Sustainable delta landscapes need smarter port city regions

Meyer, Han

Publication date
2019

Document Version
Final published version

Published in
PORTUSplus

PORTUSplus_the Journal of RETE
N. 8, November 2019, Year IX
Special Issue "*Governance in Port City Regions*"
RETE Publisher, Venice, ISSN: 2039-6422

ABSTRACT

Economic and spatial developments of port cities have large impacts on the quality of the natural environment, the safety of people living in the urbanized areas and the fresh water supply for drinking water and agriculture. Creating a proper balance among these different aspects, makes it necessary to provide new concepts and instruments at the regional scale. During the last two centuries, port city development has been defined by the paradigm of the primacy of economic development, which had to be supported and facilitated by engineering and urban planning. Following this paradigm, dynamic and ecologically rich deltas have been transformed into artificial landscapes, resulting in ecological decay, increasing flood risk in urban areas and increasing salinization of surface and groundwater. Because of climate change, these problems in port city regions are increasing exponentially.
This paper argues that new approaches should be developed in port city regions, combining ecological repair of delta landscapes by 'building-with-nature' methods of hydraulic engineering, with a transition of port city regions related to energy transition and the rise of a circular economy.
We need a new paradigm, resulting in an integrated, holistic approach of port city regions, and with governance structures which are able to implement this holistic approach.
This paper shows the essence and urgency of this new paradigm, as well as the glimpses of the start of a new approach, illustrated by the developments in two delta regions, which are the home bases of two of the largest port complexes of the world: the Mississippi river delta with the ports of New Orleans, and the Rhine-Meuse-Scheldt delta with Rotterdam and Antwerp.
The new paradigm is only possible when the governance system will change at the global, national, regional and local levels.

Sustainable delta landscapes need smarter port city regions

Han Meyer[1]
[1] Professor, Department of Urbanism, Faculty of Architecture & the Built Environment, TU Delft, Delft, The Netherlands

KEYWORDS
Dynamic delta landscapes; Port city regions; Building with nature; Design as engine of change

Sustainable delta landscapes need smarter port city regions

Introduction

Ports and port cities are facing the increasing necessity to anticipate and adapt to new developments and changing conditions in technology as well as in the natural environment.
The technological challenges concern the rise of digital technology, automatization and robotics, remote sensing and control, the availability and new possibilities of 'big data', the rise of new materials, etcetera. Also the changes in the logistic chains because of the rise of 3-D printing and the increase of a circular economy are part of the new technological and logistic challenges of ports. Dealing with these technological challenges in their policies, port authorities developed initiatives such as 'Smart Port Rotterdam' (http://smart-port.nl/) or the 'Port 101' strategic plan of the Port of New Orleans (https://www.portnola.com/info/port-101). A part of this new smartness includes the rise of regional port networks or port regions (Wang et al. 2007). Comparable with the use of the word 'smart' in 'smart cities' (Hajer, Dassen 2014), 'smart port' in the current strategic reports of port authorities and academic inquiries refers especially to the way how new technology can be used for making port logistics as efficient as possible.
However, the changing conditions in the natural environment create the need of an additional kind of 'smartness'. These changes concern the problems in the territories and waters around the ports, caused by waste and pollution by industries, dredging and canalizing of rivers, but also by the effects of climate change like sea level rise and increasing discharges of rivers. The result is the erosion and decay of these delta landscapes themselves, including ecological decay and disappearance of biodiversity, but also the increasing flood risk for the many millions of people and for the concentrations of economic activities and investments (including ports and port-related industries themselves) in these delta areas (Ericson et al. 2006; Nicholls et al. 2007; Tessler et al. 2015).
These changing conditions, and the way how to deal with it, have created a need of another 'smartness': the future and the repair of the vulnerable landscapes and ecosystems need a new approach for port development in relation to its natural and urban environment. We need *smarter* approaches for creating a sustainable balance between ports and the urbanized delta landscapes. For creating the conditions for this kind of smartness, we need to connect both worlds and both debates with each other: the lines of inquiry and debates concerning the new technological challenges in port and shipping logistics, and the lines of inquiry and debates concerning the environmental and flood risk issues of the delta regions.

These two lines of inquiry, on port city regions and on delta regions, overlap in terms of both territory and content. Conclusions and proposals resulting from one area of inquiry can have serious consequences for the other. It makes clear that a holistic strategy at the scale of the (delta-)region is necessary, and that creates the need for a comprehensive governance system at the regional scale. However, there has been surprisingly little exchange of analyses, interpretations or conclusions. It is true that various academics and professionals have addressed the need for a policy on ports and navigation that takes into account the serious impact on the environment since the 1970s (see e.g. Vandermeulen 1996). Recently, the AIVP (*International Association for the Collaboration between Ports and Cities*) has appointed '10 goals for sustainable port cities' (AIVP 2018), including the goals '*Climate change adaptation: preparing city ports for the consequences of climate change*', and '*Protecting biodiversity: city port diversity must be preserved and protected'*. And the Port of Rotterdam launched a program '*An open port in a natural delta'* in collaboration with the World Wildlife Foundation in 2015 (Port of Rotterdam 2015). All these initiatives are interesting, but they start from the assumption that the existing port systems and navigation networks will be maintained and extended – with some additional attention to avoid or compensate for environmental damage.

But delta regions find themselves in such a critical phase that more than only avoiding and compensating for environmental damage will be necessary. Many delta regions have reached a point when the role of ports, the sites of the ports, related infrastructures and land use should be discussed in a more fundamental way.

This paper attempts to link these lines of inquiry and to address the need for strategies (including governance arrangements) to develop *smarter* port cities and enhance the resilience and sustainability of delta regions.
Section 2 and 3 will explain the specific dynamics of the delta landscapes (section 2), the rise and characteristics of port regions in these landscapes (section 3) and the consequences for urban development (section 4), illustrated by the largest port regions of the North American and the European continent: the Mississippi River delta and the Rhine-Meuse-Scheldt (RMS) delta. Section 5 will compare these two delta regions and their port complexes; section 6 will argue for new approaches in the 21st century. Finally, section 7 will draw some conclusions for the governance of port cities and delta regions.

Two dynamic delta systems (2)

Rivers, coastlines, deltas, estuaries are dynamic landscapes with continuously changing relationships between land and water. The changes result from natural processes involving water flows, sedimentation, erosion and climate change (not only that of current interest, but that which is a phenomenon of all centuries).
As a result of the continual change, these landscapes show a large variety of land-water interfaces, which enable the development of rich ecosystems that provide many ecosystem services (Costanza et al. 1999). The most important ecosystem services are the processes of sedimentation and erosion. Sedimentation results finally in the *making of land:* delta territories are young, alluvial territories, produced by rivers' transport and deposit of sediment. Erosion, in contrast, results in deep waters and the disappearance of land. The balance between sedimentation and erosion is what defines the evolution of the delta territory's shape. In most delta territories, the natural processes of land making are stronger then the erosive processes. The result is a steady growth of young, alluvial and low-lying territories in deltas and coastal zones since the end of the last ice age, 10.000 years ago (Bradshaw and Weaver, 1995). This accounts also for the deltas of the Mississippi river and the Rhine (Figures 1 and 2).

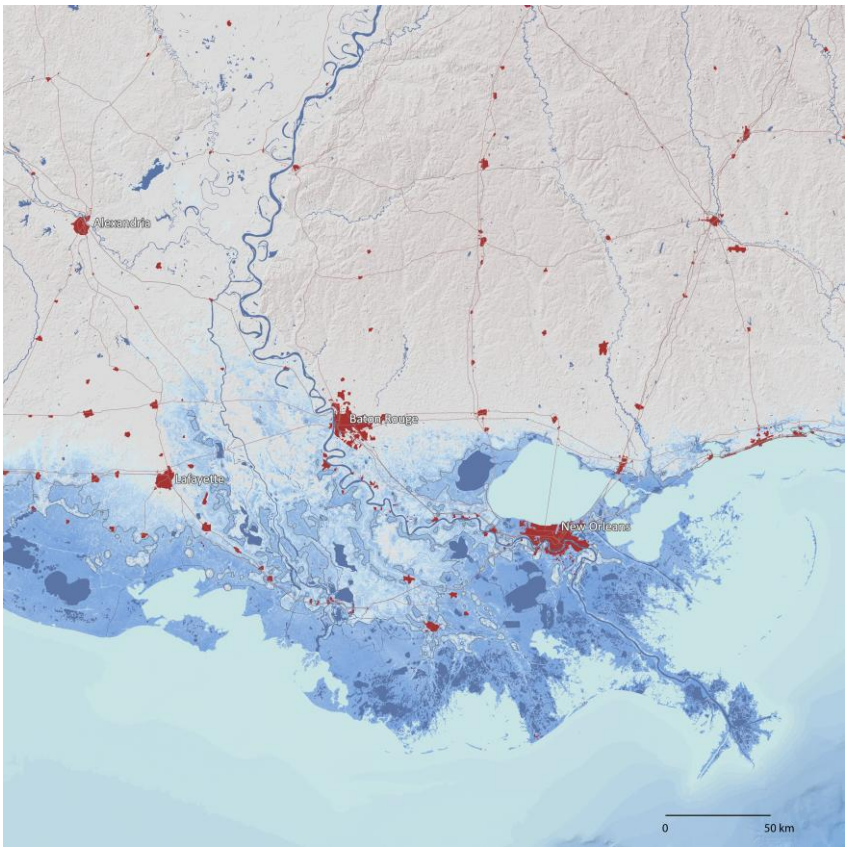

Figure 1. The Mississippi River delta.
Alluvial low lands in blue, urbanization in red.
Map by Nijhuis and Pouderoijen, TU Delft.

