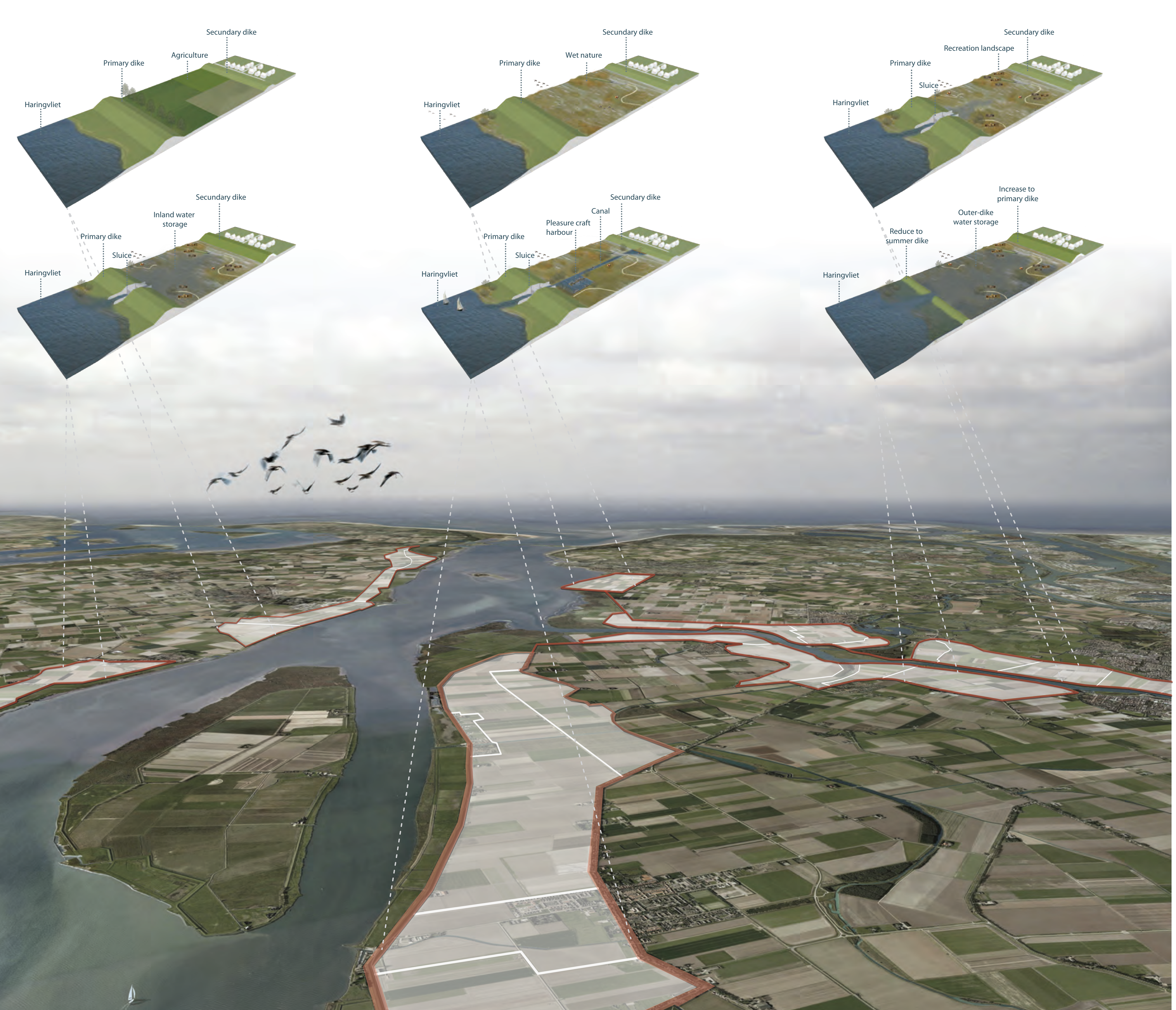


Figure 8.3 Robust Adaptive Framework (RAF), zooming in on the Haringvliet and surroundings: Multiple design options for the zones between the current primary and secondary water barriers (cross-sections)

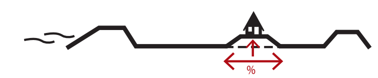
SPATIAL PRINCIPLES

1. Raising the primary dike

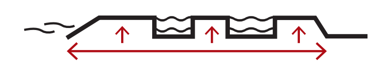
2. Raising the secondary dike

3. Moving back the dike

4. Limited building on mounds *(terpen)*

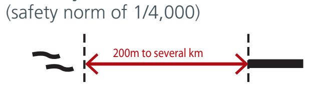


5. Large-scale nourishments – (former) harbours



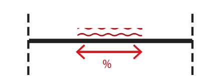
DESIGN PARAMETERS

1. Primary water barrier zone
(safety norm of 1/4,000)



2. Responding on time (1–100 years)

3. Sufficient space for water %



4. Stimulating activity

5. Comprehensive regional development

6. Functions resistant to flooding

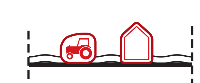
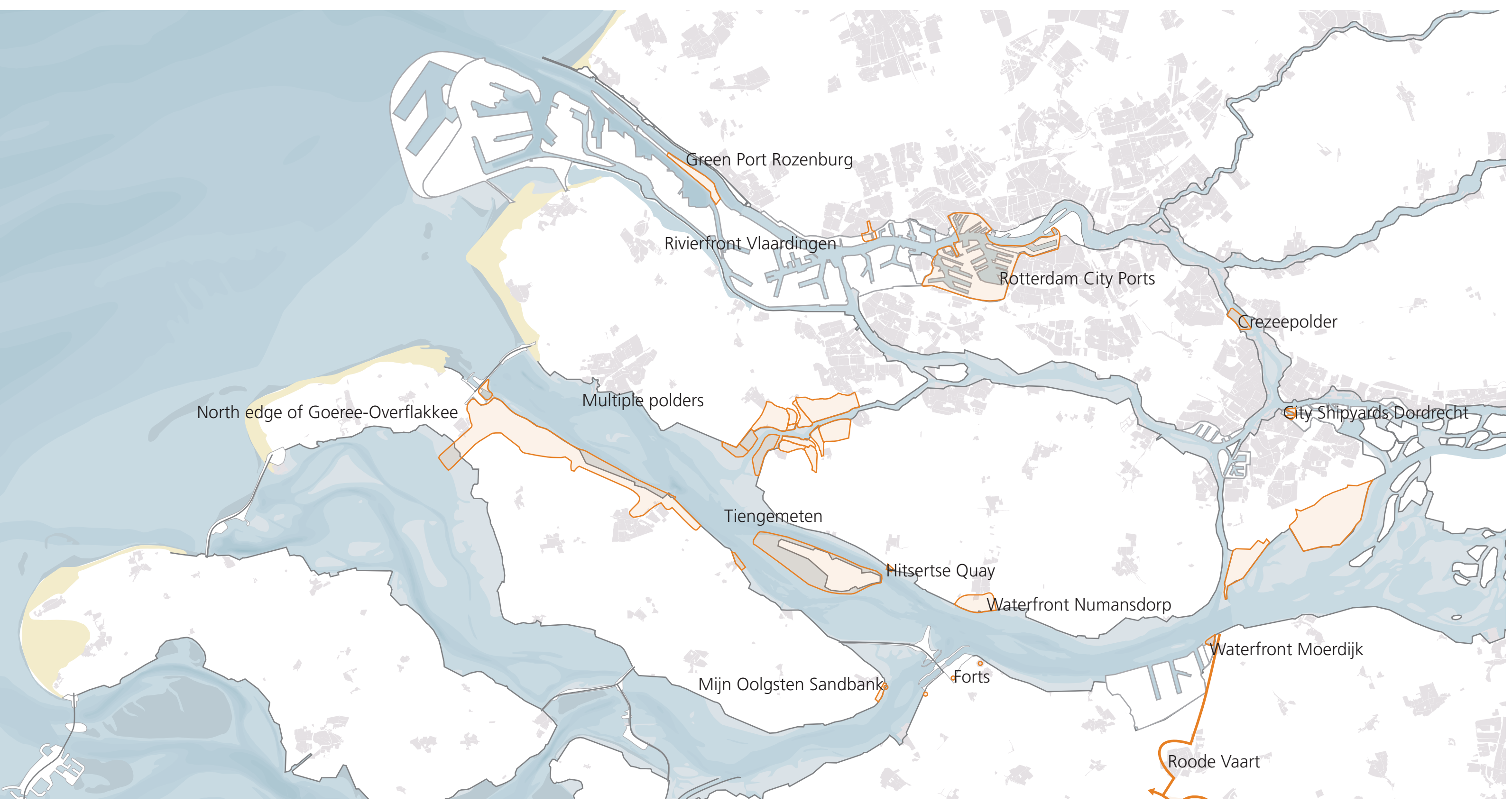


Figure 8.4 Local initiatives

Local initiative



process involving interdependent actors (local, regional and national) within a complex socio-ecological system. This governance principle has been central in the IPDD project.

With adaptive delta governance, two overall goals are pursued: increasing system robustness and increasing system flexibility (see also Van Rhee, 2012). System robustness refers to the ability of a system to continue to perform as desired under diverse and changing circumstances. System flexibility refers to the ability of a system to, at low or no additional cost, deliver different performance when required to do so by a changing situation or circumstances.

Mix of interests and governance forms

This is not to say that hierarchy is absent or obsolete in adaptive delta governance. What is most likely to be observed in actual practice in complex deltas is a mixture of various governance forms, including steering based on hierarchical principles, networks and the market. In academic literature as well, the relevance and importance of mixed forms of governance and principles of control are increasingly recognized, especially when achievement of results is important. Continuously steering towards interaction, participation and consultation tends to produce inertia; over-emphasis on hierarchical top-down control has the disadvantage of driving parties to dig in their heels, leading to resistance, delays and postponements of implementation.

Several categories of interests can be distinguished, the first of which relates to the essential values of delta systems, such as flood protection. These values, in terms such as standards of flood protection, can be specified at the national level (by the Ministry of Infrastructure and Environment) and monitored regionally (by Rijkswaterstaat and water boards). Our second category is defined as collective interests, such as nature, environment, sustainability and ecology. These interests are publicly discussed and defined. The third category is that of private interests, such as property developers and business people seeking to establish recreational facilities. Between these, different “blends” of governance emerge, with central government steering combined with collective steering via networks and self-steering via market forces or initiatives from within society.

Adaptive delta governance similarly requires a mixture of hierarchical steering, network steering and self-steering. This type of steering is then also aimed at creating enabling conditions to make such smart combinations of steering models possible. Thus, combinations of two of the three types of steering may be observed, and even all three forms together, depending on what the central task is in a particular situation.

An important precondition for adaptive delta governance is that actors start from broad systems-based definitions of the delta region. Chapter 5 discussed how these can be achieved. From there, work focused on mapping and implementing opportunities to couple measures in the domain of flood protection with spatial development and management. This was done through continued exploration of the investment agendas of various public and private parties and linking them with one another. The power of informal networks played a

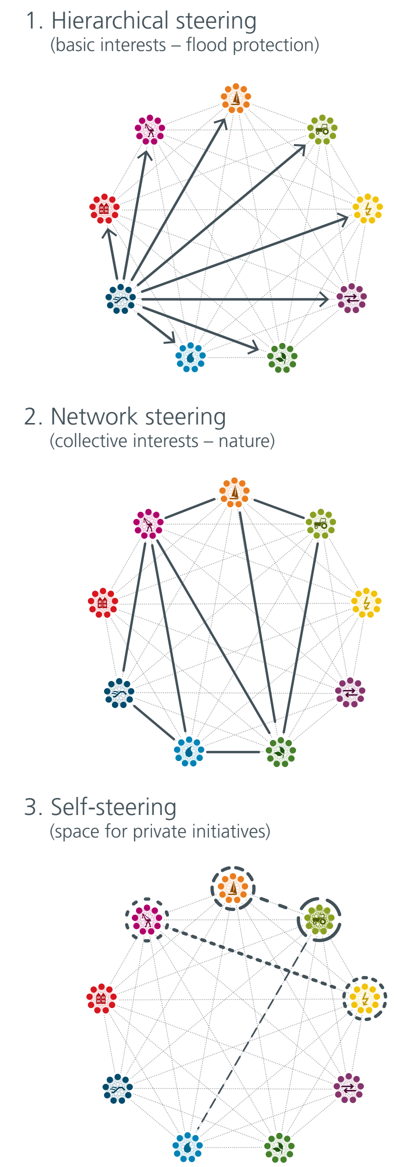


Figure 8.5 Adaptive governance

substantial role here. Participants in such networks experience greater mental space and are more open and receptive towards other actors. A relaxed and confidence-inspiring atmosphere is created in which people are more likely to think and act outside their usual boundaries (and those of their organization, discipline or industry). In such situations, integrative regional concepts are more likely to be developed, implemented and maintained. Such informal arrangements are strongly preferred over formal decision-making structures which limit room for manoeuvre, and where discussion and decision-making take place mainly along lines of formal positions, authorities and responsibilities.

