New Netherlands

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NEW NETHERLANDS

Towards transitional flood risk management anticipating to extreme future sea level rise scenarios

Master thesis
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CONTENT

ACKNOWLEDGEMENTS

This booklet to me is the beautiful ending to seven years of pleasantly struggling with my curiosities and passions. To be able to combine my education in architecture, museology and water management and my interest for visual arts in a graduation project was a joy and truly feels like the crown on my student years.

For facilitating this I would like to thank everybody involved in the project and everybody close to me, except for my parents, team Chris-Taneha-Jos and Lorenzo. For them I would like to take this opportunity to express my sincerest gratitude in more detail.

The feeling that my parents believed in me to the fullest is one of my oldest memories. For as long as I can remember they trusted my decisions, my ambitions and my motives. The calmth and honesty of my parents faith in me is touching and stimulated me to make them proud and to do all the things I enjoy doing, for which I will be forever grateful.

Chris, Taneha and Jos formed the graduation assessment committee every student dreams of. A harmonious trinity of disciplines complementing and inspiring each other and me. Our fruitful discussions and their constructive and positive feedback enthused me every time to make the most out of my research and to reach maximum satisfaction.

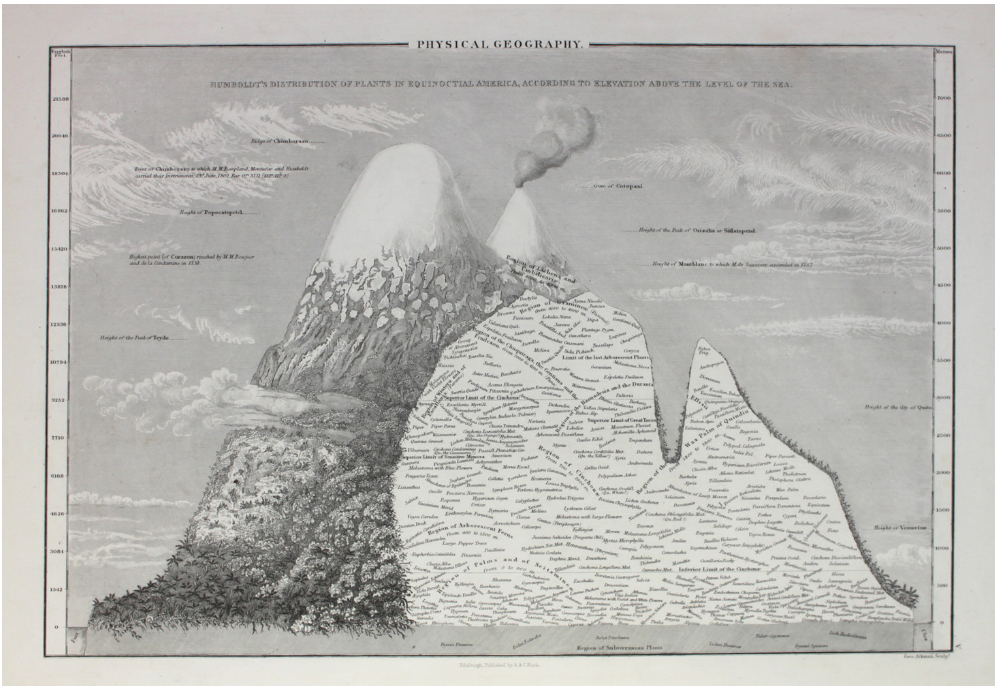
As a friend, I would like to thank Taneha. I feel lucky to have met her, both personally and professionally, as she is one of the most warm-hearted and intelligent people I know and she introduced me to the perfect fusion of my fields of interest. It was very special to me to 'close' this year a few weeks ago by seeing Acqua Alta in Venice with her.

It was a gift from Taneha, a book about the invention of nature and the adventures of Alexander von Humboldt (by Andrea Wulf), which beautifully symbolises the union of aesthetics and science. For many, Alexander von Humboldt was, as Prussian king Friedrich Wilhelm

IV once said, the greatest man since the Deluge. It was Humboldts friend, Johann Wolfgang von Goethe, who encouraged him to combine nature and arts, facts and imagination. This new emphasis on subjectivity allowed Humboldt to link the previous mechanistic view of nature as promulgated by scientists such as Leibniz, Descartes or Newton with the poetry of the Romantics. Humboldt became the link that connected Newton's 'Opticks', which explained that rainbows were created by light fragmented through raindrops, to poet John Keats, who declared that Newton 'had destroyed all the poetry of the rainbow, by reducing it to a prism'.

However with a focus on wind instead of water, Lorenzo is the person I can share my unlikely combination of passions with, beyond ways I thought were possible. He challenges me intellectually and motivates me to enjoy my work and to make my work something beautiful. I am very happy for being with him during my last years as a student as he enriched this time with all the reflexion, support and care but also relaxation, distraction, fun and mostly love, I needed. Therefore I wouldn't know a better person to dedicate my graduation work to, than to him.

Uncolored version of Humboldt's Naturgemalde which was part of his Essay on the Geography of Plants. A comparative map with the distribution of plants in Equinoctial America, according to their elevation above sea level, 1807.



ABSTRACT

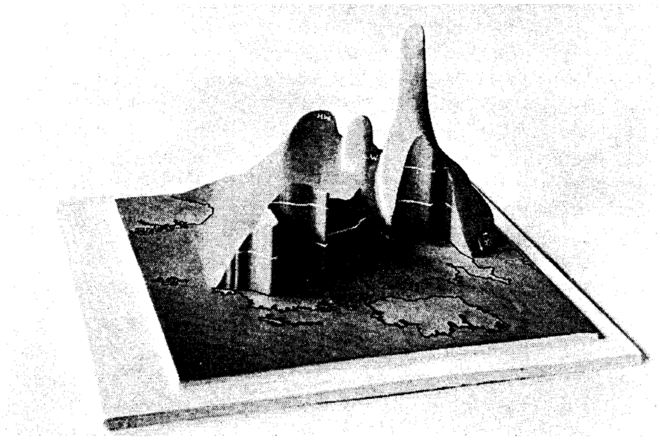
Sea levels are rising globally and the melting Antarctic ice sheet is attributed to be the primary contributor. Due to the deep uncertainty of the causal representative carbon pathways, the plausible range of sea levels rise varies between 0,26 - 2,43 m for 2100 and 0,50 - 15,52 m for 2300. To address deep uncertainty, decision making methods arise which struggle with including measures preparing the shift from incremental to transitional strategies required for the case of extreme sea level rise scenarios. This research addresses flood risk management in the Netherlands, a country which will face ecological, economical, technological and political challenges as sea levels climb. In anticipation to extreme sea level rise and its challenges, the Dutch process of coastline shortening and solidating can be carried through. Another viable option is a more gradual zone between land and water. To review both options, the distribution of systems sensitive to flooding is mapped. The overlay of systems facilitates the establishment of a framework which distinguishes elements based on their pace of transition and offers a multilayered image differentiating regions with an emphasis on either population or nature. This dichotomy structures the proposal for the transitional territorial outline by harmoniously applying a superimposed coastline and a dynamic coastline respectively. Tipping points of flood defence measures assess the physical feasibility of the transition which is mainly constrained by societal limitations. This results in incremental improvements, further increasing transfer costs, path dependency and the difficulty to shift to transitional strategies. Throughout history, only catastrophic floods were leading to transitional flood measures, but transition management is referred to as enabling development of a long-term sustainability perspective, linked to desired societal transitions, to guide accelerated social innovation in the short term. The theory's transition arena with frontrunners and a transition image is capable of opposing the resistance-giving, established standard and is instrumental for communication, discussion and evolvement of the transition of flood risk management.

1. INTRODUCTION

Coastal and delta regions globally show the attractiveness, both visually and economically, of settling in close proximity to where land, sea and waterways meet. History proves that these regions prevail when it comes to international trade, fertility of ground, living conditions and ecosystems (Constanza 1997). Which all results in increasing prosperity, continuous urban growth and therefore the occupation by the world's largest metropoles. In 1993, the year the author of thesis research was born, the world counted thirteen cities with more than ten million inhabitants, 25 years later this count went up to 34 cities. Strikingly a large and rapidly growing part of the world's population and economic centres in low-lying coastal zones (Small and Nicholls 2003), despite the fact that the amount of opportunities come with an equal amount of vulnerability, mainly caused by the presence of the element that led to the success in the first place: water.