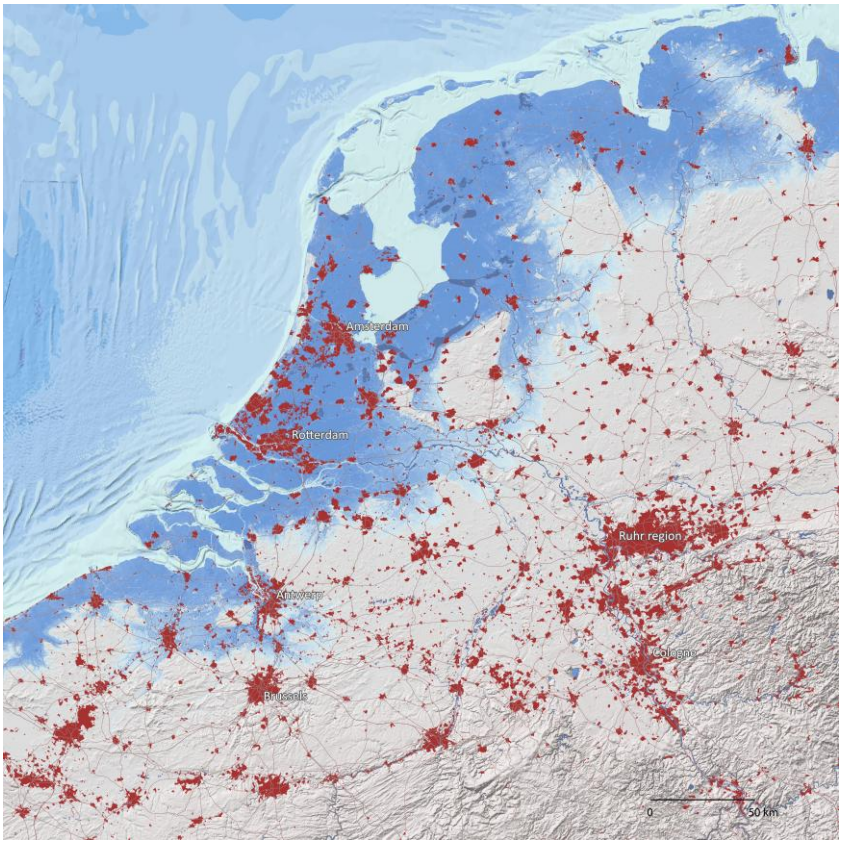

Figure 2. The Rhine-Meuse-Scheldt delta.
Alluvial low lands in blue, urbanization in red.
Map by Nijhuis and Pouderoijen, TU Delft.

A closer reading of maps of the historic evolution of rivers, deltas, estuaries and coastlines show certain trends in the 'behavior' of delta systems. By depositing sediments, rivers create their own barriers, which force them to find another route to discharge water. The result is the slow but inevitable movement of river courses and river mouths from north to south, from east to west, etcetera. We can regard these changes as a fundamental part of river and delta *system dynamics* (Kleinhans et al., 2013). Both delta systems, the Mississippi River delta and the RMS delta, show remarkable trends in their 'behavior'.

The Mississippi river, with a length of 6,275 kilometers, is the fourth largest river in the world. Its nickname, 'muddy river', refers to the large amount of sediment transported by this river and deposited near the river mouth, resulting in large expanses of wetlands and mangrove forests (Thorne et al., 2001; Walker 1994). The sediment deposits also have repeatedly resulted in blockades disrupting the river's flow. These blockades, produced by the river itself, lead to frequent changes in the river's course and have resulted in a clearly discernible movement of the river mouth from east to west and a confluence of the Mississippi river with the Atchafalaya river, some 80 kilometers northwest of the city of Baton Rouge. A part of this long-term fundamental trend, the silt blockades and changing discharge quantities have resulted in problems for navigation as well as many floods in the river valley and the delta.

During the 19th and early twentieth century, a significant debate took place regarding the most desirable way to get control of the river. Should the dynamic and capricious character of the river be accepted as a basic characteristic of the landscape? This was the plea of, for instance, Mark Twain, who started his career as a steamboat pilot on the Mississippi. He had learned to live with the constantly changing riverscape and was convinced that any attempt to control the river dynamics would result in disaster (Twain 1883/2000). Many others, including the American Union of Civil Engineers, shared this opinion (Barry 1997). However, the US Army Corps of Engineers (USACE) espoused a different view. Following the Civil War, they had acquired the responsibility to develop and maintain the Mississippi river as the country's main navigation channel and to manage flood protection for adjacent territories. The USACE decided to construct a 'harness' of dikes and dams and to secure the river course in the channel passing New Orleans (Barry 1997; O'Neill 2006). This entailed a radical intervention in the river and delta system through the building of a huge number of waterworks. These waterworks included dams and locks to prevent the confluence of the Mississippi and the Atchafalya, dikes to avoid frequent floods of the areas and cities adjacent to the river, and spillovers to create bypasses for the river water in times of extreme peak discharges (Figure 3).

Figure 3. The current main water system of the Mississippi River delta.
Map by MUST Stedenbouw.

The diking of the Mississippi river and the damming of most of its distributaries resulted in a structural decay of the delta wetlands and mangroves, which function as a buffer to decrease the power of hurricanes. The lack of a regular supply of fresh water and sediment caused the loss of more than 5,000 km^2 of marshlands during the period 1930 - 2010 (Campanella, 2014).

The rivers Rhine, Meuse and Scheldt are of quite a different size than the Mississippi river. The Rhine, with its length of 1,320 kilometers, is just a medium-sized river. The Meuse and Scheldt are even smaller. Still, the importance of these rivers is comparable to the Mississippi river in terms of the water they discharge from the European continent and the economic benefits they provide by connecting the two largest ports of Europe with the European hinterland. The Rhine, Meuse and Scheldt meet each other currently in a common delta landscape, stretching from Rotterdam to Antwerp. This confluence is a result of historic changes of the trajectories of these three rivers. The change of the course of the Rhine plays an especially important role in the evolution of this delta landscape. Until the 11th century, the main course of the Rhine ran via Utrecht and Leiden and flowed into the sea near Katwijk, around 30 kilometers north of the current city of Rotterdam (Van de Ven, 2004). Beginning in the 11th century, this river track started to silt up. The main course of the river found a new way through the current track of Waal and Merwede, which eventually joined the river Meuse, creating a common new river mouth '*Nieuwe Maas*' (New Meuse). A new era started in the 1700s, when the *Nieuwe Maas* also began to silt up and the main discharge of the river Rhine and Meuse moved southward again, to the estuaries *Haringvliet* and *Grevelingen.*

From the late 18th through the 19th century, the process of nation-building and the foundation and growth of the national engineering institution *Rijkswaterstaat* (RWS, national water management agency, founded in 1798) marked a new phase in the manipulation of the delta system dynamics. RWS worked to stop the southward movement of the main discharge of the rivers and to repair the Nieuwe Maas as the main discharge channel. They made a radical intervention in the water system by digging a new artificial connection to the sea: the *Nieuwe Waterweg* (New Waterway), completed in 1871 (Bosch, Van der Ham, 1998; Van de Ven 2008).

The role of the Nieuwe Waterweg as the main discharge channel of the rivers Rhine and Meuse was strengthened by the construction of the 'Delta Works' in the 1960s and 1970s (De Haan, Haagsma 1984; Steenhuis 2016). The disastrous flood in the delta region in 1953, with more than 1800 fatalities, was the main impetus for this new flood defense system, which was intended to protect both the people and the agricultural economy of the islands in the delta. But an additional benefit of the Delta Works was that it made it possible to regulate the discharge of the Rhine and Meuse towards and through the Nieuwe Waterweg more effectively (Figure 4). This regulation system helped maintain the depth of the Nieuwe Waterweg, preserving it as a navigation channel, and also helped to reduce salt water intrusion from the sea (Van de Ven 2008; Meyer 2017).

Figure 4. The present day main water system of the Rhine Meuse Scheldt delta. Map by MUST Stedenbouw.

Two dynamic port city regions (3)

The systems of ports and cities can also be considered dynamic and evolutionary systems, but these dynamics are not simultaneous with the dynamics of the delta territories. Not only the sizes of ports are growing, but also their numbers. Many delta regions show a rise and growth of multiple ports and port cities.

Notteboom and Rodrigue (2005) have pointed out the evolutionary changes in these port regions: from a system of scattered, independent ports, regional networks have emerged via a process of interconnection and centralization. The cases of the Mississippi River delta and the RMS delta show two different types of port city regions. Figures 5 and 6 show the spatial configurations of ports and cities in the two delta regions. These spatial configurations are quite different.