The quest for lively informal processes is highly suited to the "Development 3.0" trend, in which regional development is not supply-driven, but rather demand-driven instead. This type of regional development is increasingly based on initiatives of private parties, such as market parties, citizens and NGOs. New developments are then responses to actual demands (from the market, residents, etc.) and are no longer in the first place derived from supply-driven initiatives (e.g., a municipality with a plan for a piece of land). Furthermore, they are not focused on property development alone, but also consider the overall development of the region, steering based not only on economic values such as land and development profits, infrastructure, mobility and employment, but also on social values like sustainability, regional quality, climate, energy, health, ambience and identity. In addition, regional development is viewed through a longer-term lens, meaning that management becomes an integral part of development.

Finally, new business and financing models have emerged from more informal and demand-driven regional development processes. Parties involved in sustainable development of a region commit themselves to the region for a longer period of time, meaning that returns are also stretched out over a longer period. These new returns come not only from property development, but also from creation of other values, such as renewable energy, clean air, organic food, nature and landscape development, recreation, etc. Flexible financing structures arise based, for example, on "cash in–cash out" principles (Sorel et al., 2014). This means that development of public services closely follows the development initiatives of market parties and individuals within the region. As such, major investments can be avoided, and public services are established only when there is real demand for them. In the Netherlands, the (draft) Environment and Planning Act emphasizes this type of financing. Another principle is "the owner, not the developer, should pay". Services are not established until they are needed. Those who benefit from them, would then pay the costs. Both established developers and parties new to development would cover such costs, for example, through a combination of cost recovery via land development and a betterment tax. Moreover, the principle of "letting public services be established by private parties" can be followed. According to this funding principle, a municipality would not be obliged to establish services itself, but can leave this to project initiators within the region. Project initiators then become largely responsible for the establishment of services that elsewhere are often provided by governments.

The replacement decision as an instrument in adaptive delta governance

Elaborated in real terms, these basic principles and aspects of adaptive delta governance imply that standards for flood protection would be set at the national level. It would then be up to the region to decide how these flood safety levels can be realized in a specific region and local setting. This "leaving it to the region", however, is not done freely and without conditions or restrictions. To give new flood safety standards a degree of firmness, some type of assurance will be needed. At the same time, the directions in which solutions can be pursued are left flexible, and up to the region to decide. The region would explore possible measures for fulfilling the norms – applying the principle of multi-layer protection, nationally-mandated flood safety standards and spatial development and evacuation requirements – thus determining what mix of measures would be most effective.

In this process, the "replacement decision" instrument, as applied in the Room for the River programme, can be used. The replacement decision utilizes a mix of hierarchical and network governance modes. Basically, the parties mandated to ensure flood safety are given the opportunity to indicate how they propose to meet the standards. At the same time, regional parties have the chance to develop bottom-up initiatives and plans of their own (which will likely be more geared towards creating opportunities for regional spatial and economic development), and to link these with measures to keep the delta safe from the threat of flooding. The plans initially proposed are then "replaced" by the plans derived at the regional level.

Towards adaptive development paths and temporary planning permissions

An important element of adaptive delta governance is collaboratively developing and deciding on the development paths to be taken. Adaptive delta governance brings into focus options for the long term (beyond 2050) that are of influence on the mix of measures introduced in the short and medium term, and vice versa. By implementing measures that are temporary ("no-regret") and short-term oriented, steps forward can continue to be taken while at the same time opportunities are created for continued learning about uncertainties and investigating/exploring new (innovative) possibilities. These "no-regret" designs and ventures are not decreed from above (e.g., by the Delta Commissioner). Rather, they are the outcome of a process of joint consultation with regional partners.

In the short term, for example, "no regret" measures can be implemented, with temporary or interim planning permissions given for them. Such temporary or provisional zoning reflects a relatively new spatial planning concept, centred on flexibility in both time and space. Provisional and temporary zoning is ideally suited for areas with changing functions, high dynamics, climate adaptation and transition zones in which the nature and extent of developments are unknown and no final vision for the area is yet known or certain. Temporary and provisional zoning gives an area a useful function, while keeping it available in the longer term for future – often as yet uncertain – functions.

8.4 Pilot projects and adaptive monitoring

Adaptive delta governance and realization of a spatially adaptive framework require starting with a few pilot projects and an adaptive monitoring programme which can generate up-to-date knowledge and information (Lindenmayer and Likens, 2010). New decisions and measures can then be taken based on the information and knowledge produced. Operating in this way enables "hand on the tap" management. An example of such an adaptive monitoring system is that used in drilling for natural gas in the Wadden Sea to determine whether gas drillings have unacceptable impacts on nature and the environment and whether adjustments are needed in the drilling programme. A key aspect of such adaptive monitoring is that it must contribute to the ability to make such adjustments. This requires that the structure and process of the monitoring programme be shared among the stakeholders; otherwise the knowledge and information that comes out of it are unlikely to be used as the basis for adjustments. A monitoring programme, in other words, aims to generate reflexivity and learning that are then applied to change and adjust course.

Monitoring goals

Broadly speaking, three main purposes can be distinguished for establishing an adaptive monitoring programme: monitoring for accountability, monitoring for development and monitoring for knowledge (Grus Castelein, Crompvoets, Overduin, Van Loenen, Groenestijn, Rajabifard & Bregt, 2011).

In monitoring for accountability, the collection of data on predetermined targets plays an important role. This type of monitoring is popular in situations characterized by strong hierarchical relationships between the actors involved. This type of monitoring is often seen linked to EU directives. After a particular directive has been adopted, EU member states are required to set up a monitoring programme which prepares and submits periodic reports to Brussels. Upon failure to meet the targets agreed, some type of sanction usually follows in the form of a reprimand or even a fine. However, setting up this type of monitoring is seldom popular among the authorities concerned, except those at the top of the hierarchy. If external pressure on these programmes weakens even slightly, they often grind to a halt. Accountability is the main aim of many of these types of monitoring programmes.

The second purpose of monitoring is for development. Here, systematic information is collected in order to keep close tabs on how a system is developing, the goal being to make timely adjustments. In this type of monitoring the relationships between the actors involved play a much smaller role. Support for this type of monitoring programme is generally large. Because the information gathered does not lead to immediate sanctions among actors, willingness to share information from this type of monitoring is great. The information collected by Statistics Netherlands, for example, can be considered monitoring for development data.

Knowledge is the third purpose for establishing a monitoring programme. This form of monitoring is usually set up with a scientific objective in mind. Science seeks to increase its knowledge about the functioning of a particular system and starts a programme of periodic monitoring of that system. The use of satellites to track changes in glaciers is an example of monitoring for knowledge. These types of programmes are usually set up with great enthusiasm, but are much more difficult to continue over many years. When research budgets dry up, interest in the monitoring programme often shrivels as well.
In practice, combined forms of these various types of monitoring programmes are often observed. The relevant questions that follow are what monitoring activities are important in the context of adaptive planning in the delta and how can they be realized.

Community of Research and Practice (CORP)

As this book went to press, talks were under way concerning various locations in the Haringvliet region that could serve as pilot projects for this approach. The research institutions involved (universities, Deltares, the Netherlands Environmental Assessment Agency) and actors (municipal and provincial governments, property developers, environmental organizations, water boards, the Dutch Public Works Department (Rijkswaterstaat) and others) had together formed a Community of Research and Practice (CORP) to monitor progress and results of interventions at pilot sites, and to discuss them and make necessary adjustments. In such a community, parties can learn from each other and the pilot projects can be considered test cases for policy and implementation to be refined.

The actors within the system also develop adaptive behaviour, based on information about the system and their own performance. This has consequences for the establishment and operation of a monitoring programme:

- The variables to be monitored should be chosen by joint consultation among stakeholders. In doing so, in addition to choosing the variables to be monitored it is also important to reach agreements about spatial and temporal resolutions. It is not necessary for consensus to be reached on the variables used. Each of the subsystems involved has its own objective and the appropriate variables will correspond with these.
- How the variables are to be measured will then need to be determined. In the past, new monitoring networks were generally established for this purpose. That is often no longer necessary, as much data is already being collected. The work in this step is then mainly to select data sources that can provide the information required.
- Insights from monitoring are periodically shared with all stakeholders. The practice of combining such information with opportunities for discussion has particular influence on the adaptive behaviour of actors.

The monitoring programme itself must be adaptive too. That means the variables used should not be set in stone, but rather should evolve along with technological developments and changes in the region.

Chapter 9

International perspective

In other urban delta regions of the world, including the deltas of the Mississippi, the Mekong and the Elbe, similar quests are under way for manners to combine uncertainties about the longer term – for example, changes in water levels and rates of urban and economic development – with short-term interventions and projects. Approaching urban deltas as complex adaptive systems has proven relevant for these deltas too.

9.1 Introduction

This chapter examines the relevance of approaching urbanized deltas elsewhere in the world as complex adaptive systems. Its particular focus is on the following questions:

1. To what extent can we gain new insights by approaching other urbanized deltas as complex adaptive systems? Do other delta regions of the world also show evidence of a succession of periods of relative equilibrium alternated with periods in which transitions occur? How can the current period be characterized in these other delta regions: as a period of equilibrium or one of transition? Could an adaptive planning process – characterized by adaptivity, synchronization and mobilization – be relevant to these other delta regions too?
2. Could a closer examination of current practices and the history of these other delta regions provide new insights for the Dutch situation?

Method and structure of the chapter

The Dutch Southwest Delta is compared with three other delta regions: the Mekong Delta (Vietnam), the Mississippi River Delta (USA) and the Elbe Estuary (Germany). Dutch partners have been involved in exchanges and/or collaborations with all three of these delta regions, which is a major reason for our focus on them here. A second reason is that they represent completely different types of delta systems, in terms of geomorphology (the substratum) as well as with respect to spatial patterns and land use.

To facilitate the comparison with the Southwest Delta of the Netherlands, three research methods were applied. First, the physical and spatial status of the four delta regions were compared, using map comparisons and data analysis. Although different methods of data collection and notation were used in each country and in each delta region, conversion of these various data via GIS (geographic information system) enabled systematic map and data comparisons. These comparisons were mainly possible for the current situation in the delta regions. Use of the GIS-based method is considerably more difficult, if not impossible, for comparisons of historical situations, due to the lack of data that can reliably be converted in GIS.

Comparison of the current situations in the delta regions followed the same method as described in Chapter 2. Key features of the deltas and data on the various delta subsystems were identified and visualized, and the subsystems were furthermore clustered according the three "layers" introduced in Chapter 2 (base layer, network layer and occupation layer).

Through application of this method, map images were produced along with other graphical materials and explanatory texts presenting the key defining features of each subsystem and each layer of the delta regions under study. The relationships between the layers were also observed, as well as the physical and spatial differences and similarities between the delta regions.

The second research method involved analysis of the historical evolution of the delta regions as complex adaptive systems, according to the same method as applied and described earlier in this book for the Dutch Southwest Delta (Chapter 3). For each delta region, literature and historical maps served as resources for determining the extent that the various regions had known different periods of “dynamic equilibrium” alternated with “critical transitions”. This procedure is analogous to the retrospective analysis of the Southwest Delta presented in Chapter 3.

Finally, we investigated what the critical factors might be in the present time, which may or may not induce reinforcement of or change in the delta’s adaptive capacity. In addition, the development plans and proposals currently under consideration for each delta region were analysed to provide an indication of whether evidence is already found of some extent of adaptive planning, which could strengthen the adaptive capacity of the deltas.