In the same 25 years, general mean sea levels rose approximately 9 cm (NASA 2017) as climate change unfolded. By nature, the transition zone between land and water is subject to a fluctuating border but, as pressures from urbanisation, infrastructures and industries grew, the border became more and more static over time. Nowadays, this static frontier is constantly and increasingly challenged by pressures from water as seen in recent major flood disasters in densely populated areas. These flood events do not discriminate poorer countries from the more developed. Catastrophes like hurricanes devastating the coast of the U.S. and tsunamis raiding in Asia are not an exception, they are the announcement of the new standard (Ovink and Boeijenga 2018) and ensure flood risk management remains on the agenda.

One of the lowest delta regions in the world is the Southwest Delta in the Netherlands. Consequently the country has a long history of floods and flood risk management. In 1953 the Netherlands was hit by the 1953 North Sea Flood, taking the lives of 1.836 and homes of 100.000 after a rare combination of a spring tide, north-northwest storm and high water levels in the rivers brought the water level to + 4,5 m above sea



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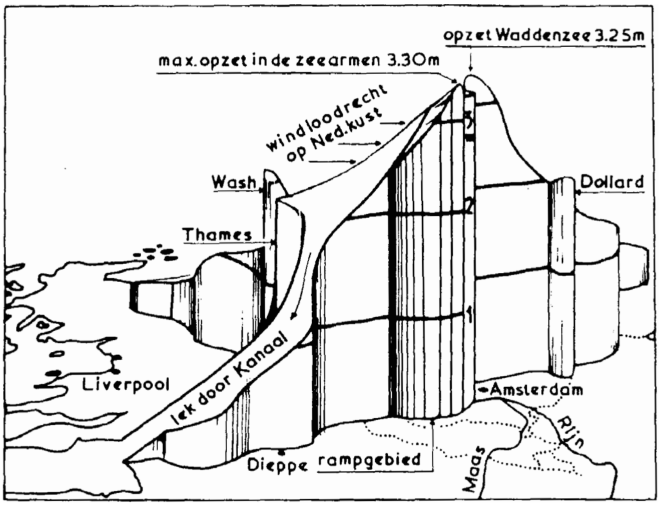


1.2

1.3

1.1 Physical model of the height of the sea level in relation to the general mean sea level during the 1953 North Sea Flood surge, seen from a western perspective.

1.2 Indication of striking points of the 1953 North Sea Flood surge, seen from a southern perspective.

1.3 Kees Molkenboer - Ship passes through the hole of a breached dike during the 1953 North Sea Flood.

level in the funnel-shaped Southern North Sea [figure 1.1]. The catastrophe was the decisive event to initiate what was later awarded the most prestigious hydraulic engineered project in the world, the Delta Works (Hage 2015). Consisting of a set of thirteen constructions the coastline of the Southwest Delta was shortened with 720 km, providing safety for the whole country, but also stimulating the integration and economic development of peripheral regions, reducing pressure on the Randstad and enhancing the unity of the Dutch territory. Flooding has not claimed a single life in the Netherlands since and flood risk management became a part of the Dutch culture and one of the country's export products with the Delta Works as a shining example for other urbanised coastal areas (Meyer 2017).

Nevertheless, water and flood risk management remains an interminable and persistent task as the climate changes, sea levels rise and river runoff varies. These developments deal with a deeply uncertain impact in the future and forecast-attempts result in a wide range of scenarios. However deeply uncertain the forecasts of climate change issues may be, in the case of sea level rise one thing is certain: it is not a question of 'if' but 'when' and 'how'. In preparation to this uncertain future, the issue's complexity should be embraced. Complexity is the new normal and challenges to change, to seek innovation and demands an approach setting aside the established standard, existing frameworks and agreements based on assumptions made in the past (Ovink and Boeijenga 2018). Addressing climate change adaptation and the complexity of flood risk management with the deep uncertain character of sea level is a collective challenge requiring global cooperation but the world turns their eyes to the Netherlands (Meyer 2017). The country's renowned water management holds opportunities to further intensify its exemplary position by exploring game-changing strategies. This research aims to cast light on the history and future of flood risk management, distill lessons learned and present possibilities in facilitating and initiating transition to transitional flood risk management in anticipation to extreme sea level rise scenarios.

2.1 PROBLEM STATEMENT

Throughout the history of floods, flood risk management strategies have been initiated in response to events of flooding. However, up until this day, in an era where knowledge advances and threats of natural phenomena are predictable, flood catastrophes still remain the decisive factor for the implementation of transitional flood risk management interventions.

Due to climate change, mainly caused by the effects of greenhouse gas emissions, sea levels are rising globally. On what extents of sea level rise flood risk management should anticipate, however, remains deeply uncertain. Policy methods therefore facilitate the decision making process for the efficient implementation of adaptive measures under the deeply uncertain character of sea level rise. In scenarios of accelerated sea level rise, however, the current flood defence strategies lack in preparing for a shift to the required transitional change to cope with flood risk (Bloemen et al. 2017). This shift is restrained by societal limits of adaptation (Adger et al. 2009) which oppose to changes in the established standard. On the long term, this will result in increasing strategy-dependency and increasing transfer costs, only further complicating the possibility to shift. In order to let knowledge, instead of catastrophes, guide transition, extreme sea level rise scenarios and the required transitional change should be explored.

2.2 OBJECTIVE

In order to address the problem stated, the objective is two-parted. The principal objective is the analysis of the transition from current flood risk management to a transitional strategy capable of facilitating extreme sea level rise. As the flood defence measures currently in place will not be sufficient to cope with sea level rise and the flood risk management strategy will not be sufficient to cope with accelerated sea level rise, the whole system needs to be reconsidered. Besides the exploration of transition in flood risk management, the objective is to sketch an image, a vision, of a possible future scenario which is sufficient. This image provides an indication of the magnitude of change and radicality, in order to create impact, increase awareness and therefore facilitate transitional flood risk management.

2.3 RESEARCH QUESTIONS

Small degrees of sea level rise cause problems throughout all scales, not discriminating prosperous regions from Third World countries. Businesses, harbours, population, municipalities, provinces, nature reserves and nations worldwide are vulnerable to sea level rise and as sea level rise accelerates and potentially reach extreme scenarios the need for transition grows. Therefore, the research poses the following question.

How best can the transition to transitional flood risk management strategies be facilitated to anticipate to extreme sea level rise scenarios?

In order to answer this question and accomplish the objective of the research a set of guiding subquestions is formulated.

Research question
How best can the transition to transitional flood risk management strategies be facilitated to anticipate to extreme sea level rise scenarios?

Subquestions
~ What is the scope of sea level rise?
~ How are future sea level rise scenarios dealt with?
~ What challenges are faced with extreme future sea level rise scenarios?
~ How can a country adapt to extreme future sea level rise scenarios?
~ To what extent can the current flood risk management deal with sea level rise?
~ How can transitional flood risk management be facilitated?

2.4 HYPOTHESIS

To answer the research questions, the research is based on the hypothesis that a multidisciplinary approach, combining engineering, design and policy will aid transition. Facilitating transition to a fundamentally different flood risk management system, however, is not expected to have one formable solution as transition of an established system addresses innumerable interconnected issues and is expected to be only possible when initiated gradually and considered as an evolving process. This research will focus on organising the initial transition.

2.5 STRATEGY AND METHODOLOGY

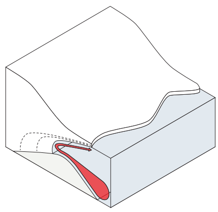
Addressing the complex assignment is made possible by abstracting the system to structures related only to sea level rise, flood risk and its management. This results in an assumption based research which allows casting light on the state of the art of flood risk management and its future as sea level rise unrolls. The research is subdivided in the research of the scope of action, the analysis of the system, the synthesis before reaching the conclusion.

In the scope of action the focus is on sea level rise. In this phase of the research the available knowledge on the natural phenomenon of sea level rise is reviewed and models dealing with the projections of sea level rise development are discussed.

In the next phase the system from and for which the flood risk management strategy is developed is analysed. The system analysis includes a disquisition of challenges faced as sea levels rise which continues in a mapping exercise. By mapping systems of direct importance to flood risk assessments, the suitability and possibilities of addressing sea level rise and adapting the system are reviewed (McHarg 1992). The extensive mapping exercise facilitate the Dutch layers approach (De Hoog et al. 1998a) and the casco concept (Sijmons 1991). These methods deduce all the processed data into a framework.

The framework is used in the synthesis phase to establish a design, visualising adaptation to sea level rise. The system analysis could result in countless variants. By addressing only one the objective of accomplishing transition is facilitated. The design is accompanied by a presentation of the stepwise phases towards the physical transition. To plot these phases, a modified version of the adaptation tipping point method is used (Kwadijk et al. 2010). In the second part of the synthesis phase the transition of flood risk management in the past and the opportunities and limitations for transition of flood risk management in the future are described. In this part of the research the focus in on the theories of incrementalism (Jones and Baumgartner 2005) and transition management (Rotmans et al. 2001).