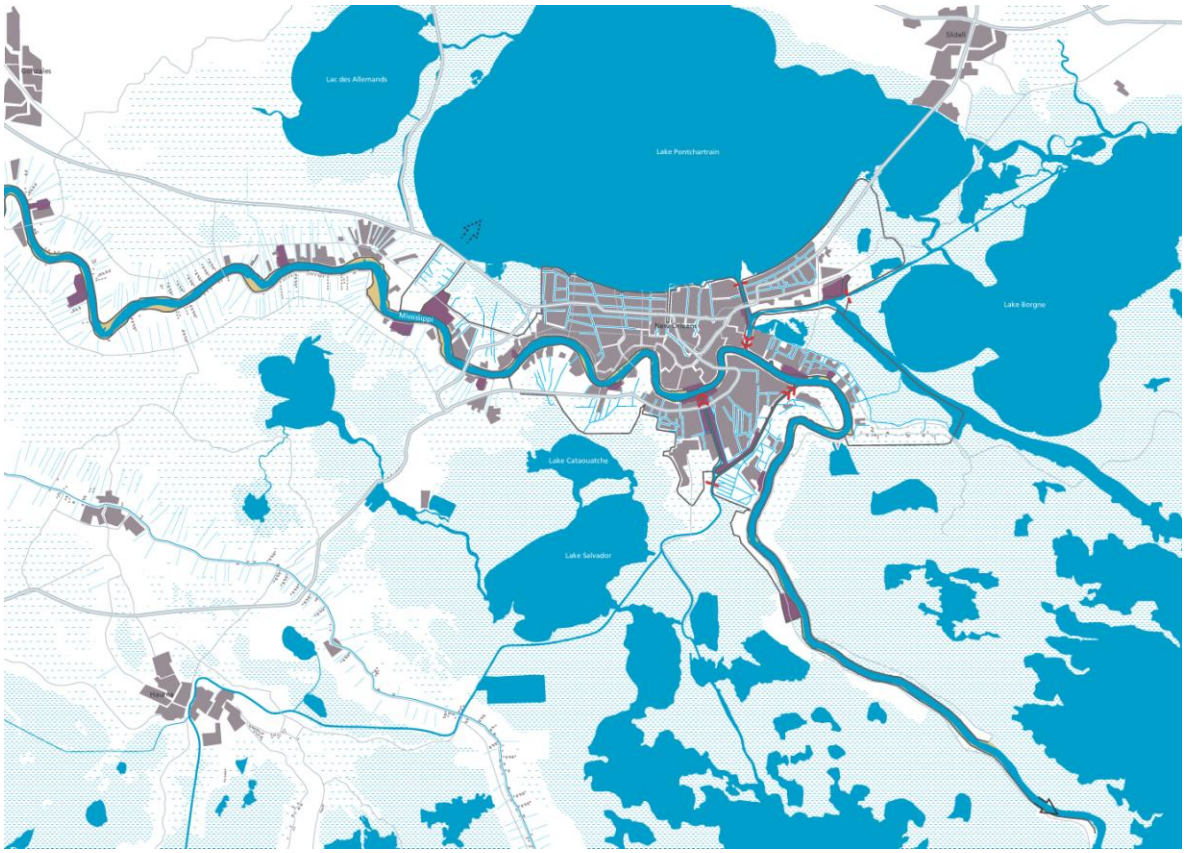

Figure 5. Urbanization (grey) and ports (purple) in the Mississippi River delta.
Map by MUST Stedenbouw.

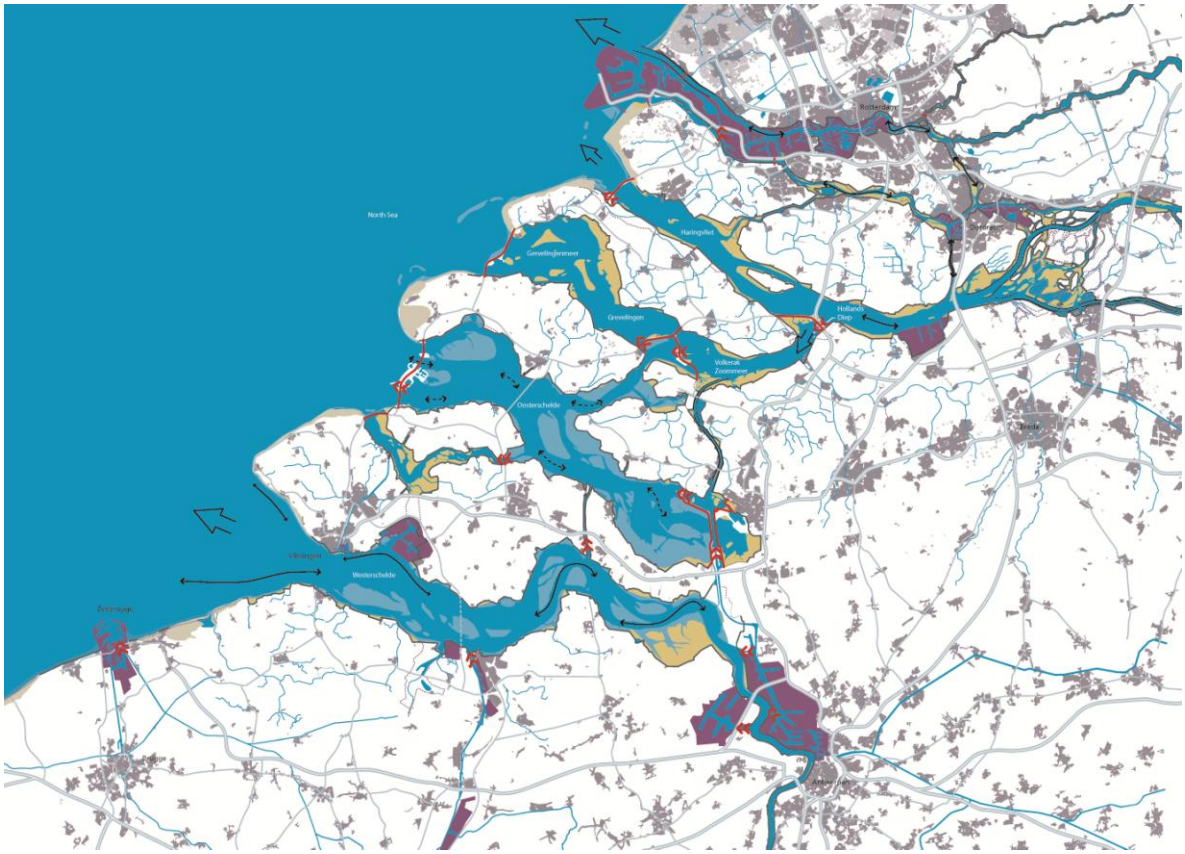

Figure 6. Urbanization (grey) and ports (purple) in the Rhine Meuse Scheldt delta.
Map by MUST Stedenbouw.

Until the mid-19th century, most of the port activities of the Mississippi River delta were concentrated in and around New Orleans. This concentration of port activities changed after the interventions of the USACE in the river system. When the USACE channeled the Mississippi river, the Lower Mississippi developed into a stretch of port terminals more than 270 kilometers long between Baton Rouge and the river mouth, coordinated and facilitated by the Greater Baton Rouge Port Authority, the South Louisiana Port Authority, the New Orleans Port Authority and the Plaquemines Port Authority. This extensive port complex can be considered the largest of the US, with a maritime freight volume of 410 million tons and facilitating more than 70% of US agricultural exports (mainly grain, corn, soy) (data by local port authorities 2017-2018). The linear shape of this regional port complex is directly related to and dependent on the USACE's hydraulic interventions, leading to the channeling of the Mississippi river. The closing of all the distributaries and of the connection with the Atchafalaya river has resulted in increased amounts of water flowing through the river bed and in an increased speed of the water flow. The consequence of these increased amounts and speeds of the water flow is that the riverbed has been scoured to incredible depths. Passing New Orleans, the depth of the river is 60 meters. Instead of a capricious river, full of continuously changing shoals, the river mouth has become an extremely deep channel, providing large sea vessels access to port terminals more than 250 kilometers upstream.

The RMS delta shows the rise of a quite different type of port city region. Many transshipment companies have several terminals in different ports in this region. The collaborations and exchange of cargo among these ports is intense. The Rhine-Scheldt canal, connecting the ports of Rotterdam and Antwerp with each other, is the busiest transport corridor for river vessels in Europe (Vanelslander 2011). The port cities are organized as a horseshoe around the northern, eastern and southern edges of the delta (Figure 7). The reason for this structure can be found in the long history of the rise and fall of port cities related to the evolution of the natural dynamics of the delta.