The final section returns to the general questions posed in the introduction and draws conclusions.

9.2 Four urbanized deltas

Characterization of the deltas

Compared with the Southwest Delta of the Netherlands, the three foreign deltas exhibit a number of different characteristics, arising from their different physical features and different socio-economic contexts.

In physical terms, following Bradshaw and Weaver (1995), deltas can be categorized as “fluvial dominated”, “wave dominated” or “tide dominated” (see Figure 9.1). The Mississippi River Delta is an example of a fluvial dominated delta, in which the formative power of the river, with inflows of huge amounts of sediment, is the dominant force. The other two foreign deltas are similar to the Dutch Southwest Delta in that tidal flows and waves emanating from the sea play a much larger role in the process of land formation. The Elbe Estuary is closest to the Dutch delta, both literally and in terms of physical features. Both are located in the extensive Northwest European lowlands, formed by a series of rivers – from the Elbe down to and including the Scheldt. While the Mekong Delta is also situated on a “delta plain” very similar to the Northwest European lowlands, it is radically different from the Dutch delta in terms of both land use and socio-economic characteristics.

The three foreign deltas were compared with the Dutch Southwest Delta using the following parameters: (1) substratum (water system, soil composition, climate, nature and ecology), (2) networks (infrastructure for water management and flood protection and for transport and traffic) and (3) land use (agriculture, ports and industry, and urbanization; income derived from land measured by GDP).

When comparing the four delta regions, the first most noticeable difference is in the rivers’ lengths, water discharges and amounts of sediment transported (Figure 9.2). The rivers of the Dutch Southwest Delta (the Rhine, Meuse and Scheldt) and the Elbe are rather modest – both in length and in terms of water discharges and sediment transport. Looking only at these

features their significance pales in comparison to “mighty giants” such as the Mississippi and the Mekong rivers. Nearly eight times more water flows through the Mississippi on average than through the three rivers of the Rhine, Meuse and Scheldt combined, and sediment transport in the Mississippi is more than 90 times that of the three rivers in the Dutch Southwest Delta combined. The Mekong is more modest than the Mississippi in both aspects (volume discharge and sediment), but still impressive compared with the European rivers. The quantities of water and sediment carried by all of the rivers has changed over the years, in part due to changes in natural conditions (increased precipitation) and in part due to human interventions such as energy generation, damming and channelling, which have mainly served to reduce the amounts of sediment to finally reach the deltas. These volumes nonetheless remain considerable, especially in rivers like the Mississippi and Mekong. This means that large quantities of material are still supplied from which land can be formed.

A second important physical difference concerns the climate, especially annual amounts of rainfall. In this regard too, the Mississippi River Delta and the Mekong Delta represent the more extreme situations compared to the European deltas. In both non-European deltas, annual precipitation is more than three times greater than in the Netherlands. Added to this, precipitation in the Mississippi and Mekong deltas is typically much more intense, occurring in the form of severe and prolonged rains that may also be accompanied by hurricanes or typhoons. The natural and climatic conditions of the Dutch delta can therefore be regarded as relatively modest and calm. This is perhaps a reason why, in the Dutch delta in particular, intensive and urbanized land use arose early on.

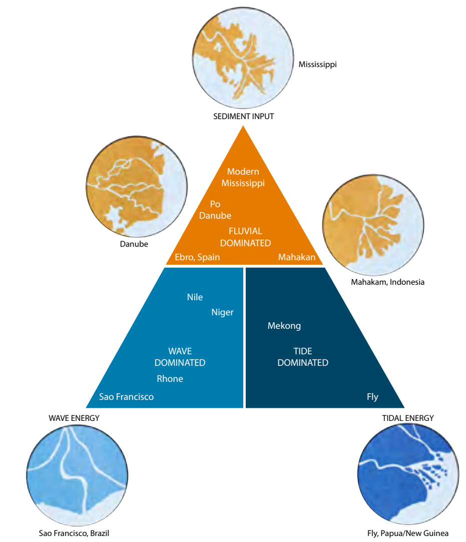


Figure 9.1 Delta typology based on natural morphogenetic characteristics: Wave energy, sediment transport and accretion and tidal energy (Bradshaw & Weaver, 1995)

9.3 Mississippi River Delta (USA)

The Mississippi River Delta is an entirely different type of delta region than the Southwest Delta. As noted, while the Dutch delta is largely shaped by the natural forces of the sea (currents, tides and wave action), the river is the dominant formative power in the Mississippi River Delta. The enormous quantities of water that flow through this river also transport large amounts of sediment, which through the centuries have settled at the river mouth in the usually quiet and shallow waters of the Gulf of Mexico. This has produced a vast marsh landscape at the river mouth with the largest expanse of mangrove forest in the world.

Three periods can be distinguished in the urban development of the Mississippi River Delta.

1. From a colonial trading post to a major port of access to the USA: Eighteenth to mid-nineteenth century

In the marsh landscape of the delta, a centuries-long process of recurrent flooding and sediment transport and accretion resulted in natural levees along the riverbanks. It was on these levees that the first colonial settlements

Figure 9.2 Comparison of four urbanized deltas: Substratum and urban patterns (top), agricultural land (middle) and traffic networks (below)

Mississippi River Delta USA | **RSM Delta** Netherlands | **Mekong Delta** Vietnam | **Elbe Estuary** Germany

Urban settlements

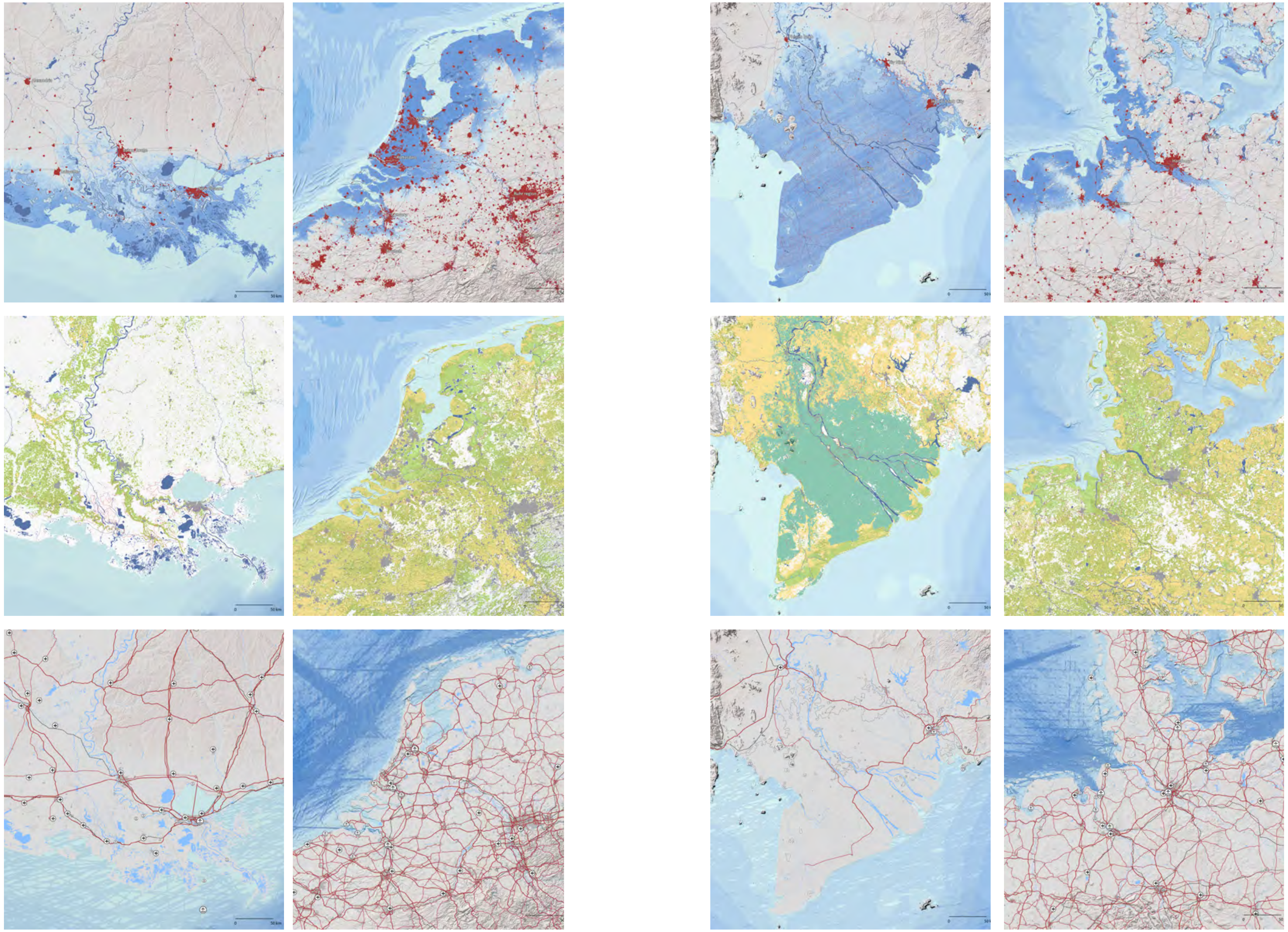
- Urban area
- Network
- Land lower than 10 meter MSL
- 5 metre MSL contour line
- Inland water body

Agricultural land use

- Post-flooding or irrigated croplands
- Cropland
- Mosaic cropland
- Mosaic pasture
- Meadow
- 5 metre MSL contour line
- Urban areas
- Inland water body

Transportation networks

- Highway
- Major road
- Local road
- Ferry
- Railway
- Airport
- Harbour (symbol size indicates harbour size)
- Intensity of commercial shipping
- 5 metre MSL contour line
- Urban areas
- Inland water body



Data characteristics compared

Missisippi River Delta

Missisippi	
Length (km)	5,900
Basin Area (10^3 km²)	3,300
Average discharge, Q (m³/s)	15,540
Sediment load, Qs (Mt/yr)	210

RSM Delta

Rhine	
Length (km)	1,400
Basin Area (10^3 km²)	220
Average discharge, Q (m³/s)	2,200
Sediment load, Qs (Mt/yr)	0.07
Meuse	
Length (km)	920
Basin Area (10^3 km²)	36
Average discharge, Q (m³/s)	320
Sediment load, Qs (Mt/yr)	0.70
Scheldt	
Length (km)	430
Basin Area (10^3 km²)	22
Average discharge, Q (m³/s)	190
Sediment load, Qs (Mt/yr)	0.75

Mekong Delta

Mekong	
Length (km)	4,800
Basin Area (10^3 km²)	800
Average discharge, Q (m³/s)	14,800
Sediment load, Qs (Mt/yr)	110 - 150

Elbe Estuary

Elbe	
Length (km)	1,100
Basin Area (10^3 km²)	150
Average discharge, Q (m³/s)	760 - 868
Sediment load, Qs (Mt/yr)	0.84

Based on data from Milliman and Farnsworth, 2013; Wohl, 2007; Tockner et al., 2009; Rijkswaterstaat, 2013