Nowadays climate change is a topic of thorough research but some of its consequences also manifest themselves in plain sight. An important consequence of climate change is the rising of sea levels globally. The Antarctic ice sheet has been designated as the primary contributor of the sea level rise phenomenon (DeConto and Pollard 2016). In graph 3.2, sea level change between 1870 and present-day is shown. Initially more rough data, derived from coastal tidal gauge records (Church and White 2011), was used and, as of 1993, with data from satellite observations (NASA 2017).

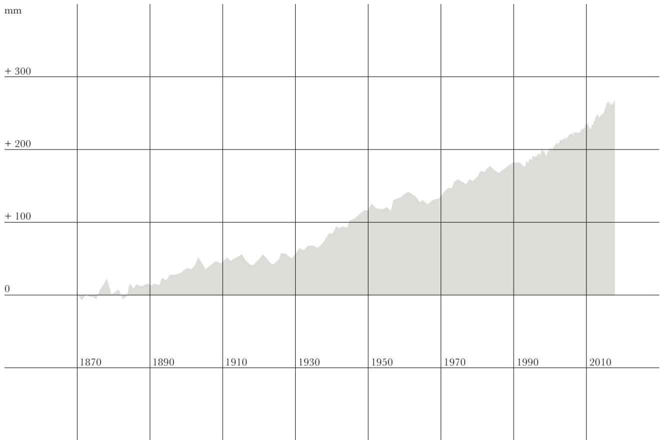


3.1 Section of Antarctic marine-based ice sheets

3.1 DRIVERS OF SEA LEVEL RISE

The primary contribution to sea level rise is the melting of the Antarctic ice sheet. Specifically, the collapse of ice cliffs and hydrofracturing. Hydrofracturing is a phenomenon where pools of rainfall or meltwater on top of the glacier's surface drain into cracks, causing fractures, which rapidly increase ice sheet mass loss (Kopp et al. 2017). Particularly West Antarctica, where big ice sheets are marine based, is vulnerable to marine ice sheet instability (Ritz et al. 2015). Figure 3.1 shows how the Antarctic ice mass gets thicker when going land inwards, the retreating ice margin will result in a growing area of ice which gets exposed to ocean water (Kopp 2017). Together with the warming water temperatures, the increasing exposure will lead to accelerating rates of retreat.

Besides the Antarctic ice sheet melt, an interwoven set of related and unrelated physical mechanisms are responsible for the phenomenon of sea level rise. To model sea level rise, a framework is used which accounts for all the key drivers, including Greenland's ice mass, mountain glaciers, the thermal expansion of sea water as it warms up, changes in winds and currents, tidal ranges, geoid shifts and land motion (Kopp 2017). Many of the natural physical climate change mechanisms are caused by acts of mankind. A good indicator for this are the greenhouse gas emissions, which strongly influence the long-term contribution of the Antarctic ice sheet to sea level rise (Golledge et al. 2015).



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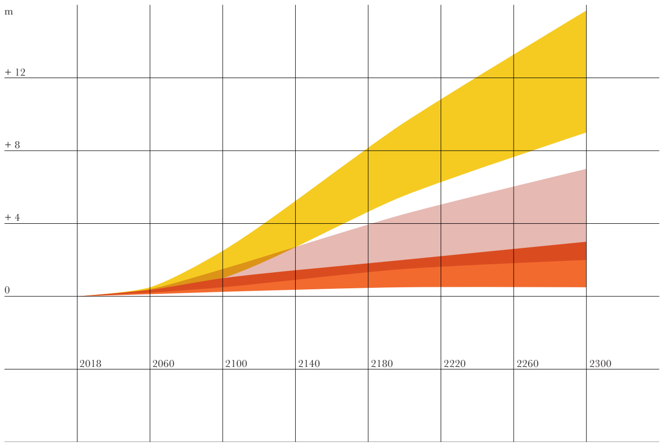

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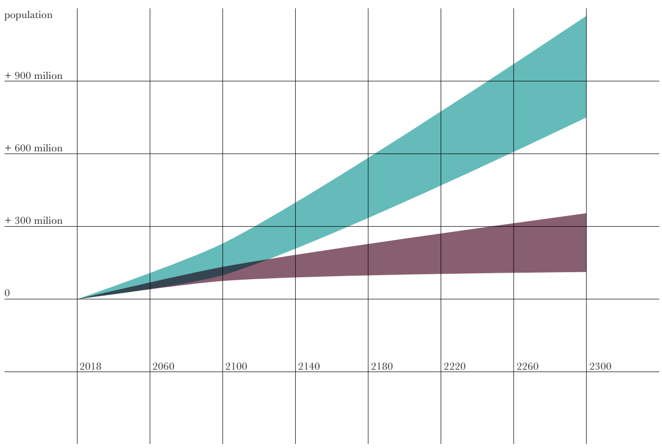


3.4

3.2 General mean sea level rise 1870 - 2018 (mm), observed with tidal gauge records 1870 - 1993 and satellite 1993 - 2018.

modified from Church and White 2011 and NASA 2017

3.3 General mean sea level rise projections 2018 - 2300 (m), depending on representative carbon pathway (high emissions yellow, medium emission pink, low emissions orange).

modified from Kopp et al. 2017

3.4 General mean sea level rise projections 2018 - 2300 (population exposure), depending on representative carbon pathway (high emissions blue, low emissions purple).

modified from Kopp et al. 2017

3.2 RANGE OF UNCERTAINTY

All drivers of sea level rise are also drivers of its uncertainty. Only greenhouse gas emissions already have an impact on sea level rise and kick off the range of uncertainty. If the emissions continue growing, global mean sea level (GMSL) rise will range between 1,10 - 2,10 m. With an emission decrease following a mid-range path, the range will be 0,67 - 1,25 m rise and even when achieving the Paris Agreement goal of net-zero emissions, this will still result in a GMSL of plus 0,43 - 0,76 m (Kopp 2017).

On their turn, the growth or fall of gas emissions will, among others, determine the range of uncertainty following from ice sheet melt. The newest Antarctic model, taking into consideration the phenomenon of hydrofracturing and the collapsing of ice cliffs (DeConto and Pollard 2016), predicts GMSL scenarios ranging between 0 and 1,50 m rise in 2100 and plus 0,02 - 17,65 m for 2500 to be plausible, merely due to the contributions of melting ice sheets. A wide range of deep uncertainty, which depends on the representative carbon pathway (RCP) scenarios listed in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2015) and the causal rising temperatures and warming of the ocean water.

In an attempt to link the before mentioned Antarctic model results into a sea level rise projection framework (Kopp et al. 2017) it was shown there is little correlation between the contribution of ice melt to sea level rise by 2050 and its contribution in 2100 and beyond. This means that current sea level observations can impossibly identify an uniquely correct probability distribution and the possibility of extreme future outcomes cannot be disregarded. The results of the combined approach to explore sea level rise highlight the divergence of scenarios [3.3]. The scenarios for low and high emissions show minimal overlap. For 2100, low emissions result in a GMSL rise ranging between 0,26 - 0,98 m, whereas high emission scenarios show a range between 0,93 - 2,43 m (based on median 5th to 95th percentile projections). By 2300, the gap between emission and sea level rise scenarios exceeds 6 m as low emissions result in a range between 0,50 - 3,00m and high emissions 9,13 - 15,52

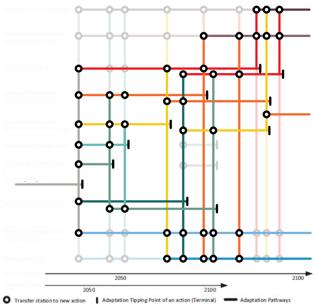
m. When these sea level rise projections are translated to population exposure, for 2100 this will affect between 75,0 - 235,5 million people globally and 82,8 - 1162,6 million by 2300 (based on median 5th to 95th percentile projections) [3.4] (Kopp et al. 2017).

3.3 DECISION MAKING UNDER DEEP UNCERTAINTY

The sensitivity of sea level rise projections between now and 2100 to deeply uncertain physical mechanisms and the wide range of this uncertainty emphasise the need for adaptive management frameworks. For every sea level rise scenario, specific flood risk management interventions are required. For what scenario to anticipate, however, again remains uncertain. Due to the deep uncertainties, there is a risk of making inappropriate decisions, too little, too late, too much, too soon (Kwakkel et al. 2016). Decision making methods offer help to manage these deep uncertainties.