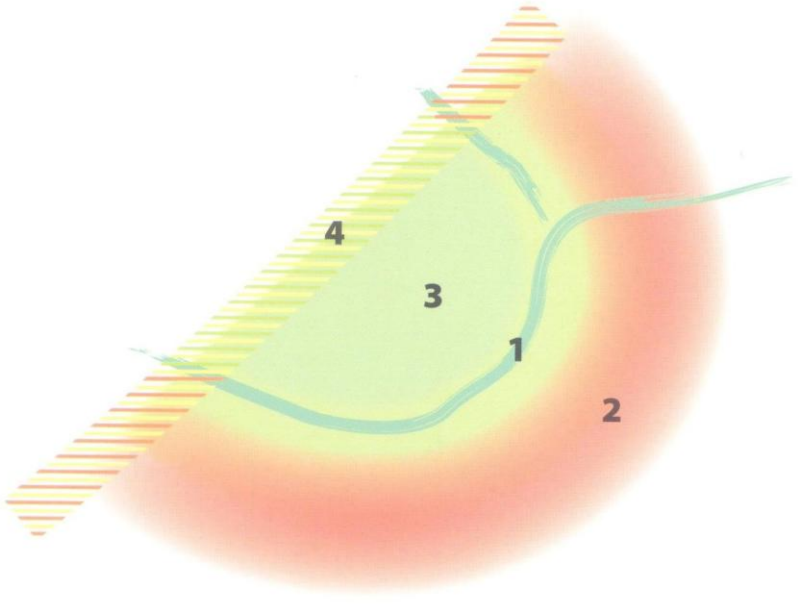

Figure 7. The 'horseshoe' structure of the RMS delta. 1: the delta waterways; 2: the urban shell; 3: the blue-green heart; 4: the delta coast. Image by Rijn Schelde Samenwerking.

In the 13th – 17th centuries, the increasing importance of the *Nieuwe Maas* as the new mouth of Rhine and Meuse together with the growth of the adjacent estuaries created the condition for the rise of a series of port cities including Dordrecht, Rotterdam, Schiedam, Vlaardingen, Goedereede,

Brielle and Zierikzee. The economic, political and military competition among these port cities resulted in a predominance of Rotterdam beginning in the 16th century.

When the northern provinces of the Netherlands came into conflict with the Spanish/Habsburg king and started to fight for their independence in 1568, the West Scheldt became a central battlefield during the subsequent 80 years, resulting in the decay of Antwerp as a port city and the rise of Amsterdam and Rotterdam as new and important port cities of the young Dutch Republic. With the end of military and political tensions between the southern and northern Netherlands in 1815, Rotterdam as well as Antwerp continued to grow as port cities.

Then, the construction and consolidation of the Nieuwe Waterweg made it possible for Rotterdam to become the most important transit port of Northwest Europe, opening the industrial center of Germany (the Ruhr area) to the North Sea. Rotterdam extended its port activities dramatically by developing a serried port territory of 12,000 hectares, which, in 2018, offered space for a total freight transport of 469 million tons (data by local port authority). The port specializes in the transshipment, storage and processing of fossil fuels: oil, gas and coal. More than 60% of the port territory is devoted to activities related to these fossil fuels.

Antwerp succeeded in growing as an important port too, connected with the German hinterland by a railway, nicknamed 'the iron Rhine'. Also access to the Antwerp port from the sea had to be improved repeatedly by dredging the West Scheldt deeper and deeper. The result is that the port of Antwerp became the second largest port of the European continent, with 224 million tons of freight transport in 2018 (data by local port authority).

Next to Rotterdam and Antwerp, some smaller ports play an important and underestimated role.
The physical conditions for a smart regional port network are already realized; the question is how this network can be used in an optimal way. We will discuss this in the final paragraph.

Two river-oriented port cities (4)

Until the early 20th century, the dominating cities in both delta regions, New Orleans and Rotterdam, were famous for their beautiful waterfronts. The city of New Orleans was built on the natural levee of the Mississippi. The tons of silt, left behind by repeated floods over many centuries, had created the elevated embankments. This process of flooding and silting didn't stop after the building of the city but continued and was used as a natural resource to build and elevate the city. The city government protected the riverfront as a public amenity, a source of silt that could be used for streets and building plots. For this reason, according to Upton, New Orleans was provided with the most public waterfront of the US in the 19th century, offering urban space with splendid views of the river landscape and port activities (Figure 8) (Upton 2008).

The USACE's changes in the river system put an end to this unique waterfront. The canalization of the Mississippi resulted in increasing heights of the river water during peak discharges, threatening the city with serious floods. To reduce the flood risk, the USACE built a dike along the river in front of the famous New Orleans waterfront, protecting the city against floods but also destroying the view of the river. During the 20th century, the dike was elevated several times and enforced with a floodwall, which created a barrier between the historic French Quarter and the river (Figure 9).
During the 20th century, the city expanded rapidly and even extended into the lower wetlands, behind the natural levees. Intensive drainage of these wetlands delivered dry and solid building plots, but resulted also in a substantial soil subsidence. Most of the urban territory of New Orleans now lies between one and three meters below sea level (Campanella 2014). So, while the water levels of the river were rising, the urban territory was expanding and subsiding. The effects of a flood would be disastrous - and they were in 2005 after Hurricane Katrina.

Figure 8. New Orleans waterfront in 1859, painted by Adrien Pessac.
Courtesy the New Orleans Historic Collection.

Figure 9. New Orleans waterfront with floodwall, 2012.
Photo by author.

Rotterdam's waterfront has experienced a similar process. Early in the 17th century, when the city expanded its territory towards the river, building a new 'water city' by reclaiming and elevating previous sandbars, the waterfront was reconstructed as a public boulevard, lined with trees that gave this boulevard its name; the 'Boompjes' (Figure 10) (Meyer 1999).

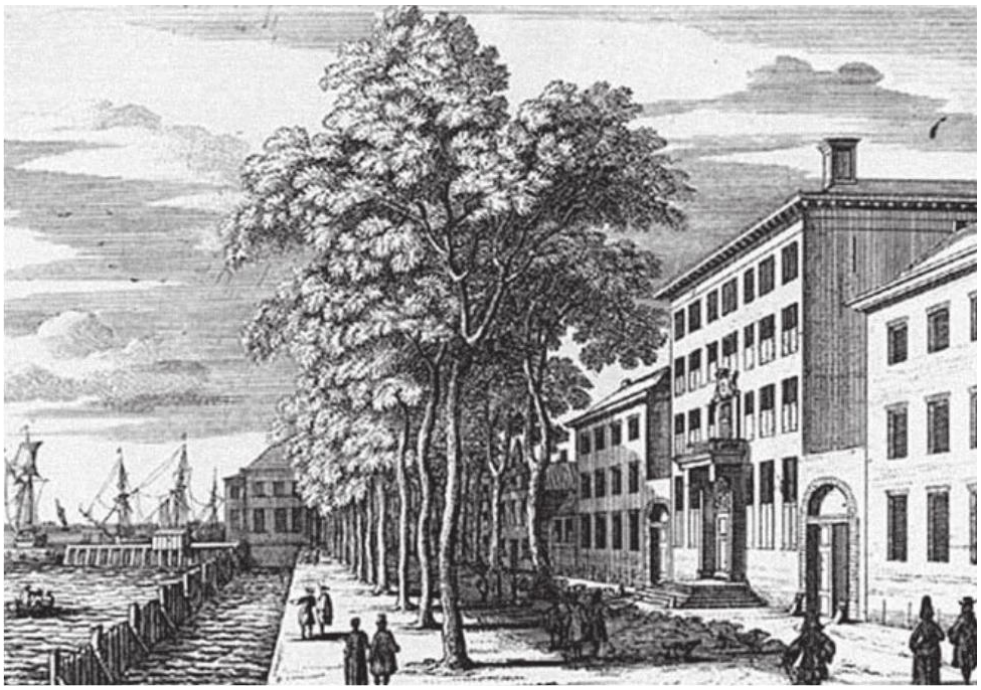

Figure 10. Rotterdam waterfront, 1700, by Petrus Schenk.
Courtesy of Gemeente Archief Rotterdam.

However, as in New Orleans, the significance of the waterfront as a central public space would disappear. The construction of the Nieuwe Waterweg resulted in an increase of the tidal range of the river near Rotterdam (Figure 11), leading to more frequent flooding of the areas outside the dikes, including the 'water city'.

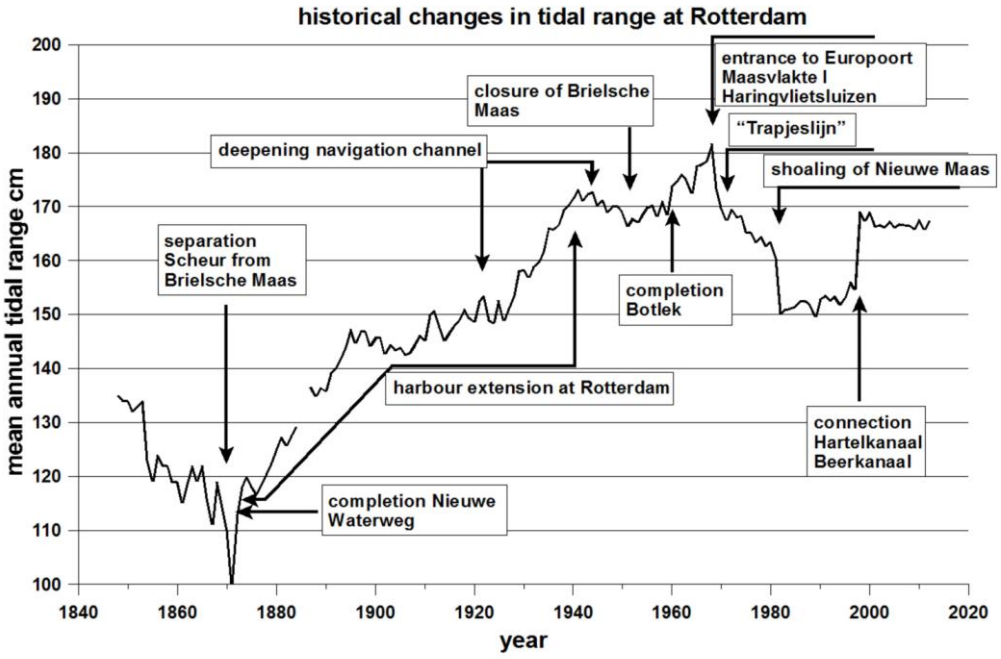

Figure 11. Historical changes in tidal range at Rotterdam. Source Paalvast 2014.