Figure 9.3 Rijn-Meus-Scheldt Delta

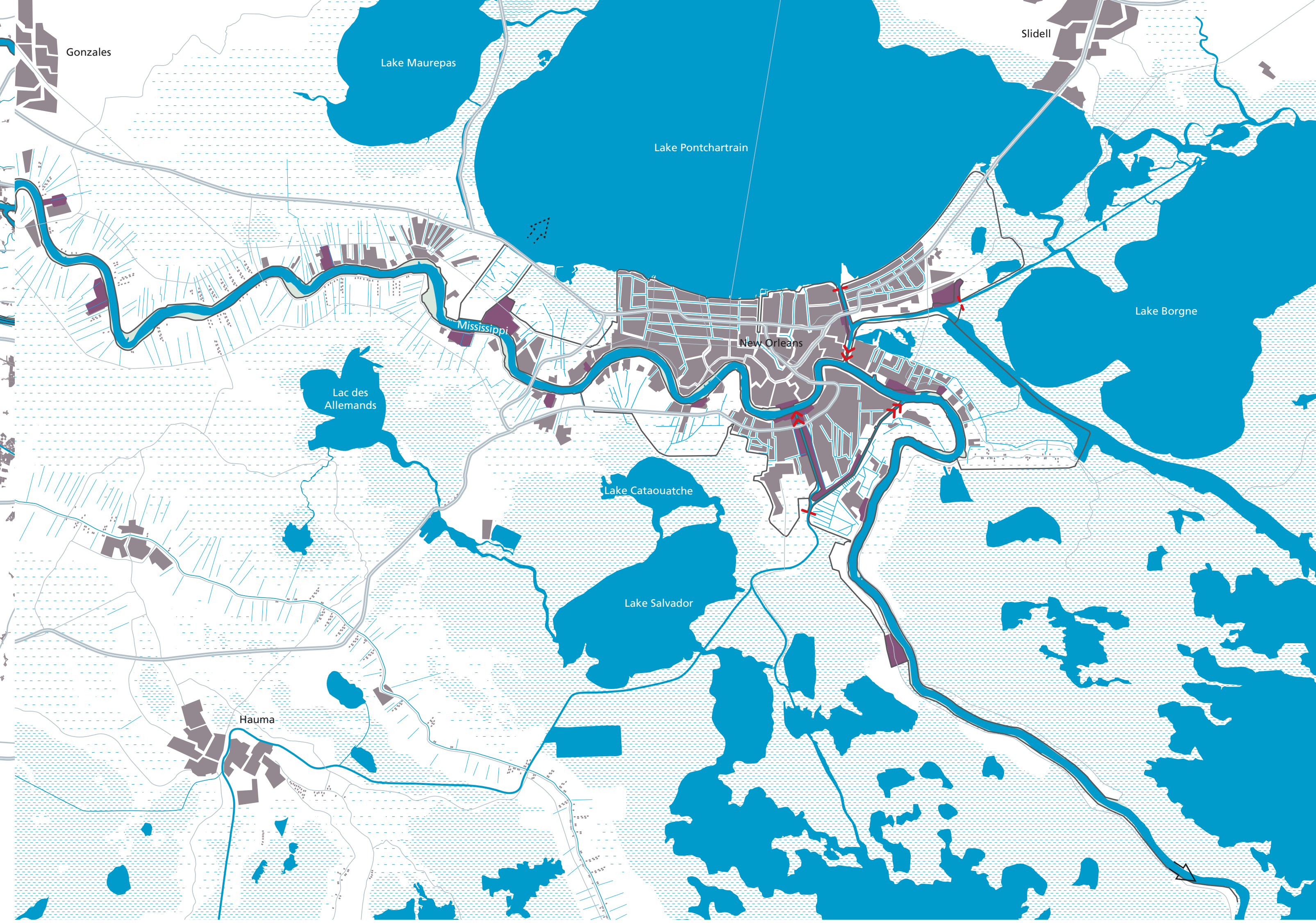
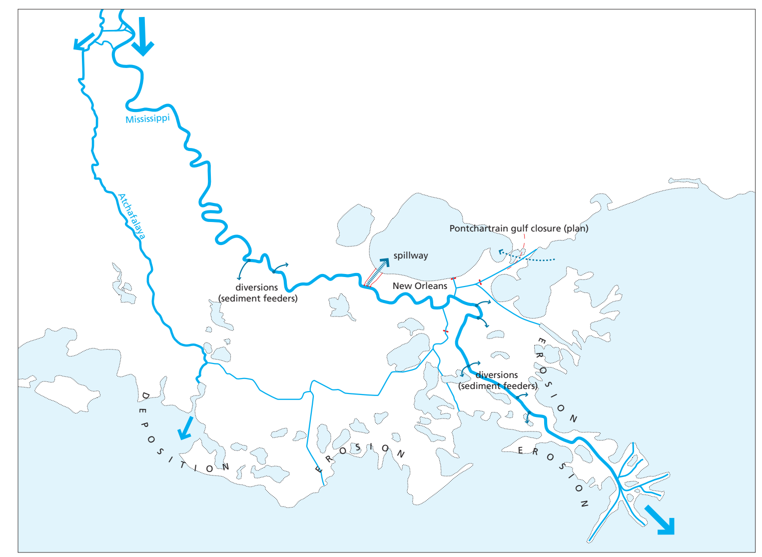


Figure 9.4 Mississippi River Delta



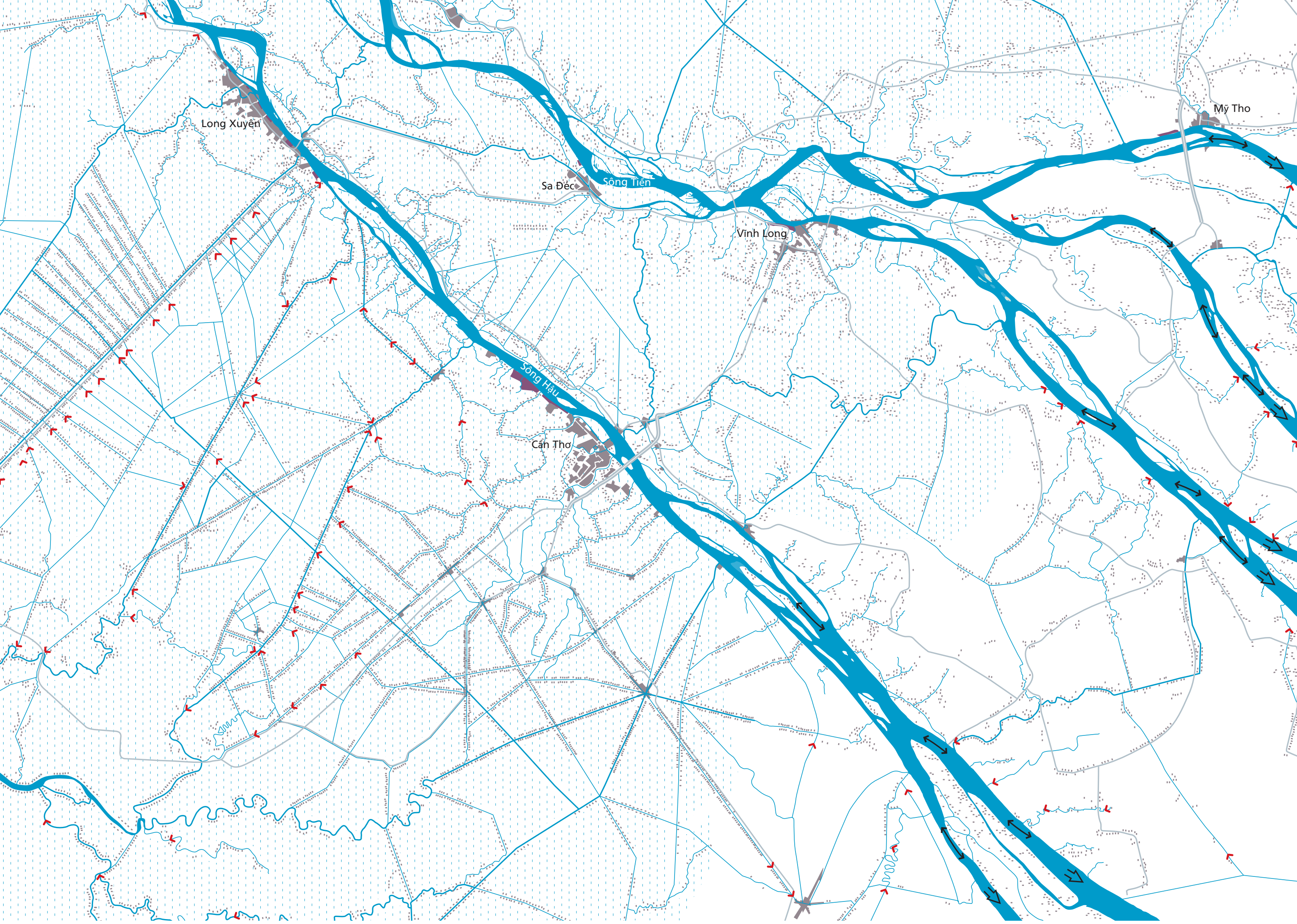
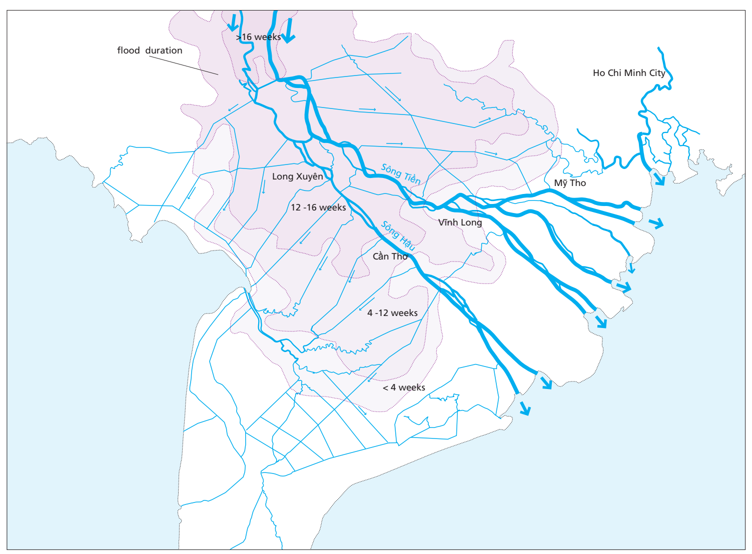


Figure 9.5 Mekong Delta



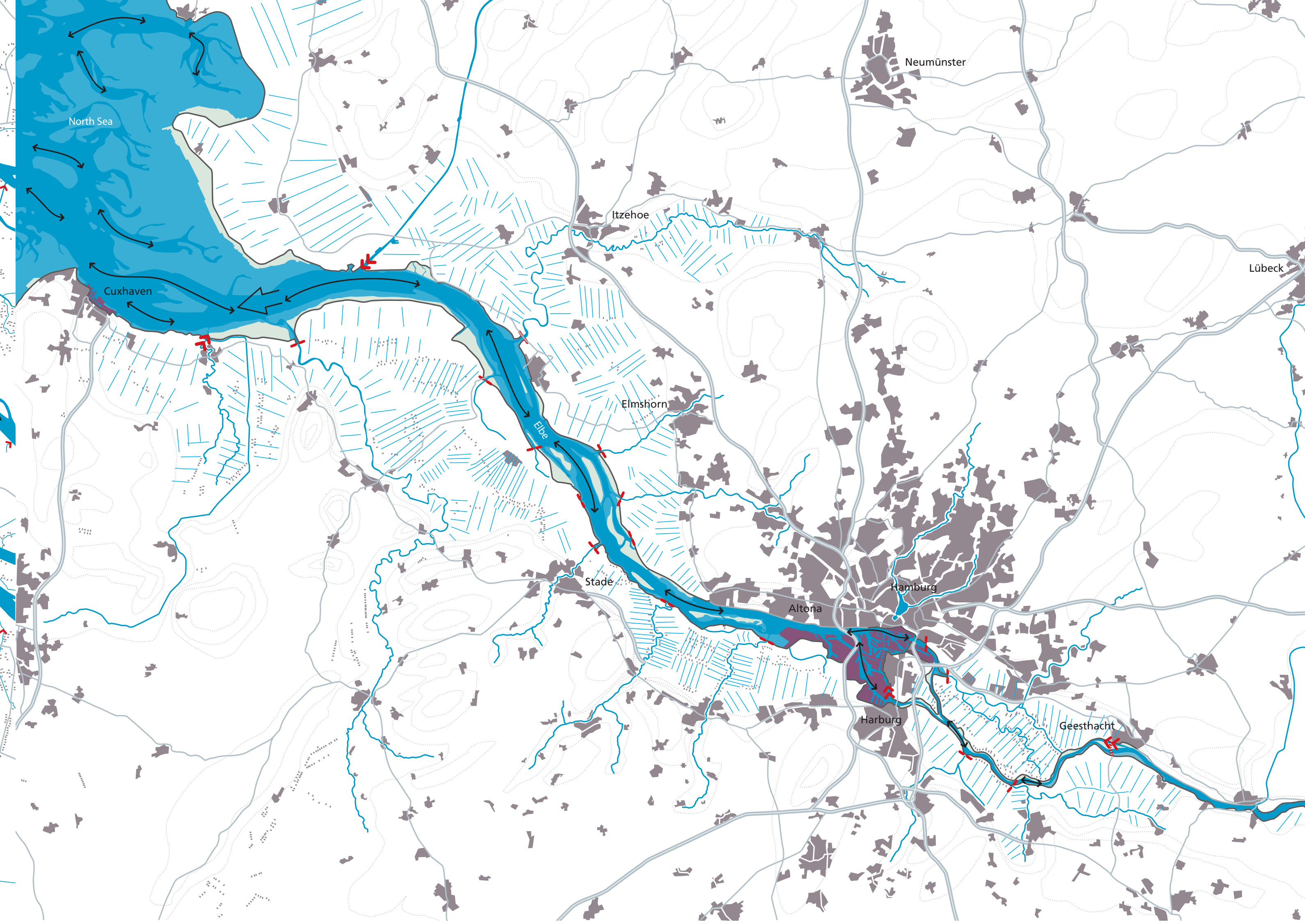


Figure 9.6 Elbe Estuary

and plantations were established in the eighteenth century. New Orleans was also established in the early eighteenth century, by the French, on a levee of the Mississippi – a higher narrow ledge amid a vast expanse of wetlands. Via Bayou St. John this location was also accessible from the more northern Lake Pontchartrain, which also provided access to open sea.