Decision making methods are a research field subject to many developments. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) lists a number of approaches for climate impact and adaptation assessment. The assessment methods can be divided into methods with a static top-down approach and a resilience bottom-up approach, depending on their perspective on adaptation assessment and their effects on processes (Kwadijk et al. 2010). When addressing climate change issues, the static top-down perspective lacks flexibility to be able to address the variability of most likely future scenarios. In the past decade, a shift from the static assessment driven methods towards a policy-oriented adaptive approach can be seen. Currently, planners rather select the adaptive approach which is founded on the the understanding that the state of a system is subject to change and sees adaptation as part of a path-dependant trajectory (Gersonius 2012). In order to enhance efficiency, a greater emphasis on integrating adaptation into policy making and development can be seen, instead of it being a stand-alone activity (Watkiss 2015).

With the growing of the range of deep uncertainties for future scenarios, like for sea level rise, the adaptive challenge grows and further development of decision making methods is spurred. As a response to this, climate adaptation research on the support of decision making is increasing (Maru and Stafford Smith 2014). This results in the availability of numerous decision making methods and tools, all with their own characteristics, advantages and limitations.



3.5 The Dynamic Adaptive Policy Pathway map.

modified from Haasnoot et al. 2012

An approach that helps making deep uncertainties manageable and structured is the adaptation pathways approach (Reeder and Ranger 2011). Adaptation pathways are an analytical approach to form an adaptive route plan of actions between so called tipping points. The tipping points are thresholds of acceptability to anticipate change in the present and clearly visualize the consequences for possibilities in the future. The route plan gives information to the decision maker but lacks in giving guidance on translating it into an actual plan (Haasnoot et al. 2012a). Dynamic adaptive policy pathways (DAPP) (Haasnoot et al. 2012a) is a method with adaptation pathways at its core and resulting from its strengths. DAPP deal with uncertainty by presenting the scenario-specific flood risk management interventions as a sequence of robust and flexible actions to take, in order to anticipate change in the present, while keeping options open for adaptation in the future. In this way, interventions can follow up one another in full efficiency and can keep on being implemented and adapted as future developments unroll. At last, the method includes contingency planning to safeguard the plan's performance. DAPP are considered to be comprehensive and more complex than traditional methods. In order to keep the method understandable, clearly delineated steps following the tipping points are defined and the visualisation of the pathways exemplifies the approach [3.5] (Haasnoot 2013). Despite its complexity, DAPP is favored by policy advisors and policymakers (EEA 2013) which can be seen in the major flood risk management challenges where the approach already has served as an inspiration and backbone, e.g. the Thames estuary (Reeder and Ranger 2011), the New York metropolitan region (Rosenzweig and Solecki 2010), the Hutt River in New Zealand (Lawrence et al. 2013) and the Dutch Delta Programme (Haasnoot 2013), even though these large scale projects have a high level of complexity where different areas have different pathways that influence each other (Van Rhee 2012).

Despite the praise, DAPP are still facing challenges when it comes to the implementation of the proposed interventions of which the inclusion of measures that prepare for a shift from incremental to transitional strategies (Bloemen et al. 2017) is an important one. Where DAPP are supposed to be neutral to the choice of magnitude, type and order of measures, practice shows that short-term incremental interventions are often preferred over transitional interventions (Bloemen et al. 2017) required to cope with extreme sea level rise. In an example of the Dutch Delta Programme, this implies a continuous reinforcement of the existing system instead of an integration or shift to a new system and a possible finiteness of DAPP.

4. THE NETHERLANDS AND SEA LEVEL RISE

Although the deeply uncertain character of sea level rise is an issue for nations globally, the focus will be on the Netherlands. The Netherlands is known to have a long history in fighting against water and at the same time owes its prosperity to it. The Dutch established and renowned flood risk management and the country's unfortunate positioning below current sea levels makes challenging extreme sea level rise in this country particularly interesting [4.2 - 4.7].

4.1 CHALLENGES

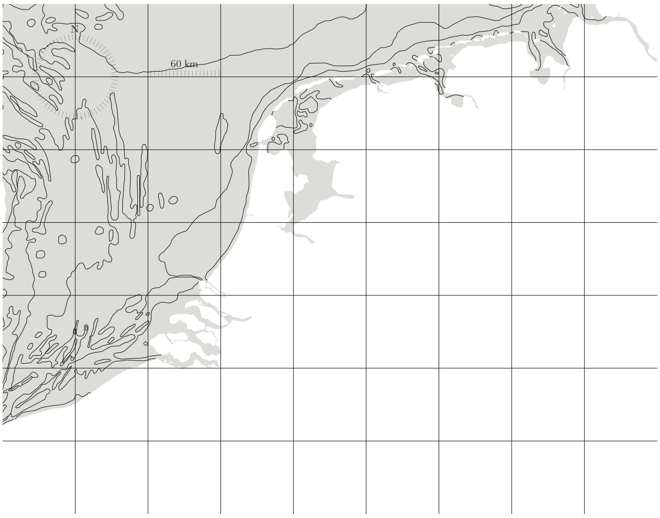
Besides the challenges faced with the adaptive approach to the deeply uncertain character of sea level rise, the country of the Netherlands will reach tipping points which will require a drastically different flood risk management system to be implemented in order to sustain its current territorial position. In a hackathon, Deltares (Haasnoot et al. 2017) explored the challenges the Netherlands will face when sea levels will rise and the rise will accelerate. In order to make an inventory of the challenges, natural, technological, physical, economical, societal, resource, and time aspects were considered. These challenges are very much subject to the development of technologies but their assessment with the current state of technology is crucial for the planning of flood risk management.

Sea level rise firstly threatens the coastal area and it will strongly affect the natural bodies in this region. The natural Dutch delta character will cease to exist and by nature the river debouchments will tend to an estuarine shape. In order to prevent this from happening and to forcefully maintain the current country's outline, the maintenance of the flood risk protecting elements requires both an upscaling of the dikes and the sand suppletion.

4.1 Sea level rise of 4 m per century requires 30 average sized dredging boats and an accompanying set of excavators on the beach to work all year round.

modified from Children of the Sea - Jozef Israëls, 1872
© Rijksmuseum 2018

The upscaling of sand suppletion is firstly limited by the availability of dredging boats. A sea level rise of 4 m per century would require approximately 30 average sized dredging boats and an accompanying set of excavators on the beach to work all year round [4.1] (Haasnoot et al. 2017). The availability of sand is a different challenge. The current sand extraction strategy binding for the



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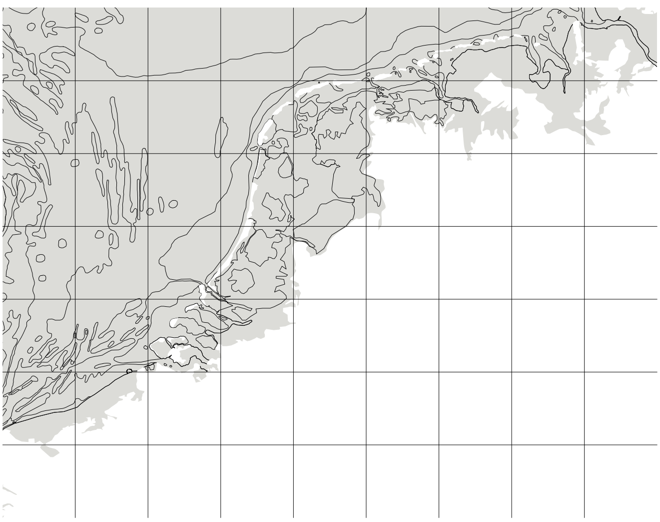
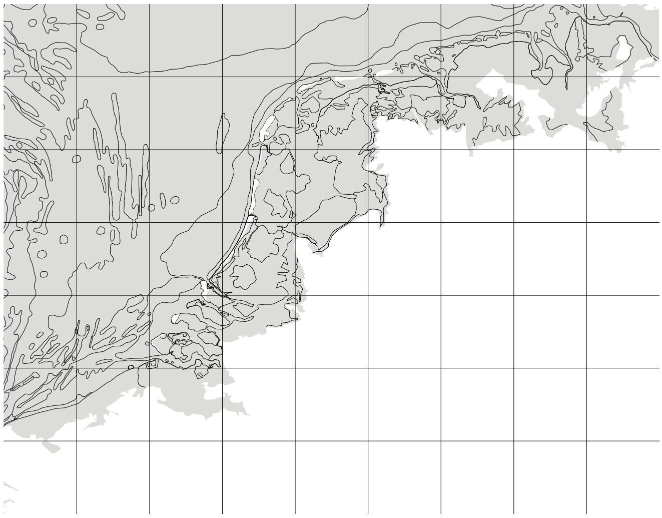