After German bombs destroyed the city center in 1940, a new dike was on what had been the waterfront of the Boompjes (Figure 12). The result was comparable with the case of New Orleans: the new waterfront was separated from the city by the new flood defense.

Figure 12. Construction of the new flood defense at the Rotterdam waterfront, 1960. Photo by J.F.H. Roovers.

However, a big difference from New Orleans is the intensive urbanization of former port areas beginning in the 1980s. The movement of the port westward, leaving behind the older port areas dating from the 19th century, meant that it was possible for the city to expand within its own limits. Since the mid-1980s, some 20,000 residential units have been built in the former port areas, along with many offices and cultural and commercial facilities. This represented a major turn in the relationship between city and river, leading to a regained significance of the river as a central public space in the city (Figure 13).

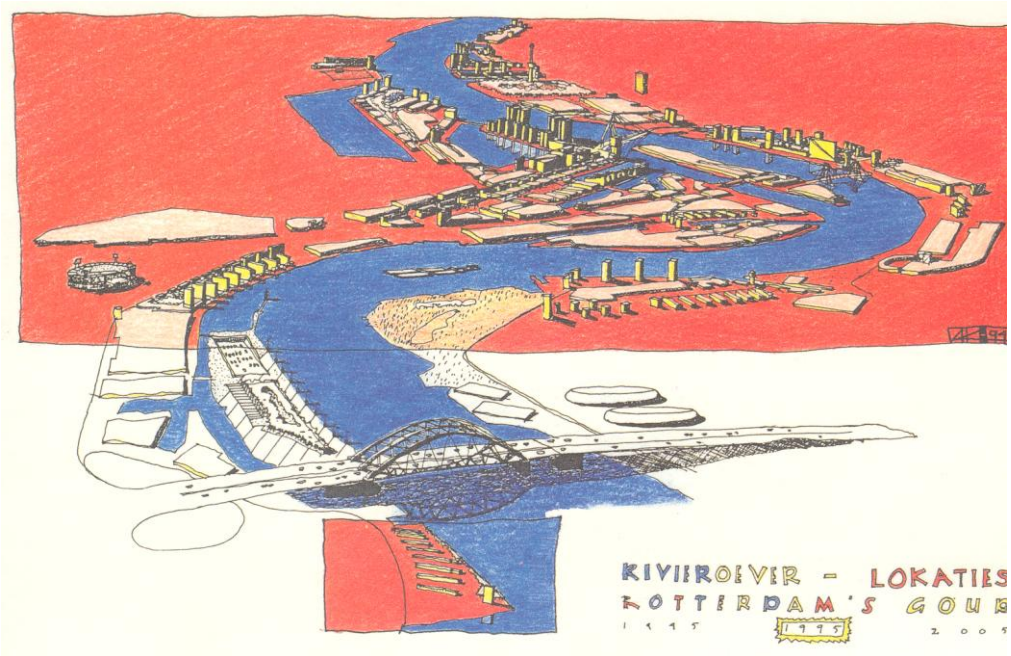

Figure 13. New river-oriented urban projects 1995 – 2005. Drawing by Rotterdam City Department Urban Planning.

The new urban districts have been built 'outside the dikes', which in the 1980s and 1990s was not yet considered a problem. Now more than 60,000 people are living in areas outside the dikes in the Rotterdam region, where they are subjected to an increasing flood risk. It is true that a new storm surge barrier (the 'Maeslant barrier') was built in the Nieuwe Waterweg in the 1990s. The barrier is supposed to be closed once in five years at maximum, which will not harm the port and navigation activities structurally. However, when the frequency of closures of this barrier begin to increase to one or more times a year, that will become another story. The economic importance of the continuation of port and navigation activities will increasingly conflict with the safety of citizens.

Taking the stock: economic benefits, ecological decay, climate change (5)

There are many differences in the character and spatial structures of the Mississippi River delta and the RMS delta, including the character and spatial structures of the regional port complexes. But there are three important common features:

- First: the water systems in the deltas of Mississippi and Rhine, Meuse and Scheldt have been changed substantially by radical hydraulic interventions during the 19th and 20th centuries, aiming to control and fix the river discharge through a specific channel.
- Second: the primary goal of these hydraulic interventions was to create optimal conditions for the growth of the ports. Systems for flood risk reduction had to be adapted to this primary goal. The economic growth, especially the growth of the port economy in both delta regions during the last 150 years, has been spectacular. Figure 14 shows the growth of the ports of the RMS delta in this period.
- Third: the hydraulic approach of the 19th and 20th centuries has come at the expense of the ecosystems of both deltas and at the expense of the safety of the inhabitants and the availability of fresh water.

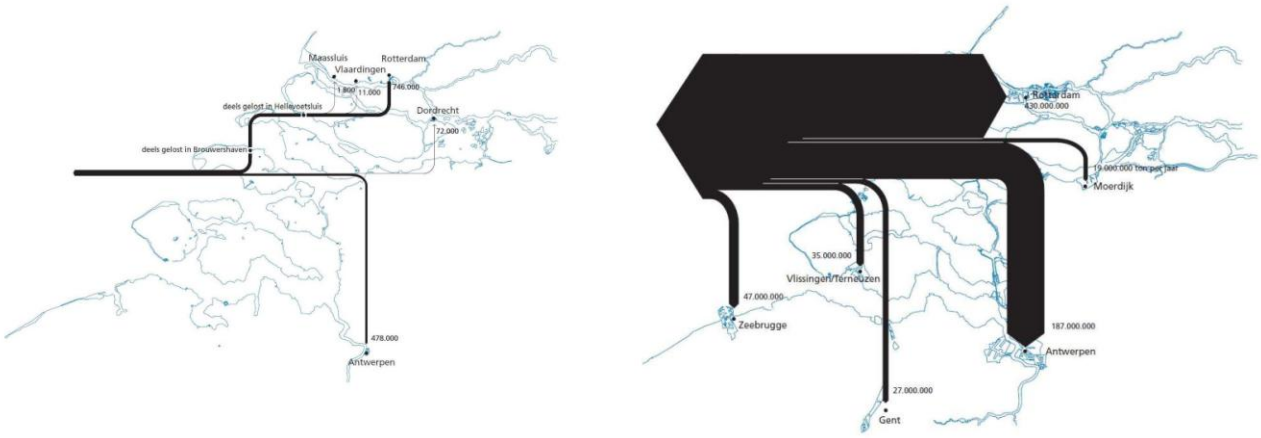

Figure 14. Volume of maritime freight transport in the Rhine Meuse Scheldt delta in 1850 (left) and 2011 (right). Source: Meyer et al., 2014.

The ecosystem decay reduces the natural ability of delta regions to serve as 'land making machines' and buffer zones that could absorb high water events (Paalvast 2014). The gradual disappearance of the wetlands of the Mississippi delta is an increasing problem for the safety of the city of New Orleans. Also, the Nieuwe Waterweg in the RMS delta has resulted in the sea's exerting a stronger influence in the Rotterdam region, with more salt intrusion which threatens the availability of fresh water (Hydraulic BV, 2015). The extremely hot and dry summer of 2018 revealed the critical situation concerning fresh water availability in the Netherlands (Ministry I&W 2018).

Also, the repeated deepening of the West Scheldt to improve the accessibility of the Antwerp port has greatly damaged the West Scheldt ecologically (Meire, van Dyck 2014). This is all the more serious because the West Scheldt is the only estuary remaining in the whole RMS delta region. These problems will not disappear future by themselves. On the contrary: recent reports show that the increasing chance of an acceleration of climate change will lead to more extremely dry summers and to a more extreme sea level rise of probably 85 centimeters (IPCC 2019) or possibly 2 meters or more by 2100 (Deltares 2018).

The need to rearrange the hydraulic systems of the deltas to achieve greater resilience and sustainability has been addressed in many proposals and initiatives. In both deltas there is a need to restore the quality of the delta as a land-making machine, which provides not only biodiversity but also safety and fresh water. 'Building with Nature' has become a slogan in the development of a new approach in both delta regions.