In addition to being a centre for the cotton and sugarcane trade, New Orleans was initially the main gateway to the USA. The catchment area of the Mississippi, including all its arms and tributaries, covers some 60% of the territory of the USA. This made the Mississippi the country's foremost transport artery with New Orleans as its largest transhipment port. Although the opening of the Erie Canal in 1825 enabled New York to assume this role of "main port" in the following decades, New Orleans remained an important harbour and grew rapidly in the nineteenth century.

Given the national importance of the Mississippi as a central transport artery, the US Army Corps of Engineers (USACE) took on an important role in the river's management (Barry, 1997; O'Neill, 2006). Dikes were constructed to improve the river's navigability, but these also led to an increased risk of flooding in the regions downstream.

As the city experienced increasing pressure from the growing population, plantations made way for new urban expansions. This process continued until the late nineteenth century. Urbanization patterns thus followed the outlines of the former plantations, which had also been established on the levees, on elongated plots perpendicular to the river (Figure 9.8).

Figure 9.7 Mississippi River Delta: Water system

2. New Orleans: A fortified city on an eroding delta

The relationship between urban expansion and natural conditions changed drastically after the late nineteenth century. Thanks to the invention of the "wood screw pump" in 1913, it now became technically possible to drain the swampy marshes and prepare the drained areas for urbanization. This draining of the marshes introduced a phase of large-scale suburban development between the levees and Lake Pontchartrain. Together with the subsidence caused by drainage of the marshes, this meant that most of the urbanized Greater New Orleans region was now situated below sea level. A central feature of the drainage system was formed by several outfall canals with an open connection to Lake Pontchartrain and built with tall concrete floodwalls. These walls formed metres-high barriers separating the urban areas on either side of the canals.

Vulnerability to flooding was also increased by the river policy of the USACE and by infrastructure for oil and gas extraction in the Gulf of Mexico. USACE river policy anticipated canalization of almost the entire course of the Mississippi River. This could produce not only very high water levels downstream, even without unusually high discharges, but it also meant that the marshes and mangrove forests in the delta would no longer be provided a regular supply of sediment and freshwater and therefore would diminish and die. At the same time, massive oil and natural gas drilling in the Gulf of Mexico led to subsidence of the sea floor. Combined, these processes have caused the loss of more than 5,000 km^2 of marshland since 1930 (Campanella, 2014).

This erosion of the delta has major consequences for the safety of New Orleans, given that foredelta vegetation greatly dampens the force of hurricanes. As this dampening effect diminishes, hurricane forces over the City of New Orleans become more and more severe. To protect New Orleans, with its subsiding soil, higher river levels and eroding delta, from flooding, the USACE has surrounded the city with a ring of barriers. This "fortification", however, has a breach risk of 1:100, and includes a number of very vulnerable elements, such as the open outfall canals mentioned earlier and the Inner Harbor Navigation Canal, in New Orleans East, which is also directly connected to open sea. In this respect, it was only a question of time before the city would be hit by a fatal flood. This happened in 2005 with Hurricane Katrina, which put 60% of the city under water and in which more than 1500 people lost their lives.

3. Stimulus for adaptive planning

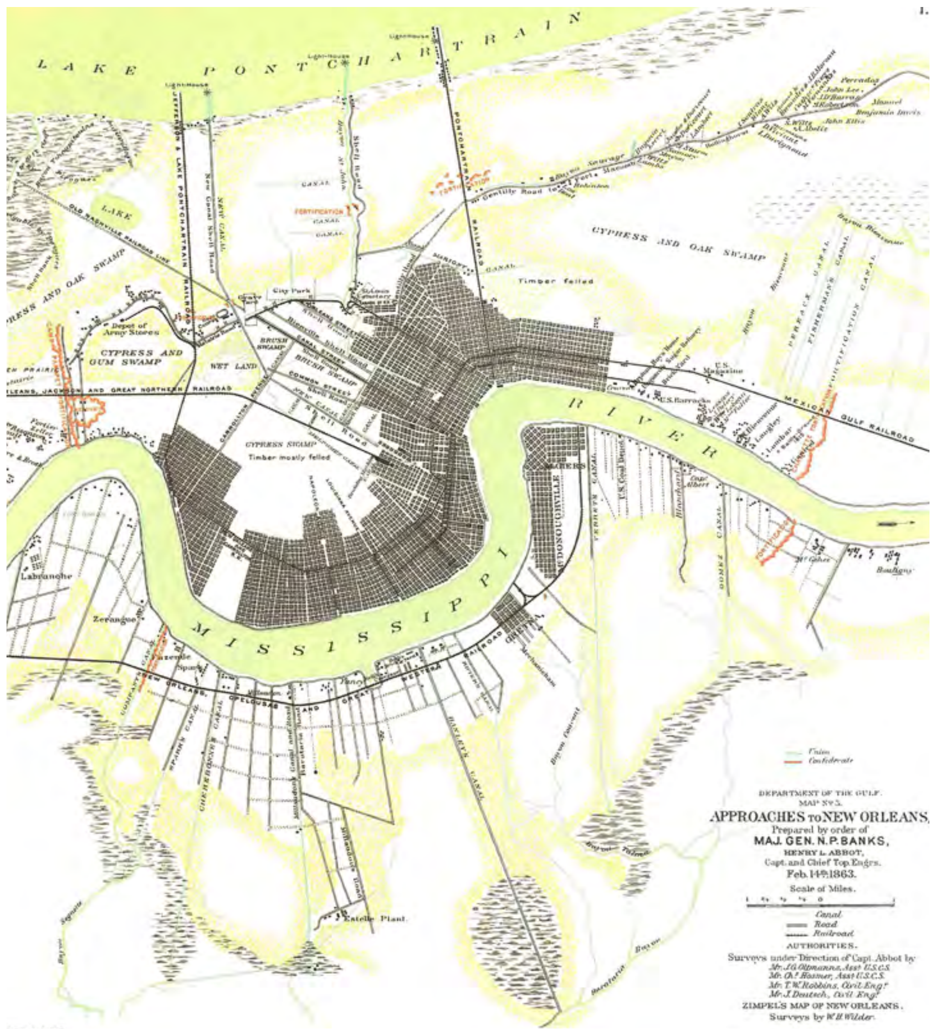
Following the devastating effects of Hurricane Katrina, initiatives for improved flood defences for the City of New Orleans got under way on three levels.

First, the USACE took measures not only to repair the "Fortress New Orleans" flood barriers, but also to construct a number of new storm surge barriers for crucial and vulnerable places, such as in the Inner Harbor Navigation Canal and in the mouths of the outfall canals (Figure 9.7). The breach risk of the flood protection system nonetheless remained at 1:100.

The second initiative concerned the action of a number of citizens, led by New Orleans-based architect David Waggonner, to develop an entirely new plan for water management in the urbanized Greater New Orleans region. Waggonner and his associates perceived the massive destruction that had struck New Orleans with Hurricane Katrina as motivation to fundamentally re-examine the relationship between the city's spatial planning structure and the water management system. Waggonner and associates assembled a team of Dutch and US designers, engineers and scientists who, initially working independently from the responsible authorities and formal institutions, studied and discussed the situation in a series of workshops entitled "Dutch Dialogues" (Meyer, Morris & Waggonner, 2010). While the team continued to function independently of the formal institutions, the results of each workshop were nonetheless always shared and discussed with these institutions, including city administrators, "Greater New Orleans Inc." (a regional economic development alliance), Louisiana's then state senator (democrat Mary Landrieu), the New Orleans Water Board, and USACE, as well as community organizations, NGOs and academics from local universities.

Gradually bonds of trust grew between the Dutch Dialogues team and the formal institutional infrastructure of New Orleans. With that increasing trust, more data was made available, providing a more substantial basis for the planning process. Eventually, the process of more than three years of Dutch Dialogues workshops (2008–2011) led to a formal commission by Greater New Orleans Inc. to draw up a plan for a *new urban water strategy*. The consortium awarded this commission, led by Waggonner, was composed

Figure 9.8 New Orleans 1863: The city was established largely on the levees of the meandering Mississippi. North of the city, the marshlands and Lake Pontchartrain can be seen (map Henry L. Abbot, US War Department, New Orleans Historic Collection)



largely of the same parties as were active in the Dutch Dialogues team. Finally, in October 2013, the consortium presented the Greater New Orleans Urban Water Plan, with the support of all the relevant institutional players (Waggonner & Ball, 2014).

The team behind the Dutch Dialogues workshops, and later the GNO Urban Water Plan consortium, were in fact experimenting with new relationships between science, governance, and design and planning (Waggonner et al., 2014). New knowledge was generated on soil composition, surface water and groundwater quality, discharge capacity of the existing drainage system, precipitation amounts and soil absorption rates in different parts of the urban region. This knowledge was used to calculate the water storage capacity required in each district. In addition, the city's overall spatial planning structure was analysed, leading to a definition of seven districts, each with its own distinct spatial characteristics.

The combination of these two analyses produced a spatial framework for reconfiguration of the water management infrastructure (Figure 9.9), also producing a new spatial outline for the city, including planning contours on the scale of the metropolitan region. The more than 15-km zone extending from downtown New Orleans to the city's main point of arrival and departure, the Louis Armstrong Airport, will be transformed according to the plan from an elongated, disorganized, peripheral zone into a central corridor with ample space for water storage.

The third initiative was the State of Louisiana's plan to bring a halt to erosion of the delta by restoring the supply of freshwater and sediment from the Mississippi River to the marshes in the delta (Coastal Protection and Restoration Authority of Louisiana, 2012) (see Figure 9.10). To make this possible, openings will have to be made in the levees at several places alongside the Mississippi, and various former river arms will have to be restored. This initiative is supported by America's Wetland Foundation, which itself is sponsored by major corporations active in oil and gas extraction in the Gulf of Mexico. With their support for rehabilitation of the wetlands, they hope to compensate for their industry's contribution to subsidence of the wetlands.