4.4

4.1 The outline of the Netherlands in 2018.
4.2 The outline of the Netherlands without its current flood defences.
4.3 The outline of the Netherlands with 1 m sea level rise without flood defence.
4.4 The outline of the Netherlands with 2 m sea level rise without flood defence.
4.5 The outline of the Netherlands with 5 m sea level rise without flood defence.
4.6 The outline of the Netherlands with 10 m sea level rise without flood defence.

modified from Climate Central 2018



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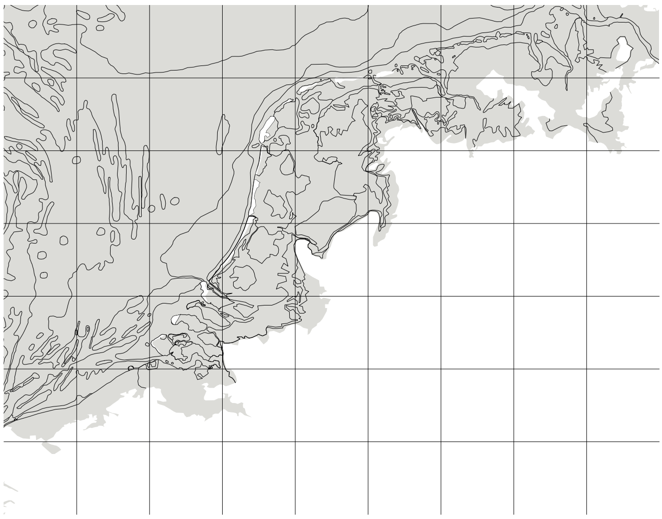

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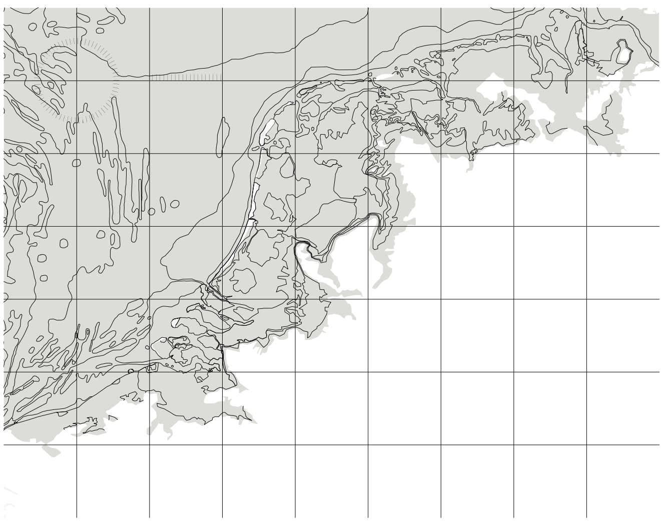
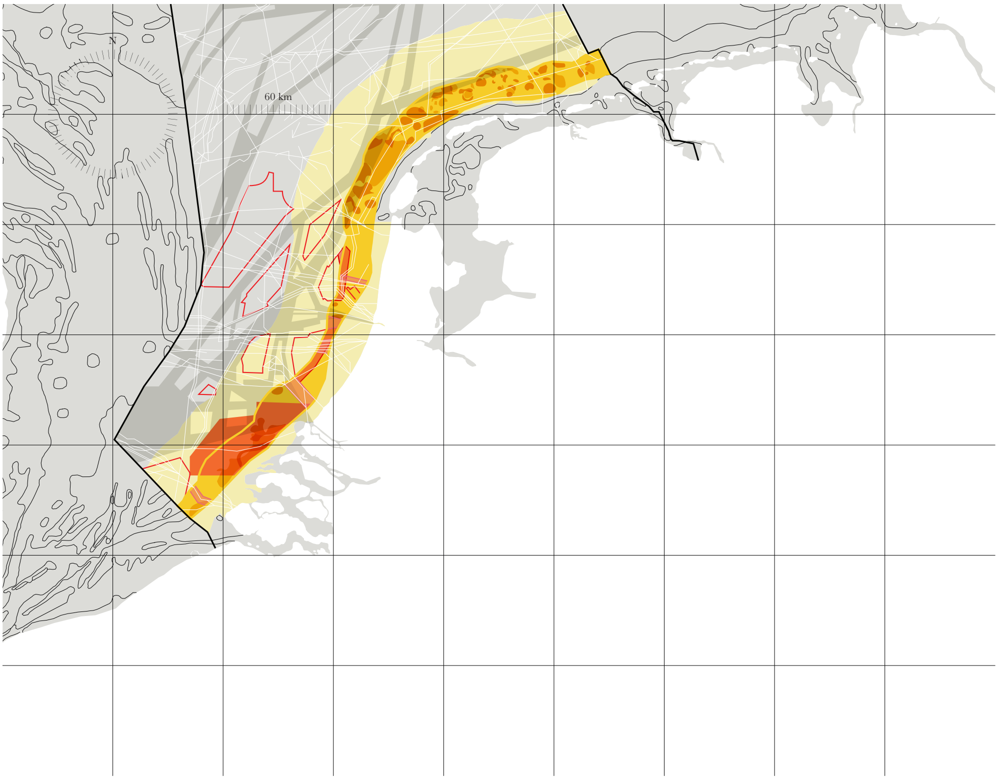


4.7

4.8 Sand extraction in the Dutch territorial waters of the North Sea.

- reserved area sand extraction
- sand layer 0 - 2 m thick
- sand layer 2 - 8 m thick
- sand layer 8 - 12 m thick
- reserved area shell extraction
- reserved area sand extraction concrete production
- preferred route cables and pipes
- cables and pipes
- wind farm
- policy intention wind farm within 12 mile zone
- shipping infrastructure

modified from Noordzeeloket 2018

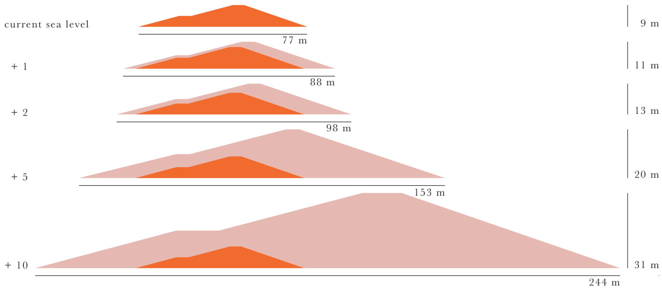


4.8

Dutch part of the North Sea (Noordzeeloket 2018) allows licensed dredging in the zone more than 12 miles of shore and no deeper than 20 m [4.8]. On average 25 million m3 of sand is extracted yearly for the usual beach nourishment and land elevation. Specific recent coastal projects are responsible for additional extensive extractions, like the Sand Engine (21,5 million m3 in 2011 and 2012), the Hondsbossche Sea Defence (35 million m3 in 2014) and the expansion of the Rotterdam harbour with the Maasvlakte 2 (213 million m3 between 2009 and 2013). The required sand extraction is expected to increase to 85 million m3 per year as sea levels rise. Consequently, the current sand extraction strategy is sufficient until the end of this century (Noordzeeloket 2018). An adaptation of the sand extraction strategy, which allows sand extraction further at sea, could be possible but is strongly limited by the present Natura 2000 areas, other activities and structures in the North Sea like fishing, windmills and pipelines, rivalry for the commercial use of sand and the quality of the sand.

The upscaling of dikes comes with the challenge of their integration. With a proviso of technological development the needed dimensions of the classic shaped dikes can be seen in figure 4.9 (Jonkman et al. 2013). Many dikes are located in close proximity to the built environment and the enlargement will in many cases result in a clash with existing structures. There are examples to be found in the past of buildings or parts of villages having to make place for the raising of dikes for which the village of Oterdum, once located nearby Delfzijl, Groningen, is a striking example. The village became subject to the strengthening of protection standards and made way for an enhanced sea dike. Oterdum is gone and only the village church, dating from 1877, and the graveyard are now symbolically represented on the raised dike with a sculpture [4.10 - 4.11] (LOLA Landscape Architects 2014).

Another important element of the Dutch coast of which its continuity is crucial for the Netherlands as a player in the economic field and the Dutch natural system, are the debouchments of the rivers at sea and the harbour connections. Until an unknown extent, natural connections in combination with open dams can deal with rising sea levels. After this point, the river outlets need



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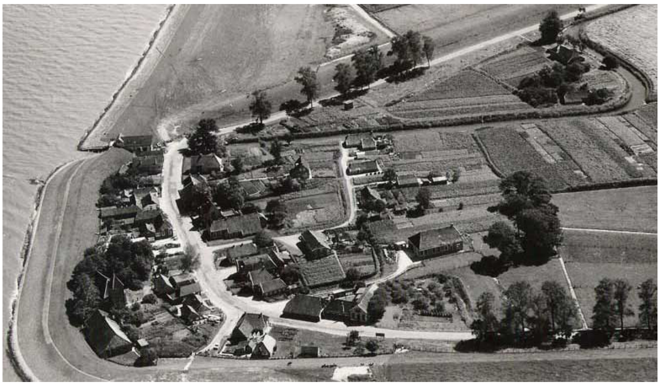


4.10

4.11

4.12

4.9 The effects of sea level rise on the required dike cross section.

modified from Jonkman et al. 2013

4.10 The lost village of Oterdum behind the old sea dike.

© H. Zwarberg 1960

4.11 The tombstones replaced to the enforced sea dike and the sculpture 'The hand of Oterdum' representing the late village.