The need for new radical approaches (6)

Both delta regions show that radical adaptations are necessary and possible. In both cases, the support and collaboration by port authorities as well as national water agencies like USACE and RWS are crucial. The essence of this support and collaboration is a 'smart port policy':

- At the local scale, the Port of Rotterdam should (and is able to) develop a strategy to abandon the deep sea port functions in the upstream areas. Taking into account the substantial effects of energy transition, the domination of fossil fuel related port areas will come to an end in the future; the port can anticipate this development in a creative way.
- At the regional scale, better coordination and collaboration among the ports in the same region is possible. This will contribute to a better balance between the port economy and the sustainability and resilience of the delta landscape. In the RMS delta, there are several deep sea ports like Vlissingen and Zeebrugge that are able to take over tasks from Antwerp and Rotterdam. It is true that a region like the RMS delta has a strong historic ballast of competition between nations (The Netherlands and Belgium), cities and ports. But more coordination and agreement on common goals can make the RMS delta a real regional port *network,* in line with the ideas of Notteboom and Rodrigue (2005). It is promising that several initiatives are working to improve coordination and negotiations at the regional level, like the Rhine-Scheldt Delta Samenwerking (Rhine Scheldt Collaboration, Verbeek et al. 2006) and the Vlaams-Nederlandse Delta (Flemish Dutch Delta, Vanelslander et al. 2011). These initiatives should be embraced and supported by the national governments.
- At the international scale, agreements and rules concerning the maximum sizes of ships will be necessary. The ongoing increase of the size and sea gauge of oil tankers and container ships has a limited economic benefit but a huge ecological impact on the delta landscapes.

Addressing the need of radical adaption's leads to the question who and which institutions are in charge. Both delta regions show extremely complex governmental structures, without a clear hierarchy or decision model. The national water management authorities (USACE and RWS) and the port authorities are sectoral institutions (responsible for water management and port management). They work separately from each other, have their own goals, management structures and policies, but are very dependent on each other at the same time. USACE and RWS both are *national* water management authorities, but are quite different. During the process of nation building in the 19th century, many western countries were struggling with the question of whether the national institutions for water management should be civil or military organizations (Barry 1997; Lonquest et al. 2014). While the Dutch decided to organize RWS as a civic institution under the responsibility of a minister of public works (in 1798, during Napoleonic domination..!), the American debate resulted in delegating responsibility for national water management to the army. The national waterways (with the Mississippi river as main corridor) and the coastal zones were considered crucial for the safety and protection of the nation, and guarding this national

interest was (and still is) considered the primary task of the military. This means that, in the large national territory of the US, local and regional priorities always take second place. In order to avoid too much involvement of the regional departments of USACE with the region itself, regional USACE officers are replaced every three years. A close interaction between USACE policies and ambitions of regional institutions (including port authorities) is rather difficult in this context. Also the Dutch RWS, despite its holding the status of a civic institution, has a reputation of being an autonomous and authoritarian organization, detached from local communities or environmental organizations with their specialism (Pollmann 2006; Metze 2009).

However, notwithstanding the strong tradition of the USACE as well as RWS to keep their distance from local interests, a move towards more integrative approaches, taking into account specific environmental and spatial qualities, can be perceived since the 1980s (Willingham 2014; Saeijs 2006). In the Netherlands, the development of the Room for the River program represented a fundamental culture change in the RWS, leading to a new balance between the central coordination of goals and standards for the river area as a whole and flexibility and involvement of local stakeholders at the local level.

The port authorities in the two delta regions are organized very differently. The four port authorities in the Mississippi river delta are public agencies, representing the interests of municipalities ('parishes') along the banks of the river. It is difficult to discuss fundamentally reorganizing the port system with four different port authorities, let alone moving port terminals to another site in the delta region.

In the Netherlands, the port authority of Rotterdam became a public agency of the City of Rotterdam in 1932. Following the wave of privatization of public institutions in the 1990s and the beginning of the 21st century, the Rotterdam Port was turned into a limited company in 2004. It is true that the only two shareholders, the City of Rotterdam (70%) and the national state (30%), are public institutions. But the 'behavior' of the port authority since 2004 has become more corporate. Before 2004, the City of Rotterdam was able to consider investments and profits of the port in relation to the city's other public policy goals. Since 2004, the Port Authority has functioned as an autonomous company. Nevertheless, the Rotterdam Port Authority aspires to become the most sustainable and environment-friendly port of the world (Rotterdam Port Authority, 2012). Similarly, the four port authorities in the Mississippi delta have expressed goals concerning sustainability and environmental quality in their annual reports.

Despite the changed ambitions of the water management authorities and port authorities concerning environmental policy and sustainability, a real breakthrough towards a fundamental system change was forced by outsider and non-institutional organizations and citizen's initiatives.
In the Mississippi river delta, it was Hurricane Katrina (2005, more than 1800 deaths, estimated property damage $125 billion) which demonstrated the vulnerability resulting from the combination of a decreased buffer capacity of the delta, a subsided urban territory and a relatively poor flood defense system. A group of citizens, led by local architect David Waggonner, took the initiative to press for a fundamental revision of the water system of the Greater New Orleans metropolitan area and of the Mississippi river delta as a whole. They organized a series of design workshops with American and Dutch experts, titled 'Dutch Dialogues' (Meyer, Waggonner, Morris 2009). After five years, the final result was the new 'Greater New Orleans Urban Water Plan' (Waggonner Ball Architects 2013; Waggonner et al. 2014), which was accepted and supported by the boards of all *parishes* (the Louisiana equivalent of municipalities) of Greater New Orleans.

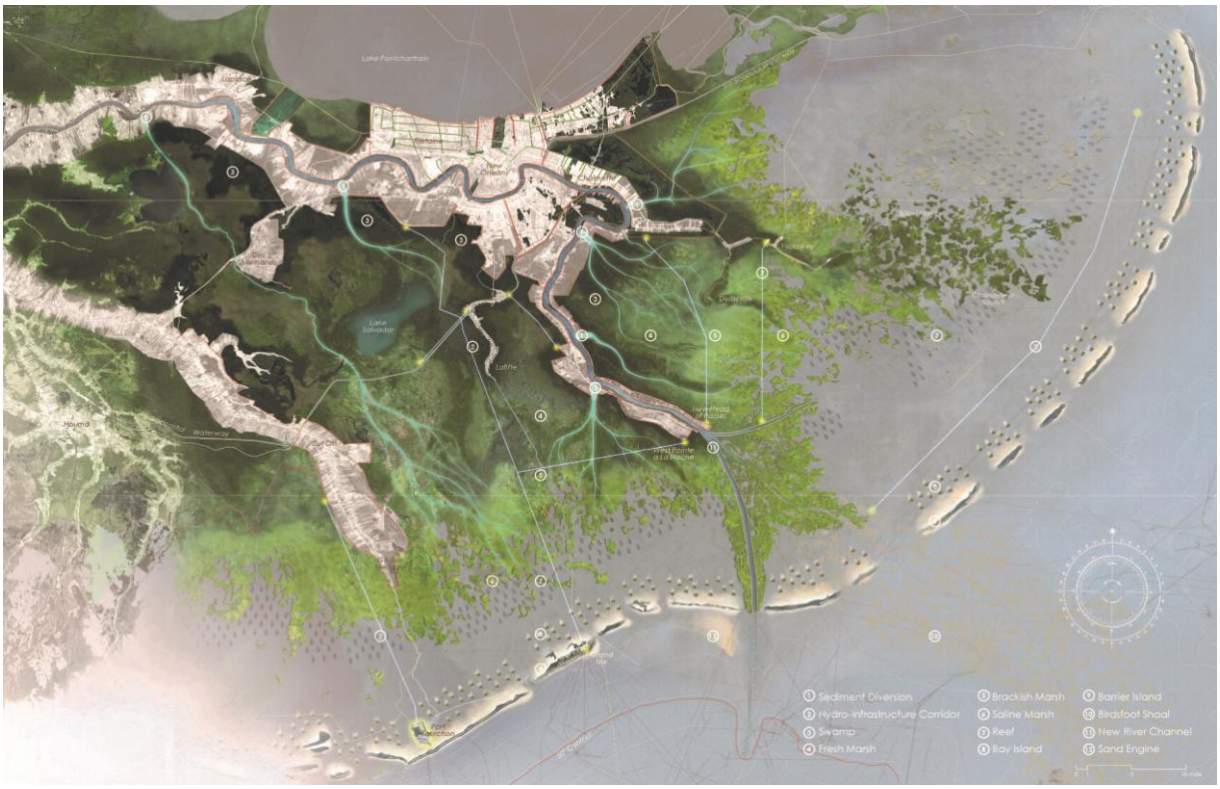

Figure 15. 'Misi Ziibi'. One of the three winning designs of 'Changing Courses' for restoration of the delta around New Orleans. A key feature is the reconnection of old tributaries to the main river. Design by John Hoal, Derek Hoeferlin, Mike Patorno, HKV, Robbert de Koning, 2015.

Parallel to this process, the State of Louisiana took the initiative for the new Louisiana's Coastal Master Plan (Louisiana Coastal Protection & Restoration Authority 2012). As a follow-up, a competition 'Changing Courses' was organized in 2013-2014, in order to achieve implementable design proposals at the regional scale. The three winning teams all addressed the need in the delta to repair the river's sediment and fresh water supply by reopening the distributaries to the wetlands and even to reconsider the Mississippi-Atchafalaya confluence (Figure 15). This approach would influence water levels and sediment deposits in the main river itself, leading to more shallow waters. A current discussion in the Mississippi delta is what the consequences of this approach could and should be for the policy of the port authorities. As a follow-up and convinced by the new approach of New Orleans, the 'Dutch Dialogues' concept has been embraced and applied by several other coastal cities in the US, including Norfolk, Houston and Charleston.