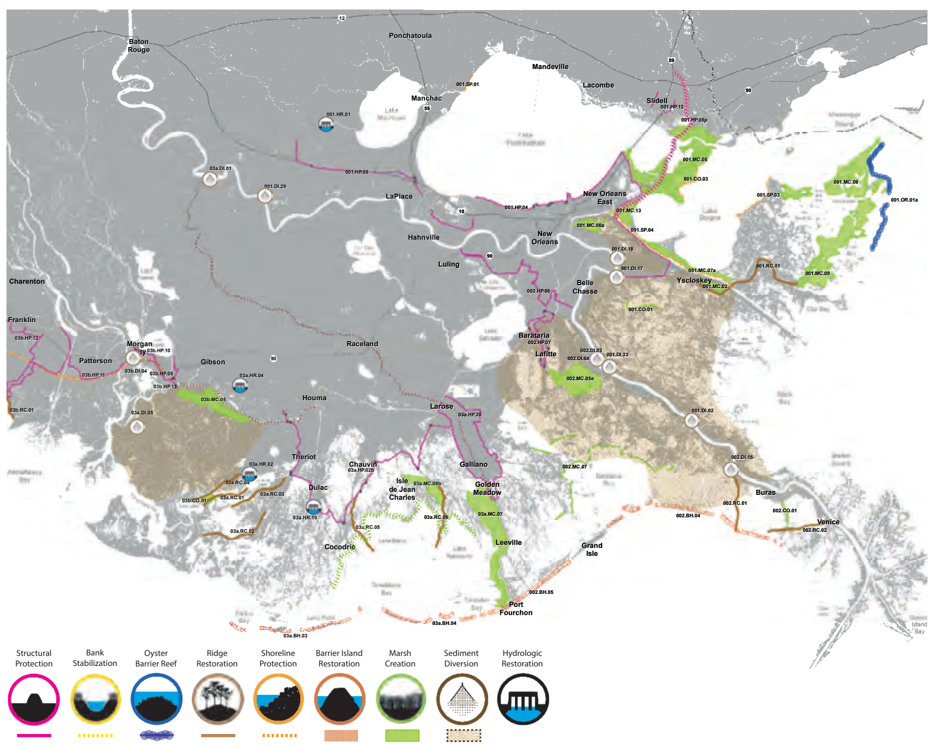
To find the best options – technically, spatially and socially – for revitalizing the supply of freshwater and sediment to the delta, a design competition was announced in 2014 entitled "Changing Course" seeking proposals on how such measures might be elaborated (http://changingcourse.us).

9.4 Mekong Delta (Vietnam)

The Mekong Delta is, in terms of delta type, very similar to the Northwest European lowlands: it is a young landscape formed almost entirely by rivers and sea, with an average elevation of approximately 0.8 m above sea level. Its networks, including water networks, are entirely different however, and the Mekong Delta's highly dispersed urban occupation pattern is also very different from those in Europe. From the Cambodian capital Phnom Penh, the Mekong River splits into nine branches, which together form a delta re-

Figure 9.9 New Orleans: Framework of a new water management system. GNO Urban Water Plan 2013

Figure 9.10 Louisiana’s Comprehensive Master Plan for a Sustainable Coast. Coastal Protection and Restoration Authority of Louisiana, 2012



gion covering 5.5 million ha, 3.9 million ha of which is within Vietnamese territory. This means that the Vietnamese part of the delta has a surface area comparable in size to the whole of the Netherlands; population numbers are also comparable to those of the Netherlands (some 17 million inhabitants). The system of (water) networks and the urban occupation pattern, however, differ significantly from the Dutch situation.

In the evolution of the Mekong Delta since the beginning of the nineteenth century, three periods can be distinguished.

1. Transformation of the Mekong Delta into a labyrinth of canals and inlets

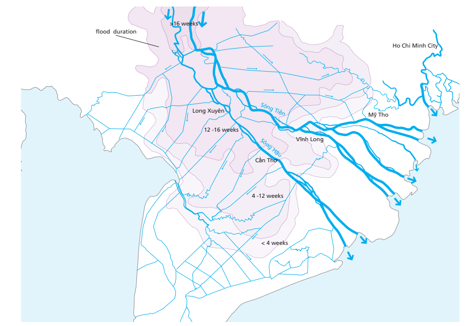


Figure 9.11 Mekong Delta, Water system

Until mid-nineteenth century, the Mekong Delta remained a primarily “wild” delta with extensive wetlands, wide riverbeds and vast expanses of mangrove. Some sparse habitation and land clearing took place on the higher levees on the banks of the river branches.

This situation changed drastically and in a just short time with the arrival of the French. France had maintained close military and economic relations with Vietnam starting in the eighteenth century. This led to a trade monopoly for France in a number of concession areas. In 1887, the whole of Vietnam, together with Laos and Cambodia, was annexed as French Indochina. For the Mekong Delta, the arrival of the French signalled the start of a period in which almost the entire the Mekong Delta was brought into cultivation for rice production on a very large scale. Marshes were drained, mangrove forests were cut down, and with the construction of an intricate network of canals, the required infrastructure was provided for irrigating rice fields and transporting the rice. For the Vietnamese population, a new livelihood opportunity opened up: that of rice farmer. Housing was located on low dikes along the canals, resulting in a diffuse pattern of urbanization in the form of built dike ribbons extending along the canals, though there was also a small number of larger urban nuclei.

An interesting aspect of this infrastructure, which was built under colonial rule, is the significant role it played in bringing an end to that same colonial rule. The canal network altered currents and sedimentation patterns throughout the delta. Within the canals, shallows developed in some places, while deeper tidal channels were created elsewhere. The native population was familiar with these peculiarities of the waters; but the French and later the US soldiers were much less so. During military operations French and US vessels often found themselves stuck in shallows of the canals, where they were an easy target for the Vietnamese freedom fighters (Biggs, 2010).

The canal system in the Mekong Delta gave rise to a unique situation that sets developments in this region apart from those in most other deltas. Large areas of the delta still undergo regular flooding, meaning that the irrigation necessary for the rice fields takes place “naturally” as it were. Where flooding does not occur as a function of high water levels in the rivers, artificial irrigation is employed with water provided via small sluice gates in the dikes along the canals.

Along with the regular irrigation of the rice fields, a regular supply of sediment has been provided. This sediment then settles out of the irrigation wa-

Figure 9.12 Two options for the Mekong Delta: Closed system (left) and open system (right). Illustrated by Pham Dieu of the TU Delft, 2013

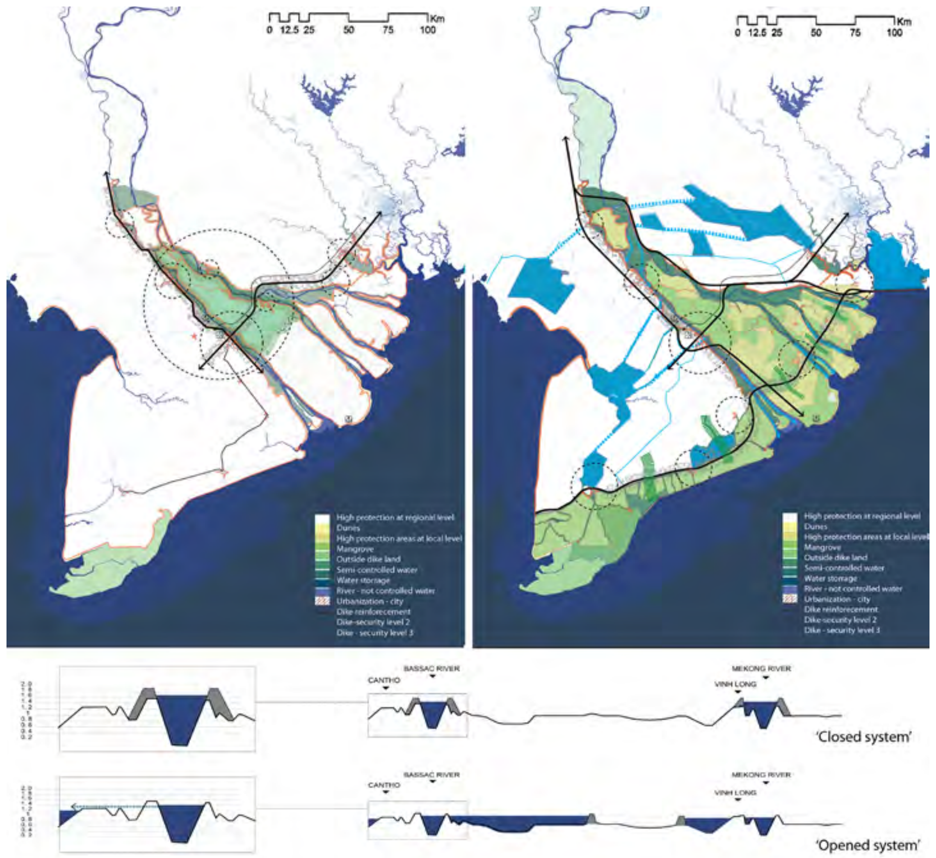


Figure 9.13 Possible urban expansion of Cao Lanh, Mekong Delta: Urban growth in higher and raised areas, separated by areas for rice cultivation and water retention. Trang, 2013

ters onto the rice fields, building up the soil profile. Through this process, soil accretion in the delta has taken place at about the same rate as sea level rise.

The styles of buildings constructed in the delta were also adapted to the phenomenon of recurrent flooding: buildings were constructed either on the dikes buttressing the canals, on stilts or floating.

2. "Doi Moi": Industrialization and urbanization of the Mekong Delta

After the Second World War, the Mekong Delta remained a hotbed of conflict for some 20 years, as a war for independence raged fought by the Vietnamese first against the French and later against the Americans. With the end of that war in 1974 a new era donned, especially following the launch of "Doi Moi", or economic liberalization, which from 1986 stimulated strong economic growth and urban expansion.

This growth led to two, at the time, somewhat conflicting developments. First, rice cultivation intensified and increased in scale, and Vietnam became the largest exporter of rice in the world. Second, urban nuclei expanded rapidly, keeping pace with the rise of industrial economies in these nuclei. An example is the city of Can Tho, in the heart of the delta. Can Tho grew from 180,000 inhabitants in 1979 to a population of some 1.1 million in 2006. However, this urban growth was no longer accomplished with types of structures tailored to the risks of high water – despite the fact that more than 70% of the city is situated in low-lying areas, less than one metre above sea level. These areas are extremely vulnerable to flooding, due both to high water in the rivers and to heavy and prolonged rainfalls during typhoons. Similar conditions are observed in other cities in the Mekong Delta.

An additional complicating factor for both rice cultivation and flood prevention is the construction of river dams upstream in China and Cambodia. These block the supply of freshwater and sediment, making rice field irrigation and sediment transport and accretion increasingly problematic (Miller, 2006).

3. Stimulus for adaptivity

Numerous studies have been carried out since the early years of the twenty-first century, seeking ways to improve the relationship between the water system and spatial planning developments in the Mekong Delta. Within Vietnam, these studies have been variously initiated by national-level authorities, such as the Ministry of Agriculture and Rural Development (MARD), and by local administrators, such as the Municipal Council of Can Tho.

The Mekong Delta is also a subject of intense interest among foreign engineering companies, design firms and universities. French, German, Belgian, Dutch, Australian and Japanese institutions have been involved in studies of the region, solicited as well as unsolicited. These have resulted in two main options for the long term, which have been proposed in numerous variants (Marchand et al., 2011) (Figure 9.12).

The first option, following the classic Dutch example, is to provide the different estuaries with storm surge barriers, while also establishing a large freshwater storage area in the heart of the delta from which the rest of the delta could be irrigated in dry periods. In addition, flood protection and drainage systems would have to be upgraded in cities like Can Tho.

The other option is to maintain the delta as an open system and provide a number of large reservoirs on the outskirts of the delta that can be used for water storage during periods of extremely high river discharges – again, with reservoir water used for irrigation in dry periods. Urban development would then have to be limited mainly to the higher-elevation areas. Expanding on the existing natural variations in elevation, cities could initiate reclamation works, raising up lands surrounding their urban core. Zoning plans could be developed to guide such activities so that as cities grow, those areas where building and reclamation works are and are not permitted are specified. Lower-lying areas could remain in use for rice-growing.

A mixed pattern would therefore result in which both safe housing is provided and rice cultivation could be continued. Application of this concept of large reservoir construction and designation and development of higher grounds for buildings, can be viewed as a spatial planning framework that is also adaptive, which is to say, it can be adjusted over time to adapt to changing conditions (Trang, 2013) (Figure 9.13).

For now, the highly sector-based organization of the Vietnamese government bureaucracy hampers further elaboration and implementation of these plans.

9.5 Elbe Estuary (Germany)

The Elbe Estuary is not, strictly speaking, a delta; the river does not split into multiple branches at the mouth. The river mouth does have all the characteristics of an estuary, such as a long (more than 80 km), gradual transition from freshwater to saltwater. The issues and especially the complex combination of problems faced in the Elbe Estuary are similar to those in the Southwest Delta of the Netherlands.

The River Elbe is located on the edge of the Northwest European lowlands and flows directly past the older and higher-elevation Pleistocene grounds on which most of the city of Hamburg has developed (Boetticher, 2005).