© RCE Rijksdienst Cultureel Erfgoed 2018

4.12 The locks of the Three Gorge Dam on the Yangtze River nearby Sandouping, China bridge a height difference of 113 m and let boats cross in 30 minutes.

© Pam Brown 2013

to be closed off and the height difference between water levels needs to bridged, both for transportation over water and river water discharge. This results in the challenge of keeping rivers navigable and harbours accessible. Examples of sluices and boat lifts, bridging the gap between different water levels, can be found and are being upscaled to dimensions required for extreme sea level rise in the Netherlands [4.12].

The Netherlands not only faces a future of rising sea levels, its ground levels are also subsiding. Figure 4.13 shows the regions subject to most subsidence, coinciding with the Randstad and the outflow points of the largest share of the Dutch river water [4.14]. The subsiding of the Rhine debouchment and the Rhine and Meuse valley results in an increasing difficulty of discharging the river water out to sea and causes the Gelderse and IJssel valley to become preferable flowpaths.

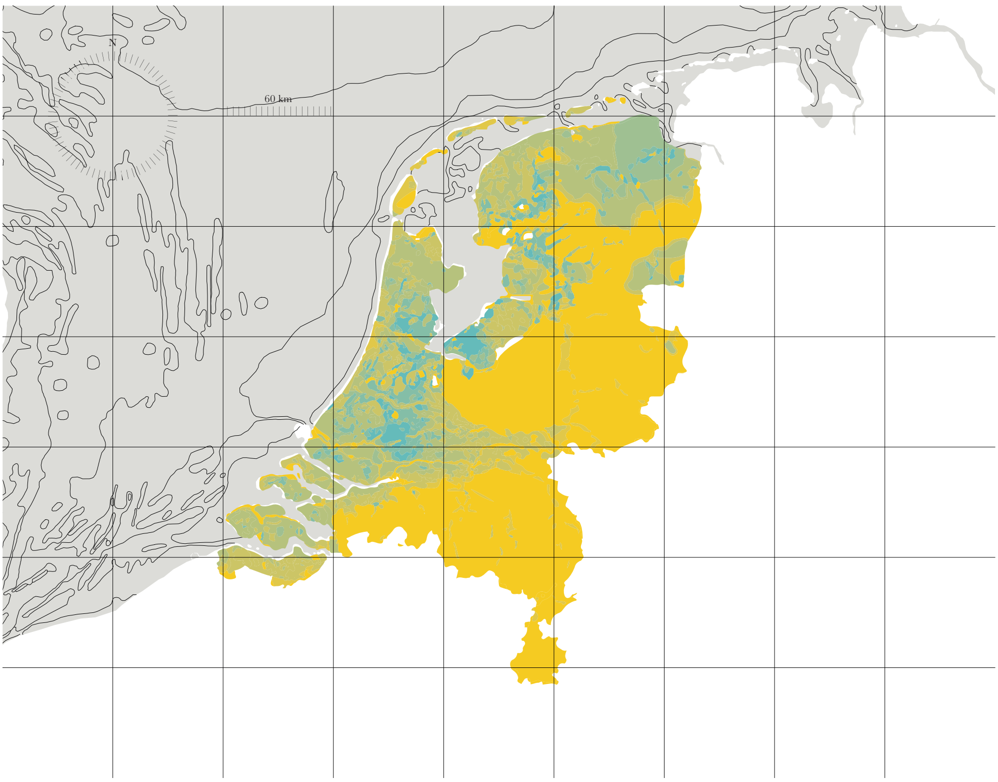
To change the distribution of river water outflow to other valleys and the IJsselmeer brings us to the next challenge. Pumps will be required to discharge the water up and out to sea. The Afsluitdijk and the IJsselmeer make a start for the developments required. As peak discharges to the IJsselmeer already increase, tidal-depending discharge via the sluices in the Afsluitdijk will not be sufficient and the installation of pumps is assessed (De Ingenieur 2015). The capacity of pumps does not define a threshold, the placement and the energy demand of the pumps however do. A set of the current biggest pumps available requires a stretch 6,6 to 11,1 km to process the max discharge of the Rhine and the Meuse and would require an additional power plant for energy supply (Haasnoot et al. 2017). The pumping capacity is directly related to the storage capacity of the IJsselmeer. If for any reason the pumps fail, the buffer capacity of the IJsselmeer needs to be secured.

Sea level rise will also result in groundwater related challenges. Increasing seepage from groundwater and increasing upward groundwater pressure are directly noticeable as sea level rise, salinisation and a change of sweet and salt water distribution, however, will take hundreds of years (Haasnoot et al. 2017). The groundwater related problems will limit itself to the

4.13 The projections for subsidence in the Netherlands, 2018 - 2050.

none
0 - 0.5 cm
0.5 - 1 cm
1 - 10 cm
10 - 30 cm
30 - 50 cm
50 - 200 cm

modified from Deltares 2017



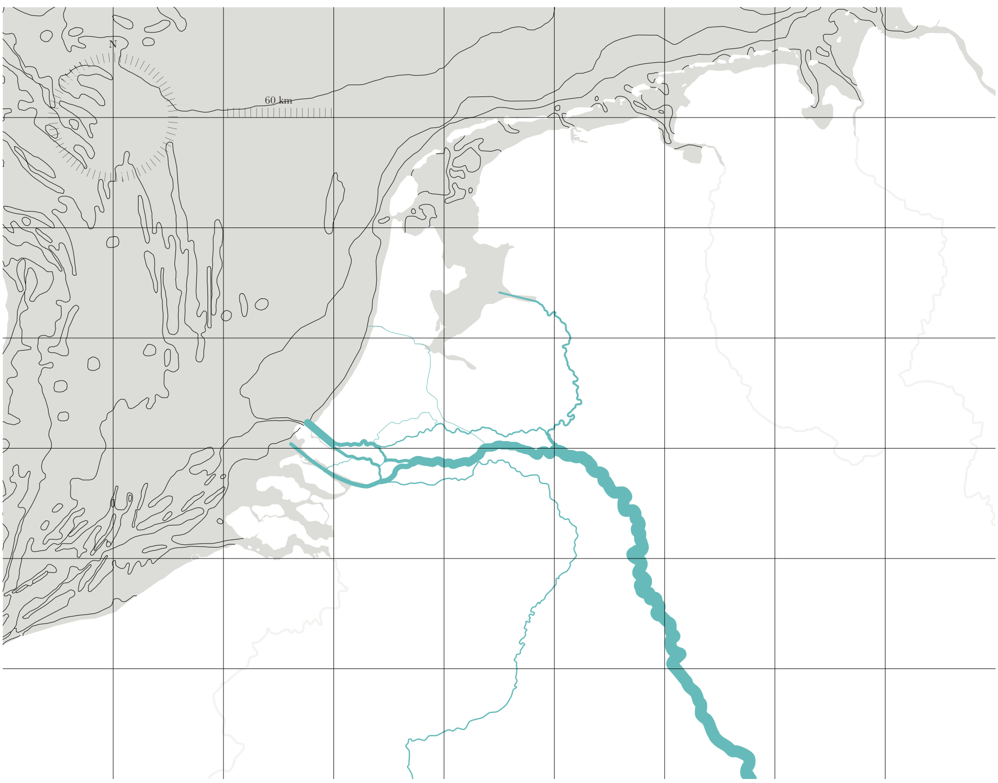
4.13

4.14 The distribution of river water discharge in the Netherlands.

inflow	
Rhine	89,9 %
Meuse	10,1 %

outflow	
IJssel	14,4 %
Noordzeekanaal	0,6 %
Nieuwe Waterweg	57,4 %
Haringvliet	27,6 %

modified from Lamm 2014



4.14

first 10 to 15 km from the coast. This region, including large parts of the Dutch Randstad, home to the biggest cities of the Netherlands, will get to deal with extensive groundwater nuisance. The large and deep freshwater bodies of Dutch drinking water suppliers Dunea, Waternet and PWN can handle a GMSL rise of approximately 5 to 7 m, the smaller freshwater bodies on the Wadden islands, Friesland, Groningen and the northern parts of Noord-Holland and southern parts of Zuid-Holland, will disappear with GMSL rise of 4 m (Haasnoot et al. 2017).