In the Netherlands in 1993 and 1995, extreme peak discharges resulted in two extreme high water events in the central river area; 250,000 people had to be evacuated in the 1995 event. These events led to a fundamental updating of the water system strategy. Prior to these high water events, in the 1980s, an intensive debate had arisen regarding the river landscape due to the RWS decision to strengthen the existing dike system. The private organization Eo Wijers Foundation organized a design competition in 1986, resulting in the prize-winning entry 'Plan Ooievaar' ('Plan Stork') (Leeflang 1986). This plan represented a plea for the repair of the rivers' ecosystems, by widening riverbeds instead of narrowing them and building higher dikes. After the high water events of the 1990s, the principle of the Plan Stork concept was adopted and applied by RWS in a new program for the whole central river area. The result was the 'Room for the River' program (2005- 2015), which led to a structural change of the river beds in the east and central parts of the Netherlands. Many narrow river beds, bordered by high dikes, were transformed into broad river landscapes, creating space for large amounts of water during periods of peak discharges, and at the same time creating conditions for ecological repair and new spatial qualities (Sijmons et al. 2017).

As a follow-up, in 2009 the national government installed a special and independent Delta commissioner, who presented a new national Delta program in 2014, with an annual budget of ca. 1 billion euro. The most difficult but essential challenge of the new Delta program is a reconsideration of the artificial river mouth of the Nieuwe Waterweg (Delta commissioner 2014). The pressure for this reconsideration accelerated because of a conflict between the Port of Rotterdam, which was preparing a new port area on reclaimed land in the sea ('Maasvlakte 2', Meuse plain 2) and the Milieufederatie (alliance of environmental organizations). This alliance was fighting against the reclamation and pleading for the repair of tidal ecosystems in the river mouth and a reopening of the estuaries south of Rotterdam (WWF 2009). The conflict between the port authority and environmental organizations seemed to end in a hopeless juridical clash in the Dutch supreme court, but finally resulted in an agreement between the port and the environmental alliance in 2009 and in a collaboration between the port authority and the World Wildlife Fund. One of the concrete results of this collaboration is the plan 'The River as a Tidal Park' (Figure 16). The plan aims to restore the conditions required for typical delta ecosystems and related biodiversity in and alongside the river, by transforming steep quay walls into gradual green slopes and repairing sandbanks and shallow waters in the river and former harbor basins.

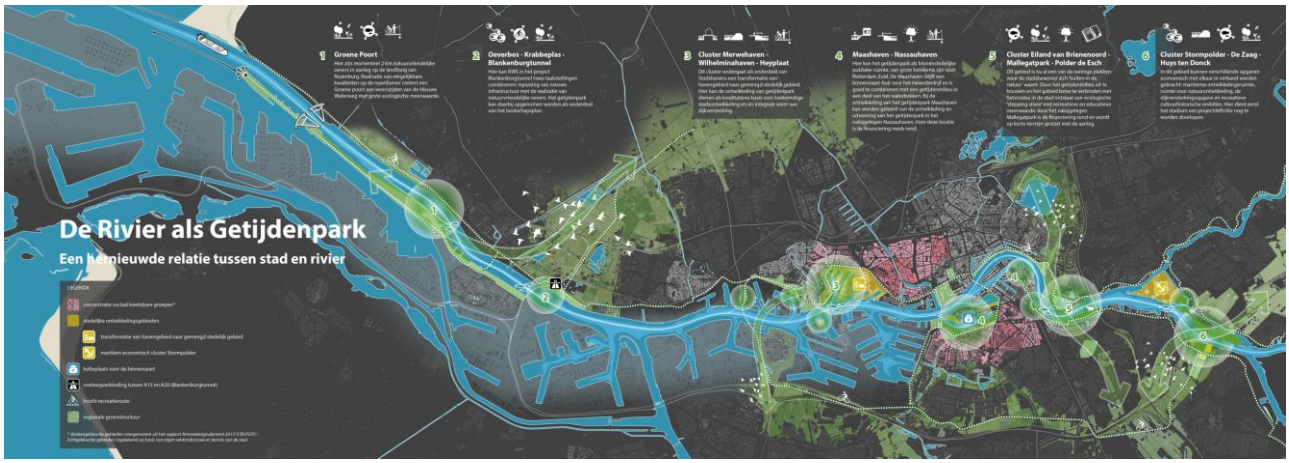

Figure 16. Masterplan 'The River as a Tidal Park', by City of Rotterdam, Port of Rotterdam, World Wildlife Fund and ARK, 2016. Map by De Urbanisten.

In the long term, implementation of the plan should lead to a radical reversal of the trend of the last 150 years, transforming the Nieuwe Waterweg from a navigation channel to an estuary, making the river mouth more shallow, and creating more room for the 'natural behavior' of the river to discharge most of its water volume to the southern estuaries of Haringvliet and Grevelingen, which offer conditions suitable for adaptation to high water events (Meyer et all. 2015). The plan's structural intervention can restore the deltaic ecosystems, including a substantial reduction of the tidal range (and high water events) in the urban areas as well as a reduction of the salt water intrusion.

To conclude (7)

Considering the long term as well as the recent history of both deltas and port city regions and the consequences for the future, we can come to several conclusions. First: for more than 150 years, national water agencies like USACE and RWS have tried to get the water systems of the deltas under control, primarily because they wanted to support and stimulate navigation and port development. The hydraulic policy was focused on the fixation of the water discharges in a harness of dikes, dams and dredged channels. This policy has resulted in explosive economic development of the ports during these 150 years. With this thorough spatial and physical reorganization of both deltas, it seems that there is no 'return' possible to a situation which creates more room for the natural tendencies of both river systems. The path dependency of the processes of the last one and a half century seems to have created an inevitable continuation of

the strengthening and extension of man-made infrastructures. However, the side effects of this approach - ecological decay, increasing flood risk of urbanized areas and increasing salt intrusion - have become too serious to be ignored. Climate change is enhancing these side effects and brings these regions into a critical phase. The need to develop new integrated strategies for the delta regions, working *with* the natural dynamics of the delta regions instead of trying to stop them, has been acknowledged and embraced by a wide range of institutions and organizations, including state-institutions like the State of Louisiana and the Dutch government's Delta program.

'Path dependency' has its limits. Scientists like Scheffer (2009) have shown that if the continuation of the current path of a complex system leads to exceeding the system's critical limits and therefore to the collapse of the system as a whole, it is necessary to choose another path (Scheffer 2009). The 'other path' in our two cases would be the development of a new balance between man-made systems and natural dynamics.

Second: critical events like natural disasters and societal clashes seem necessary before policy-makers will stop and reconsider the seemingly natural continuation of the prevailing policy of national water management institutions and port authorities. In the Mississippi river delta it was the disastrous flood in 2005, caused by Hurricane Katrina, which brought about a fundamental change of the mindset in the institutional arena. It was clear that a simple repair of the destroyed flood defense system and a continuation of a 'business-as-usual' policy would be unacceptable. In the Netherlands, the two extreme high water events in the 1990s and the societal and juridical clash between port authority and environmental alliance have resulted in important changes in the strategies of water management authorities and port authorities. Instead of continuing their autocratic and inaccessible decision-making culture, both types of organizations started to open up and to include local communities and 'outsider'-organizations in formulating new strategies. This means for other delta regions that it is smart not to wait for the disaster or societal clash, but to try to prevent these by choosing a different path earlier.

Third: In both delta regions, it was not the established institutions, but 'outsider' organizations and private initiatives that played a decisive role in coming up with new approaches. In the Mississippi river delta, it was the citizen's initiative of Waggonner cum suis, which brought national institutions like USACE together with local levee boards and urban planning commissions, regional planners with neighborhood committees and designers with scientists, resulting in new ideas about the relationship between urban development and water management in New Orleans and in the delta as a whole. In the Netherlands, outsider organizations like the Eo Wijers Foundation and the World Wildlife Fund played a decisive role in the search for new concepts and approaches for the Dutch delta.

Fourth: 'Smart' strategies for deltas and port regions require smart holistic concepts, which combine innovative hydraulic engineering ('building with nature') and urban planning with innovative solutions for ports and navigation, related to energy transition, a circular economy and the digitalization of logistics and transport. This means that port regions need to be smarter than just smart in terms of smart logistics and transshipment technology. Finding this new, smarter, path for the future development of the delta and port region cannot be developed only through scientific research or by organizing meetings and conferences. The creativity and the conceptual thinking by designers is of decisive importance. This also has been the experience in both delta regions during the last decades: the design workshops of Dutch dialogues, the design competitions organized by Changing Courses on de Mississippi river delta and by the Eo Wijers Foundation in the Dutch river area have helped achieve a breakthrough in the thinking and policy of public institutions and port authorities. Bringing together the creativity of designers, the knowledge of scientists and the strategic and practical insights of open-minded civil servants and administrators made it possible to chart a new path in both delta regions.

References

AIVP 2018, https://www.aivpagenda2030.com/

Barry J. M. 1997. Rising Tide. The Great Mississippi Flood of 1927 and How It Changed America. New York: Simon & Schuster.

Bosch, Jan Willem, Clim Sorée, 2018, Hydrobiografie Schelde-estuarium [Hydrobiography Scheldt estuary], Den Haag: College van Rijksadviseurs.