Three periods can be distinguished in the evolution of the Elbe Estuary.

1. First phase of city formation and reclamation

Around 1200 the harbour and city of Hamburg were established at the mouth of the River Alster where it meets the Elbe. The first land reclamation works began there in the thirteenth century, taking place in the Elbe's catchment area. From the fifteenth to the seventeenth century, dike construction and drainage techniques were improved with the help of Dutch engineers, and the Elbe became more intensively regulated. This improved regulation of the river made the ports of Hamburg, Altona and Harburg more accessible, and enabled them to expand. Land reclamation and river regulation, at this point, had little impact on river levels and tidal movements. However, the dikes remained relatively low and flooded regularly, meaning that reclaimed lands frequently had to be relinquished back to the river. One consequence of this flooding was creation of the Elbe River Island, surrounded by the Northern Elbe and Southern Elbe (Bracker, 1988).

2. Port expansion, river improvement and administrative unification

Drastic changes took place over the course of the nineteenth and twentieth centuries. Initially technological developments in both shipping and dredging led to fierce competition between the ports of Hamburg, Altona and Harburg. The battle between Hamburg and Harburg concentrated on improving access to the Northern Elbe for the benefit of Hamburg and Altona and to the Southern Elbe to the detriment of Harburg. However, interventions on the Hamburg side to increase flows through the Northern Elbe threatened to render the Southern Elbe unnavigable. In 1937, the three cities were unified into the Federal State of Hamburg, bringing an end to the competition.

Figure 9.14 Elbe Estuary, Water system

The Federal State of Hamburg has been very eager to keep the port and employment associated with it within its administrative boundaries. It is for this reason that the main port activities have not been moved to the river mouth. The course of the river from Hamburg to the river mouth falls under the jurisdiction of two other federal states: Schlesweig-Holstein and Lower Saxony.

With a new common policy for the three ports came even more emphasis on deepening the main navigation channel, and more port areas were constructed, resulting in a further narrowing of the river. In addition, many tributaries and inlets, which had played a role as water storage areas during high water periods, were dammed off. The result was a substantial increase in tidal range (from 1.90 m in 1800 to 3.62 m in 2000), with extreme high water peaks of more than 6 m above mean sea level. In 1962, severe flooding during a storm surge resulted in 312 fatalities, and 60,000 people lost their home.

Nevertheless, just recently (1996) a 170 ha area outside the dikes was reclaimed for construction of Finkenwerder Airfield for the company Airbus. With these reclamation works a valuable nature area was lost, and a former river arm (the Alte Süderelbe) was severed from the Elbe, with the loss of substantial water storage capacity as a result (Glindemann et al., 2006).

To compensate, the Island of Hanhöfersand (104 ha) a few kilometres downstream was redeveloped into an intertidal area, and similar plans are being made for the Borghorster-Elbwiesen area further downstream. The Hamburg nature conservation council has asserted, however, that these projects do not sufficiently compensate for the loss of nature and water storage capacity formerly provided by the Alte Süderelbe.

3. Stimulus for adaptive planning

Since the late twentieth century a strategic rethink has gotten under way regarding the relationship between regional development and river management policy. Measures to narrow the riverbed and deepen the navigation channel, particularly in the past century, have taken such large proportions as to significantly change the water levels in the river, and protection against high waters is becoming increasingly problematic.

In a project to redevelop the port area, which is outside the dikes, and create a new urban residential and commercial district (HafenCity) on the right bank of the River Elbe, attempts are being made to find a suitable response to these problems with a design concept centred on flood-proof styles of building on low quays and a flood-proof street network situated higher up. The height of this road network is derived from expectations regarding possible extreme peak water levels in the future. Recent calculations, however, suggest that the estimates used have already been superseded and even higher water levels will have to be taken into consideration. So flooding of HafenCity in its entirety remains a possibility in the future.

These and other factors have stimulated discussions on the best way to approach the problem. Instead of attempting to protect the city and countryside from the threat posed by continually increasing water levels, calls are now being increasingly made to address the underlying causes of the higher water levels: the narrowing of the riverbed and the deepening of the navigation channel of the River Elbe.

A major boost for these developments was provided by the focus of the Internationale Bauausstellung (IBA) or International Architectural Exhibition on Hamburg and the Elbe River Island in the 2006–2013 period (IBA, 2009). Under the auspices of the IBA, more than 70 projects were initiated in and around Elbe Island, as experiments for testing new concepts of urban land use and new schemes for river management. Building on mounds, floating houses and multipurpose flood barriers were used to test ideas for intensifying use of urban lands while also enabling parts of Elbe Island to function as an overflow area, effectively widening the riverbed, during high water events.

At a more fundamental level, however, restoration of estuarine dynamics in the Elbe is needed to dampen the increased influence of the sea. To this end, the Hamburg Port Authority, together with the federal government of Germany, is developing proposals for widening the riverbed and artificial construction of sandbanks in the river mouth. These measures should reduce tidal influences in the estuary, hence also diminishing the vulnerability of Hamburg and Elbe River Island to flooding (Glindemann et al., 2006) (see Figure 9.15). The most effective measure would be to move the entire port to the river mouth. But this, for the time being, is a bridge too far, in the current political context.

9.4 Conclusions

Our examination of the three foreign deltas as complex adaptive systems demonstrates that, like the Dutch Southwest Delta, the development history in these deltas too can be divided into a number of periods. In each delta, transitions from one period to another were related to a changing dominance of one or of multiple subsystems, with corresponding changes in governance structures and new technological tools. These transitions often did not occur as sudden changes, but instead were lengthy processes, sometimes lasting for decades.

At present, we observe in all three deltas impetuses towards a new transition, motivated by the need to stop further erosion of the deltas alongside

the need for revitalization in the economic and spatial constellation. The erosion is somewhat the result of changing natural conditions, but to a large extent it has been caused by human interventions such as land reclamation and artificial means of lowering groundwater levels, river normalization, narrowing riverbeds, damming and the deepening of navigation channels. These interventions were observed in all of the deltas and are foremost factors contributing to increased vulnerability to flooding, saline intrusion and environmental degradation.

In addition, spatial and economic development in the delta regions require fundamental choices to be made. This is clearly visible in the case of both the Mississippi River Delta and the Mekong Delta, as well as in relation to the Elbe Estuary. All three face the challenge of developing new perspectives on economic development in relation to new forms of land use and new ways of dealing with delta dynamics. A fundamental reassessment of future spatial development in relation to development of the delta is therefore also under discussion in all three delta regions.

Figure 9.15 Design of the Kreetsand Tidal Park riverbed widening project (Hamburg Port Authority, Studio Urbane Landschaften Hamburg / OSP)

Relevance of approaching the delta as a complex adaptive system

In all three of the foreign deltas studied, to a greater or to a lesser extent, new experiments are under way aimed at developing a new approach to the complex problems of the delta. Though recognition of the delta as a complex system is generally observed, a method of dealing with this complexity is far from universally available. The three foreign examples demonstrate three different but equally interesting attempts to establish a new relationship between design, planning and engineering with development of scientific knowledge and governance. In all three cases, attempts were made to force a breakthrough in relation to the hitherto usual way that these three factors related to one another. To force these breakthroughs, unconventional actions and methods were applied, in the form of creation of special “soft spaces”, such as the Dutch Dialogues workshops in New Orleans and the IBA in Hamburg.

Consistently important in these has been that the initiators of these actions and methods have not positioned themselves entirely outside of conventional practice, but in fact have sought constant contact and dialogue. The end goal was, after all, in all three cases, to change those existing practices in such a way as to open new action perspectives.

By organizing a new design-knowledge-governance “triangle”, in addition to the existing, institutionalized triangle, a “free environment” was created for experimental design, research and debate, which nonetheless remained in constant dialogue with the existing triangle. Through this interaction, the existing triangle was set in motion, changed and mobilized to new forms of action (see Figure 9.16). These examples of the creation of a “free environment” are very similar to the DENVIS experiment that was developed for the Dutch Southwest Delta.

To a large extent, the three deltas investigated also managed to achieve breakthroughs, with new action perspectives as a result. However, this did not happen without a fight – considerable time was invested in the effort in all cases. The process from the start of the Dutch Dialogues until completion of the GNO Urban Water Plan encompassed more than five years.

In Hamburg, the IBA similarly extended over five years, during which new experiments were conducted in the field of spatial development and water management on the Elbe River Island and a broad public debate was organized. In this case, it was the city government itself that recognized the need to create a "free environment" outside existing formal frameworks, to achieve new forms of regional development amid the complex dynamics of the Elbe Estuary. The difference between Hamburg and New Orleans is that in the former not only were designs created, data collected and consultations held during those five years, but also practical experiments were conducted. These experimental pilot projects provided the raw materials for monitoring, evaluation, debate and forming opinions on follow-up.

In New Orleans, implementation of the GNO Urban Water Plan began with execution of a number of pilot projects. These will also be continually monitored and adjusted by the institutions that have committed themselves to the plan's implementation. The various agencies that have taken this upon themselves form a "Community of Research and Practice" (CORP): execution of the pilot projects will generate materials that will be further investigated, monitored and evaluated, and should lead to insights for making adjustments to both the projects themselves and the practices of design, knowledge and governance.

Both in New Orleans and in Hamburg, practices have become established in which the implementation of projects is no longer a goal in itself, but instead part of a process of continual reflection and adjustment. Not only are the spatial plans and projects related to them adaptive, but the practice of design, knowledge and governance is adaptive too (Figure 9.17).

These observations lead to two conclusions. First, in other delta regions of the world there is also a need for an approach that is able to cope with the complexity of the region and the associated knowledge and governance infrastructure. The creation of a "free environment" or "soft space" for development of new relationships between design, knowledge and governance is seen in all of the deltas as an essential process for forcing breakthroughs that could lead to new practices. This leads to the conclusion that a more systematic approach to urbanized deltas as complex adaptive systems fulfils a highly felt need. The approach presented in this book for the Southwest Delta, with DENVIS as an example of how a "soft space" can be organized, could also be of great significance for other delta regions.

Second, experiences in New Orleans and Hamburg, conversely, are meaningful for the further development of the Southwest Delta. The new "learning practices" developed, especially in New Orleans and Hamburg, with a "Community of Research and Practice" generate definite prospects for follow-up to the IPDD project in the Southwest Delta.

Robust adaptive frameworks

In all three delta regions, we see the contours emerging of spatial frameworks in which the component parts can still be elaborated in different ways and over the course of time can change in shape and programme. The frameworks represent not only a spatial structure, but also the consensus reached on that structure among the stakeholders involved. It is the framework within which action can be undertaken.

In the Mississippi River Delta, the combination of two ingredients enabled this product to emerge: first, the new framework for the urban water system in the GNO Urban Water Plan; and second, the openings in the levees of the Mississippi that await implementation in the context of the restoration of freshwater and sediment supply to the foredelta.

Application of a "robust adaptive framework" also appears pertinent to the Mekong Delta in relation to the option of retaining the delta as an open system; but in terms of social context it is still difficult to achieve.

In Hamburg and the Elbe Estuary, the initiatives associated with the IBA provide a valuable basis for such a framework. Here, however, the spatial framework would be much more effective if it were combined with shifting the port terminals for the largest sea-going ships to the river mouth, so that dredging of the main channel could be less deep, and if, in addition to Elbe River Island, the riverbed could also be widened elsewhere downstream. This will primarily require closer cooperation and coordination between the three states with administrative territories along the Elbe Estuary, both regarding economic policy and in terms of river management and water management.

In all three cases, we observed that realization of an *adaptive* framework requires that an adaptive governance structure also be in place.