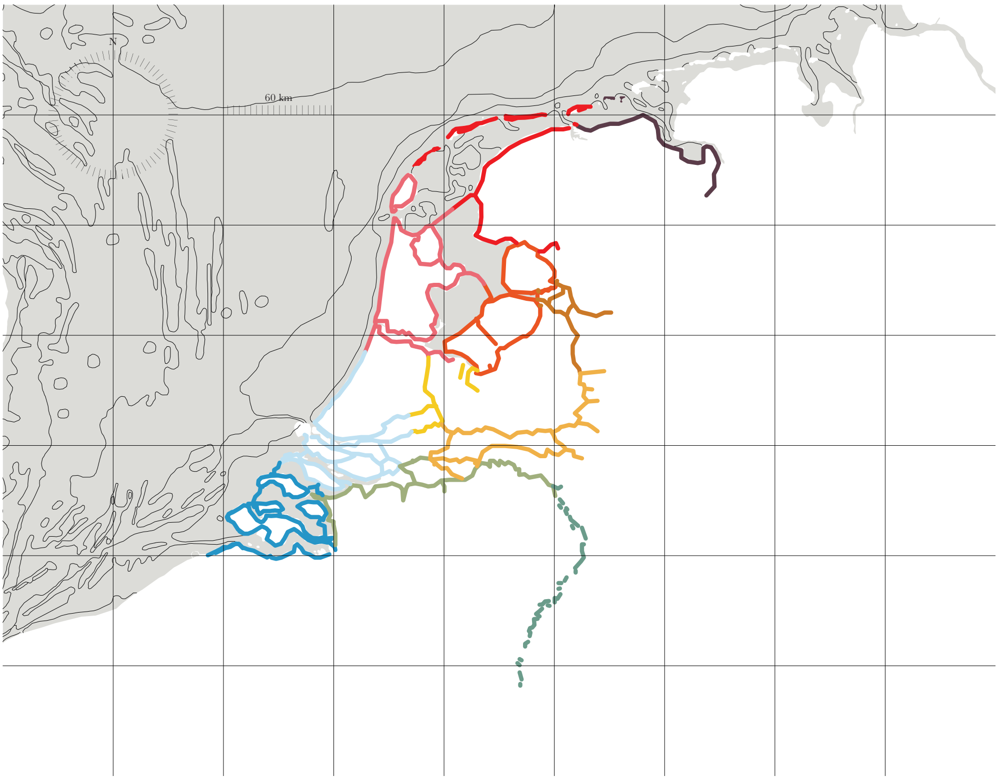
An aspect which is related to all the challenges is the financial aspect. The Netherlands is one of the countries in the world which spend most on flood risk management (Meyer 2017). The current annual national water management budget of national-, provincial- and municipal governments and waterboards and drinking water suppliers varied between €4 and 7 billion (Deltacommissaris 2015; 2017; Haasnoot et al. 2017) roughly in the last couple of years. This budget equals approximately 1,1% of the Dutch GDP. Solely on flood protection investments the national government and waterboards yearly have a budget of around €1 billion (0,2% of the GDP). This amount is, according to the Delta Commissioner, to be considered negligible compared to the annual earnings of the country of €850 billion it ensures (Meyer 2017) and the value of the protected area with a magnitude of €1800 billion it protects (Deltacommissaris 2015). Haasnoot et al. (2017) predicts the current annual national water management budget to increase to €26 billion per year as sea level rise enrolls to extreme scenarios, equalling 3% of the GDP. Extreme sea level rise scenarios also influence the settling climate, with the lack of faith that the Netherlands will be a secure country to live and for companies as sea levels rise. International examples only show the effects of a flood disaster, when many decide not to return to the region of the disaster, resulting in economic shrinkage (Haasnoot et al. 2017).

As not only the magnitude but also the lead time of extreme sea level rise scenarios are deeply uncertain, the last challenge is related to time. The Netherlands consists of a set of approximately 3.767 km of dunes and primary

4.15 The length of primary dikes and dunes in the Netherlands.

Groningen	115 km
Friesland	245 km
Flevoland	235 km
Noord-Holland	394 km
Overijssel	272 km
Gelderland	565 km
Utrecht	111 km
Noord-Brabant	330 km
Limburg	169 km
Zeeland	554 km
Zuid-Holland	777 km

modified from Inspectie Leefomgeving en Transport 2013



4.15

dikes [4.15] and a current enforcement rate of 25 km per year (Haasnoot et al. 2017). Adapting all dikes to a sea level rise scenario, however uncertain, would take 150 years. Even when doubling the rate, whatever limitations infrastructures, manpower and policy may offer, the need for a different approach is proven.

To summarise all challenges listed above, one all-embracing task description is defined to deal with extreme sea level rise scenarios:

The efficient securing of delta stability for the Netherlands to coexist as a prosperous nation by making reasonable and beneficial investments for interventions.

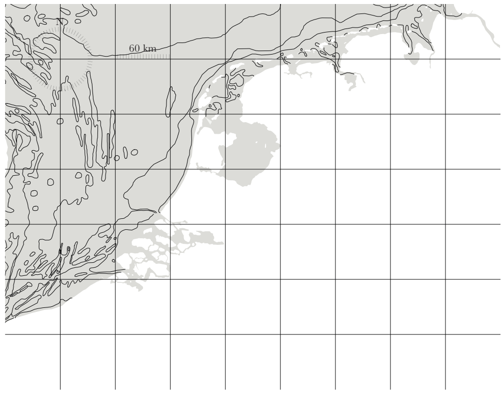
4.2 THE SOLIDIFYING COAST / THE DYNAMIC COAST

'The efficient securing of delta stability for the Netherlands to coexist as a prosperous nation by making reasonable and beneficial investments for interventions'. This task appears not only to be valid for extreme future sea level rise scenarios as the task corresponds with Dutch flood risk and coastal management of the previous centuries. In this period the most striking types interventions of this management are the reclamation of land and the implementation of flood defences shortening the Dutch coastline. This manipulating development took a major leap with the Zuiderzee Works and the Delta Works. The purpose of these projects was not only to secure safety from floods for the whole nation, but also to stimulate the integration and economic development of peripheral regions, reduce pressure on the Randstad and enhance the unity of the Dutch territory (Meyer 2017).

In anticipation to extreme sea level rise and its challenges, the process of coastline shortening, and all the accompanying interventions, can be carried through [4.16 - 4.19]. However, the continuation of superimposing a controlled coastline also has an opposite approach. If the solidification of the border between land and water proceeds undisturbed, nature will soon be something only found in zoos. Nature needs space, it needs the space that is still and increasingly taken by human adjustments (Van Broeck 2018). Therefore another viable option of preparing for extreme level rise could be a more natural attitude to flood risk management, emphasising to live

4.16 The outline of the Netherlands in 1500, 2600 km long.
4.17 The outline of the Netherlands in 1850, 2100 km long.
4.16 The outline of the Netherlands in 1950, 1600 km long.
4.16 The outline of the Netherlands in 2018, 880 km long.

modified from Vos and De Vries 2013



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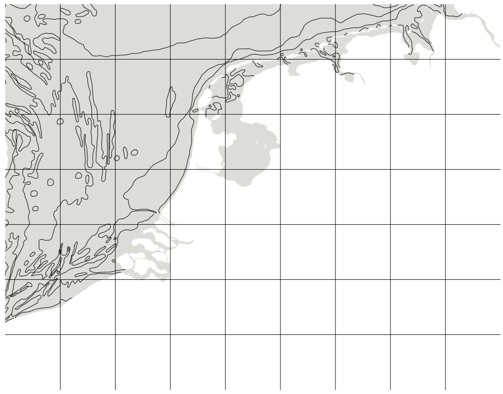
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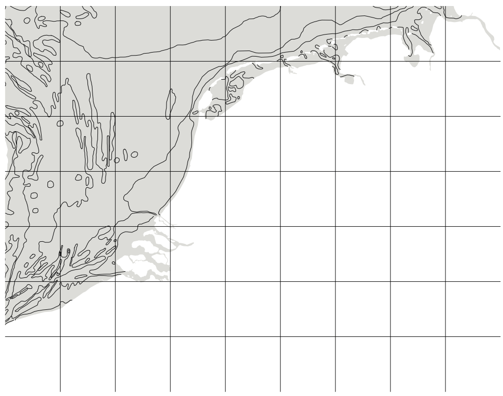
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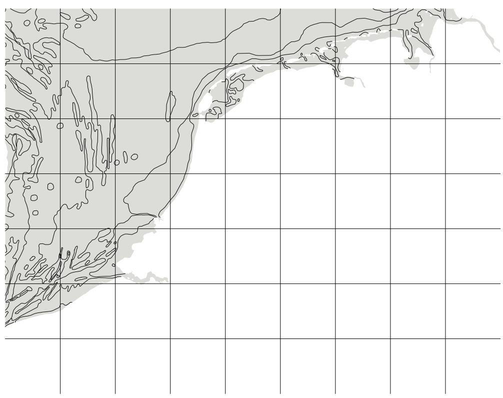

4.19

with water, rather than struggle to defeat it. This implies more room for water and for gradual transition zones between land and water (Meyer 2017). The opportunities of combining coastal reinforcement and a dynamic coastline have until a certain extent already been studied in Atelier Kustkwaliteit (Coastal Quality Workshop) (Brand et al. 2014) in which 'seaward' and 'landward' variants of flood defences were considered with a strong emphasis on spatial quality [4.20]. In practice, seaward examples can be found in the Hondsbossche Sea Defence and the Sand Engine and landward in the Waterdunen. From a societal point of view, the challenges presented for the Netherlands may raise questions about the ratio of costs and benefits and when a tipping point for this ratio is reached (Haasnoot et al. 2017). Hence, the possibilities of coastline shortening and coastline 'remediation' on a national scale are examined.