Bosch, A., and W. van der Ham, 1998, Twee Eeuwen Rijkswaterstaat (1798–1998) [Two centuries National water management agency], Zaltbommel: Europese Bibliotheek.

Bosselmann, Peter C., 2018, Adaptations of the Metropolitan Landscape in Delta Regions, London and New York: Routledge.

Bradshaw, M., R. Weaver, 1995. Foundations of Physical Geography. Boston, MA: Wm.C. Brown Publishers.

Campanella, R., 2014, Fluidity, Rigidity, and Consequence. A Comparative Historical Geography of the Mississippi and Sénégal River Deltas and the Deltaic Urbanism of New Orleans and Saint-Louis. Built Environment, 40(2), 184-200.

Costanza, R., D'Arge, R., Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K. et al., 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature, 387, 253-260.

De Haan, Hilde, Ids Haagsma, 1984, De Deltawerken. Techniek, politiek, achtergronden [The Delta works. Technology, politics, background], Delft: Waltman.

Delta commissioner, 2014, Delta program 2015. Working on the delta. The decisions to keep the Netherlands safe and liveable, The Hague: Ministry of Infrastructure and Environment.

Deltares, 2018, Mogelijke gevolgen van versnelde zeespiegelstijging voor het Deltaprogramma. Een verkenning [Possible consequences of accelerated sea level rise for the Delta program. An exploration], Delft.

Ericson Jason P., Charles J. Vörösmarty, S. Lawrence Dingman, Larry G. Ward, Michel Meybeck, 2006, 'Effective sea-level rise and deltas: Causes of change and human dimension implications'. Global and Planetary Change 50/1–2,63–82.

Hajer, Maarten, Ton Dassen, 2014, Smart about Cities. Visualizing the Challenges for 21st Century Urbanism, Rotterdam: nai010 Publishers.

Hydraulic BV, 2015, Verzilting door verdieping Nieuwe Waterweg en Botlek. Deelonderzoek MER [Salt intrusion by deepening Nieuwe Waterweg and Botlek. Partial investigation Environmental Impact Assessment], Havenbedrijf Rotterdam [Port of Rotterdam].

IPCC (Intergovernmental Panel on Climate Change), 2019, The Ocean and Cryosphere in a Changing Climate, Monaco.

Kleinhans, Maarten G. , Frans Klijn, Kim M. Cohen, Hans Middelkoop, 2013, Wat wil de rivier zelf eigenlijk? [What does the river want itself?], Utrecht: University of Utrecht / Deltares.

Leeflang, H., 1986, Jury rapport Ideeënprijsvraag Nederland rivierenland [Jury report ideas competition the Netherlands – land of rivers], The Hague: Eo Wijers Stichting.

Lonquest, John, Bert Toussaint, Joe Manous Jr., Maurits Ertsen, 2014, Two Centuries of Experience in Water Resources Management. A Dutch- U.S. Retrospective, Alexandria, Virginia: U.S. Army Corps of Engineers and Rijkswaterstaat.

Louisiana Coastal Protection & Restoration Authority, 2012, Louisiana's Comprehensive Master Plan for a Sustainable Coast, Baton Rouge: State of Louisiana.

Meire, Patrick, Mark van Dyck, 2014, Naar een duurzaam rivierbeheer. Hoe herstellen we de ecosysteemdiensten van rivieren? De Schelde als blauwe draad [Towards a sustainable river management.

How do we repair the ecosystem services of rivers? The Scheldt as a blue thread], Antwerp: University Press Antwerp.

Metze, Marcel, 2009, Veranderend getij. Rijkswaterstaat in crisis: het verhaal van binnenuit [Changing tide. Rijkswaterstaat in crisis; the story from inside], Amsterdam: Balans.

Meyer H., 1999, City and Port. Transformation of Port Cities. London, Barcelona, New York, Rotterdam, Utrecht: International Books.

Meyer, Han, David Waggonner, Dale Morris, 2009, Dutch Dialogues. New Orleans - Netherlands. Common Challenges in Urbanized Deltas, Amsterdam: SUN

Meyer, H. and S. Nijhuis, eds., 2015, Urbanized deltas in transition. Amsterdam: TechnePress.

Meyer, Han, Arnold Bregt, Ed Dammers, Jurian Edelenbos, 2015, New Persepctives on urbanizing deltas. A complex adaptive systems approach to planning and design, Amsterdam/Delft: MUST Publishers.

Meyer, Han, 2017, The state of the delta. Engineering, urban development and nation building in the Netherlands, Nijmegen: VanTilt.

Ministry I&W (Infrastructure and Water Management), 2018, Delta program 2019. Continuing to work on the delta: Adapting the Netherlands to climate change in time, The Hague: Ministry I&W.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McClean, S. Ragoonaden, C.D. Woodroffe (2007), Coastal systems and low-lying areas. Climate change 2007: Impacts, Adaptation and Vulnerability. Contribution of working group II to the 4th Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F.Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge: Cambridge University Press UK, 315-356.

Notteboom, Theo, Jean-Paul Rodrigue, 2005, Port regionalization: towards a new phase in port development, Maritime Policy & Management, vol. 32, issue 3, 297-313.

O'Neill K. M., 2006. Rivers by Design. State Power and the Origins of U.S. Flood Control. Durham: Duke University Press.

Paalvast, Peter, 2014, Ecological studies in a man-made estuarine environment, the Port of Rotterdam, Nijmegen: Radboud University.

Pollmann, Tessel, 2006, Van Waterstaat tot Wederopbouw. Het leven van dr.ir. J.A. Ringers (1885-1965) [From water management to postwar reconstruction. The life of dr.ir. J.A. Ringers (1885-1965)], Amsterdam: Boom.

Port of Rotterdam 2015, Een open haven in een natuurlijke delta [An open port in a natural delta], https://www.portofrotterdam.com/en/files/open-haven-in-een-natuurlijke-delta

Rotterdam Port Authority, 2011, Port Compass 2030.

RWS (Rijkswaterstaat), 2005, Mapping safety in The Netherlands. Main report on research into flood risks, The Hague: RWS.

Saeijs, Henk. L.F., 2006, Turning the Tide. Essays on Dutch ways with water, Delft: VSSD.

Scheffer, Martin, 2009, Critical Transitions in Nature and Society, New Jersey: Princeton University Press.

Sijmons, Dirk, Yttje Feddes, Eric Luiten, Fred Feddes, Marc Nolden, 2017, Room for the River. Safe and beautiful landscape, Wageningen: Blauwdruk.

Steenhuis, M., 2016, De Deltawerken, Rotterdam: NaiPublishers.

Tessler Z.D., C. J. Vörösmarty, M. Grossberg, I. Gladkova, H. Aizenman, J. P. M. Syvitski, E. Foufoula-Georgiou (2015), 'Profiling risk and sustainability in coastal deltas of the world'. Science 349/638 pp. 638-643.

Thorne, C. R., O. P. Harmar, and N. Wallerstein. 2001. Morphodynamics of the Mississippi River. Pentagon-Report A236064. Washington, DC: Storming Media.

Twain, Mark, 1883, Life on the Mississippi, Boston: James R. Osgood & Co. Re-edited by Dover Publications Inc., Mineola (NY) 2000.

Upton, D. 2008. Another City, Urban Life and the New American Republic. New Haven: Yale University Press.

Van de Ven, G. P. 2004. Man-Made Lowlands, History of Water Management and Land Reclamation in the Netherlands. Utrecht: Matrijs.

Van de Ven, G.P., 2008, De Nieuwe Waterweg en het Noordzeekanaal, een waagstuk. Onderzoek in opdracht van de Deltacommissie. [The New Waterway en the North Sea Canal - a Venture. Research commissioned by the Delta committee] Den Haag: Deltacommissie.

Vandermeulen J.H., 1996, Environmental trends of ports and harbours: implications for planning and management, Maritime Policy and Management, 23:55-66

Vanelslander, T., Kuipers,B., Hintjens, J. & Horst , M. van der, 2011, Ruimtelijk-economische en logistieke analyse: de Vlaams-Nederlandse Delta in 2040. Antwerpen/Rotterdam: Universiteit van Antwerpen/Erasmus Universiteit Rotterdam.

Verbeek, Marja, Erik de Koning, Dominique ELshout, 2006, Rijn Schelde Delta, Bergen op Zoom: Rijn Schelde Delta Samenwerking.

Waggonner Ball Architects (red.), 2013, Greater New Orleans Urban Water Plan. New Orleans: Greater New Orleans Inc., https://livingwithwater.com/

Waggonner D., N. Dolman, D. Hoeferlin, H. Meyer, P. Schengenga, S. Thomaesz, J. van den Bout, J. Van der Salm, C. Van der Zwet, 2014, New Orleans after Katrina: Building America's Water City, Built Environment Vol.40, nr 2, pp. 281-299.

Walker N. D. 1994. Satellite-Based Assessment of the Mississippi River Discharge Plume's Spatial Structure and Temporal Variability. Gulf of Mexico OCS Region: U.S. Department of the Interior– Minerals Management Service.

Willingham, William F., 2014, The U.S. moves towards more integrative approaches in water management, in: Lonquest et al. 2014.

WWF (World Wildife Fund) 2009, Met open armen: Voor het belang van veiligheid, natuur en economie [With open arms. In sake of safety, nature and economy]. Zeist: WWF.