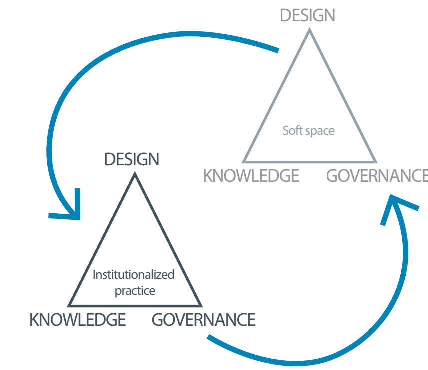


Figure 9.16 Development of a "soft space" or an environment in which design, knowledge and governance are given free rein, in continuous dialogue with institutionalized practices of design, knowledge and governance

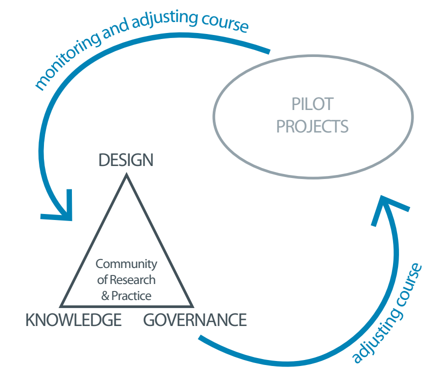


Figure 9.17 Community of Research & Practice: Start of pilot projects which via permanent monitoring lead to adjustment of design, knowledge and governance practices as well as of the projects themselves

Chapter 10

Conclusions and reflections

The aim of the Integrated Planning and Design in the Delta (IPDD) project was to develop an adaptive approach to planning and design for complex delta regions. During the past years, through a rigorous interdisciplinary process of exploration, experimentation, discussion, building and consideration, an initial version of such an approach was developed. This chapter closes with a presentation of conclusions and reflections on the usefulness of the approach proposed.

10.1 Conclusions

From the historical reviews conducted of both the Southwest Delta in the Netherlands and other delta regions of the world, change emerges as the most constant factor in all delta areas. It is also striking that multiple subsystems are always involved, and that the driving forces are invariably a blend of bio-physical and socio-economic factors. This combination of intense dynamism and strong interaction between natural substrate and human activities necessitates near-continuous influencing via planning and design.

The first conclusion of this research is that deltas in general – and the Southwest Delta in particular – can be viewed as complex adaptive systems. These systems, moreover, are composed of subsystems that each have their own goals, interact with one another, sometimes counteract one another, are dependent on one another and have their own histories. Such a system is in open communication with its surroundings, and is capable of anticipating on the developments occurring around it. As a result, the system and its subsystems are in a state of continuous active adaptation to both internal and external developments. While to the outside world, the system may appear to be in balance, adaptations are nonetheless almost constantly happening to keep the system in balance or to find a new, for example, more sustainable balance. Spatial planning and design play an important role in this.

The second conclusion is that there is no such thing as a single best or "one-size-fits-all" planning and design methodology for deltas. Rather, the approach to planning and design must itself also be adaptive, in order to keep up with the dynamic and situation-specific nature of the underlying subsystems. It is therefore better to speak of an adaptive approach than of an established planning and design methodology. Achieving an open relationship between design, knowledge and governance is an essential element of such an adaptive approach. For this, realization of a free environment or *"soft space"* is essential. Within the IPDD project, the DENVIS methodology played an important role in creating such a space; examples from other countries too – such as the International Bauausstellung in Hamburg and the Dutch Dialogues in New Orleans – demonstrate that creation of a soft space can play an important role in establishing a constructive relationship between design, knowledge and governance.

The third conclusion is that adaptive planning should offer scope for synchronization of all the relevant processes within in the subsystems of the delta. This does not necessarily mean that total integration should be the objective, because that would in practice be tantamount to identification of a single structure into which all the diversity of the delta would have to be fit. Instead, synchronization should be understood as the need to allow for nonsimultaneity, for variety and for differences in the rhythm of processes and the dynamics of the diverse subsystems. An important lesson learned from planning in the Netherlands in the recent past is that too much emphasis on integration can lead to conflicts and deadlocks in spatial development. Adaptive planning and design aim to enable each subsystem to evolve in such a way that combinations of developments with other subsystems are possible, but these combinations do not necessarily have to be implemented simultaneously. The different subsystems thus have freedom to develop, but within the limits and possibilities of the system as a whole.

The fourth conclusion is that based on general characteristics of complex adaptive systems, standard analysis steps can be formulated that are essential to the adaptive approach to planning and design:

- First, complex adaptive systems are composed of a large number of subsystems, which mutually influence one another. Therefore an analysis of these subsystems is required, including their mutual interactions and the nature of their interactions (Chapter 5).
- Second, the behaviour of complex adaptive systems is to a large extent path-dependent. This means that a retrospective analysis of CAS systems and subsystems and the interactions between these is required (Chapter 3).
- Third, complex adaptive systems are open systems, in continuous interaction with the outside world, and on the basis of that interaction also adapt. This means that adaptive future scenarios must be developed incorporating a combination of external influences and internal adaptation (Chapter 4).
- Fourth, because a CAS is characterized primarily by network management with little hierarchy, intensive dialogue is required among the actors in the subsystems (Chapter 7).
- Finally, complex adaptive systems (sometimes) display unpredictable emergent behaviour. Constant monitoring of the evolution and adaptation of the actors is therefore required (Chapter 8).

What are the consequences of these findings for practice, for research and for education? This question is addressed in the final sections of this conclusions chapter.

10.2 Practical relevance

The previous section described the findings of this project in rather generic terms. Our conclusions were based on concrete products and tools developed for decision support that can be, or already are being, used in practice. Their relevance stems from four factors in particular.

- *Role of design: Dealing with uncertainty*
  The approach proposed in this book takes uncertainty as a characteristic feature of complex tasks, and this uncertainty is accepted and serves as the starting point for planning needs. Adaptation is the key concept in dealing with uncertainty: adaptation by individuals, by organizations, by scientists, by designers, etc. The role and nature of the design is essential here. The design no longer has the aim of indicating a final end-situation that is to be achieved; rather, the design indicates where, what and how changes can be made in the course of time. The result of this is that in the design and in decisions associated with the design, potential adjustments will always have to be taken into consideration. This is no simple task, and requires that the actors involved adopt new ways of working.

- *New planning schema: The Robust Adaptive Framework (RAF)*
  A new planning schema was developed that is both robust (able to withstand cyclical and structural changes over a long period of time) and adaptive. This planning schema can be seen as a new, more adaptive version of the framework schema developed for the Dutch "Room for the River" programme. An essential aspect of the Robust Adaptive Framework (RAF) is the definition of zones rather than drawing of sharply delimited boundaries. These zones form gradual transitions instead of hard divisions between different functions, between water and land and between types of land use. In the case of the Southwest Delta, such zones pertain especially to land-water boundaries, in the form of the inter-dike zones along the Haringvliet and Hollands Diep and the zones outside the dikes along the River North, the New Meuse and the New Waterway. The RAF structure was adopted to a large extent from the final advisory report of the Rijnmond-Drechtsteden delta sub-programme (2014).

- *"Soft space": The Delta Envisioning Support System (DENVIS)*
  To achieve a new relationship between design, knowledge and governance, the Delta Envisioning Support System (DENVIS) was developed and operationalized for delta areas. With it, designers, geo-information specialists and stakeholders from various organizations (e.g., government, commercial enterprises and civil society) and sectors (e.g., agriculture, nature conservation, water management, urban planning and energy) interact with one another to arrive at joint executable designs for delta areas. Because practitioners in other delta areas are also seeking means to implement the "soft space" concept, DENVIS could play a significant role in these other deltas too.

- *iMaps: Application for seeking relationships between plans*
  To put geo-information to effective use in DENVIS, an iMaps application and iMaps intervention scheme were developed to provide designers and stakeholders from the subsystems quick insights into the conditions in the area and the relationships between plans.

10.3 Scientific relevance

Theory on complex adaptive systems has been evolving for several decades, but translation of that theory to practice has proven difficult. In the current research, general and theoretical concepts derived using CAS reasoning were elaborated for and tailored to delta regions. As such, it fills an existing knowledge gap regarding the translation of theoretical concepts from systems thinking for a real-world field of application (deltas). There is much demand for adaptive approaches, but these approaches have as yet remained mostly confined to theory and wishful thinking. The IPDD project represents a serious attempt to develop concrete methods, techniques and tools derived from the adaptive planning perspective. Adaptive planning was elaborated in the form of a collage of related tools and methodologies: retrospective analysis, future outlooks, actor analysis, plan analysis and envisioning. The approach to adaptive planning developed was mirrored, and evaluated for feasibility for delta areas in other parts of the world, thus testing its external validity. Still lacking, however, is a scientific evaluation of the application of the adaptive approach to planning in practice.

10.4 Implications for teaching

The results of the IPDD project provide guidance not only for development of research and practice, but also for education – as this is where the people are being trained who will be active in the field of spatial planning in the future. To achieve innovations in the design-knowledge-governance triangle, a free environment or "soft space" is required, and education is arguably the most important soft space we have available. Educational settings are ideally suited for free experimentation with new relationships between design, knowledge and governance. An important conclusion is thus that such interdisciplinary experiments should be wholeheartedly supported and stimulated. Obstacles that hinder creative interactions between disciplines are often raised and cultivated early in educational programmes. A key finding in this regard is that such obstacles should not only be cleared, but that new teaching methods should be developed to stimulate productive interaction, mutual understanding and cooperation.

Recent initiatives such as the inter-departmental "Delta Interventions" graduate atelier at the Delft University of Technology (TU Delft) and the cooperation between TU Delft, Wageningen University and Research Centre and the Massachusetts Institute of Technology under the Amsterdam Institute for Advanced Metropolitan Solutions (AMS) should therefore also be encouraged and deserve follow-up.

10.5 Finally

This section concludes our practical and scientific quest for a new approach to planning and design for delta regions. This quest has not yielded any new methodologies that can be employed like a recipe in a cookbook. What this quest has produced is the understanding that deltas function as complex adaptive systems, and therefore the approach taken to planning and design for delta areas must itself also be adaptive in nature. The research presented in this book experimented with various aspects of this adaptivity, resulting in an initial version of an adaptive approach that in practice also seems to deliver good results.

Adaptation never stops, and the same is true for planning and design. The insights presented in this volume should therefore be interpreted primarily as a source of inspiration, stimulating readers to experiment with concepts, tools and techniques for establishment of robust and adaptive deltas.

Bird's-eye view of the Southwest Delta (Google Earth)

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Added value: Progress through collaboration

The Netherlands is an urbanized delta where innovative solutions have been explored for centuries. The province of South Holland is at the centre of this delta. The majority of the Dutch live and work here, most of them below mean sea level. One of the world's largest sea ports (Rotterdam) is located here, and the region is also home to a cluster of higher-education, research, government and industry, all of which produces a huge economic potential. In 2012, the universities and research institutes in the region launched the Delta Technology & Water valorisation programme, or VPdelta for short. The goal of this programme is to bring scientific, commercial and public stakeholders together to increase and advance innovation and entrepreneurship. The programme supports the development of feasible, affordable and dynamic local water management solutions for the Dutch delta, solutions which are also valuable exports as "Dutch water know-how".

How does the programme do this? By teaching students entrepreneurial skills and supporting clusters of start-up businesses with manpower and mindpower. By helping companies to identify business opportunities and by helping government to find concrete answers and solutions to management and technical issues. Another key task is to make sure that people know about these innovative solutions. 'Seeing is believing' applies to delta technology, too.

For example, a special test and demonstration facility, called Flood Proof Holland, has been set up in Delft. Local residents as well as foreign visitors can see how various semi-permanent flood barriers work and judge for themselves. The project has achieved substantial publicity both in the Netherlands and elsewhere. Interest from a Dutch development organization for one of the products on display, the Green Soil Bag, led to the first mega-order from Bangladesh: a good example of aid and trade working hand-in-hand.

A similar project is Aqua Dock, a 'showcase for water' being developed at the RDM campus in Rotterdam to demonstrate innovative water-based projects, including examples of floating constructions. VPdelta views floating construction as an approach that will make urban design resilient to climate change.

Rotterdam has shown itself to be a centre of excellence and an international leader in climate adaptation, partly due to the local authority's Rotterdam Climate Proof initiative. As the project's manager Arnoud Molenaar says, 'A city on a delta has to deal with water from four sides: the river, the sea, rainfall and groundwater. Thinking about the future now is a lot cheaper than having to adapt every building 40 years from now.'

In another project, an urban planning bureau is working with VPdelta to make the Zomerhof district of Rotterdam resilient to climate change. Various innovations from the VPdelta project are being applied, among them the so-called 'polder roof', a special green roof with an increased capacity to collect, retain, and gradually release rain water.

The power of the VPdelta programme is that by linking all stakeholders the development and implementation of innovations is increased.

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