4.20 Sketch of the Dutch coastline sometimes maintained, sometimes reinforced, sometimes extended seawards and sometimes further reinforced on the landward side.

4.3 DUTCH DISPERSIONS

In order to explore the possibility for coastline shortening and coastline remediation, different systems of the Netherlands of direct importance to flood risk are mapped. This mapping exercise follows the basic proposition that the Netherlands is built up by the sum of historical and physical processes with different dynamics and constituting different social values (McHarg 1992), giving an intrinsic suitability for either coastline shortening or remediation. For that reason, the Dutch dispersions of flood risk management elements, protected nature, water, economy, population and heritage are presented. Although the distribution of elements like traffic infrastructure and drinking water and energy supply are likewise sensitive to flooding, these elements are considered to be more flexible than the static distributions of flood risk management elements, protected nature, water, economy, population and heritage in scenarios of extreme sea level rise. The complex system of the Netherlands was brought to a level of abstraction which enables distinct prioritisation but therefore disregards interconnected parts of the system.

4.3.1 FLOOD DEFENCE

In dealing with flood risk, an initial distinction can be made between manmade and natural protective elements. The presence of manmade flood risk management elements means that mankind has yet intervened in the existing natural landscape in order to protect oneself. Natural protective elements originate from everlasting natural developments of a landscape and are therefore continuously subject to uncontrolled change. Many natural elements, however, have already been affected by interactions between these natural processes and human activities, especially in the Netherlands. Manmade flood defences can be distinguished into primary and secondary dike systems and dams. In total they form a web of structures linking all provinces of the Netherlands with a total length of 3.767 km (excluding the secondary secondary dikes) as made visible in figure 4.15. The extensive inventory is drawn up below and visualised in figures 4.21 - 4.28.

Natural flood defences

Dunes

The network of dunes around the Netherlands functions as a natural coastal defence. Dunes are the product of a never ending process of balancing between sedimentation and erosion by wind and water (Lijn43 2012). A broad zone of dune landscape is the ideal crumple zone against threats from sea but where their span is narrowest, dunes have over the years been reinforced by man (LOLA Landscape Architects 2014).

Sand-drift dunes

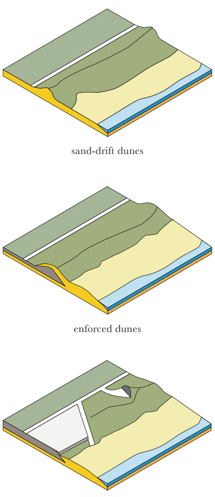
This dune type arises with the natural phenomenon of sand-drift. Where sand blown by wind accumulates at natural, or in some cases even manmade, elevations in the landscape. Grasses growing on the dune keep the sand at its place. Sand-drift dunes are subject to a continuous process of growing, with the wind's sand supply, and eroding, with high water. Sand-drift dunes are mainly to be found in the Wadden region.

Enforced dunes

Dunes that, to whatever extent, have been subject to interactions by man, fall within the category of enforced dunes. This category includes natural dunes that are enforced with a dike core or dikes, dunes and even beaches that intentionally have been topped with additional sand in order to reduce wave height

4.21 The distribution of dunes over the Netherlands.
4.22 A categorisation of dunes in the Netherlands.

4.21



4.22

and compensate for structural coastal erosion (Lijn43 2012). These practices can be found along the west coast of the Netherlands. The Sand Engine project will also be attributed to this category, even though it does not include a dune, it is an important flood defence intervention by man building with nature.

Multifunctional dunes

In this category, dunes have been, partially or fully, overtaken by manmade structures. The dune is enlarged and covered with a hard revetment to provide space for parking, roads, walking and bicycling paths or recreation. Examples can be found at the busiest beach destinations in the Netherlands.

Manmade flood defences

Primary dike systems

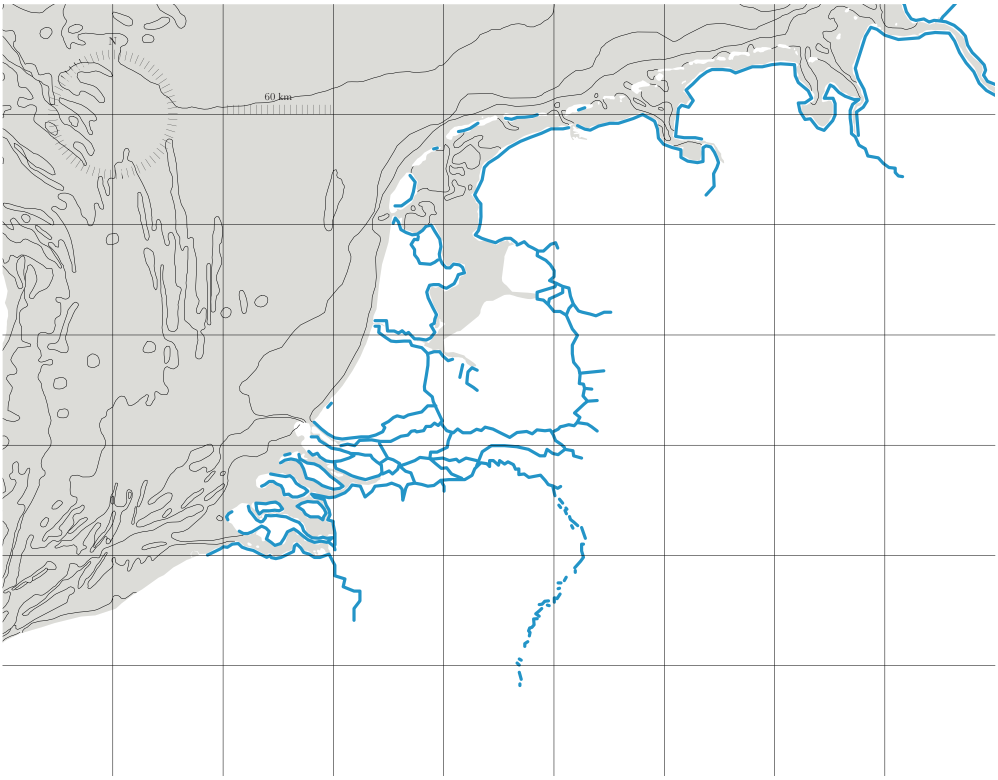
There are many types of dikes. This set of dikes is part of the primary flood defence category because of their boundary positions. Of all countries in the world, The Netherlands, in particular, has an important dike culture. Here, the major dikes are not only the sea dikes but also the inland river dikes which are part of the so called dike rings. These are linked rings of flood defences that protect specific areas against flooding from both sea and rivers (LOLA Landscape Architects 2014).

Sea dikes

Primary - secondary - tertiary dikes

The combination of primary, secondary, tertiary and sometimes even quaternary dikes are the result of of accretion. This process of land reclamation was popular centuries ago in the north of the Netherlands and implies that a low dike is constructed in front of the coastline. When the sea would overtop the dike, the clay brought with the waves would settle behind the dike (LOLA Landscape Architects 2014). Once the land was high enough, the low dike was replaced with a flood defence dike, wherafter a second low dike would be constructed in front of the new coastline to continue the accretion and land reclamation. This process would repeat itself three or four times and in the last century the latest dike became a part of the Dutch Delta Programme. The dikes this set of dikes consists of are also called

4.23 The distribution of primary dikes over the Netherlands.
4.24 A categorisation of primary dikes in the Netherlands.



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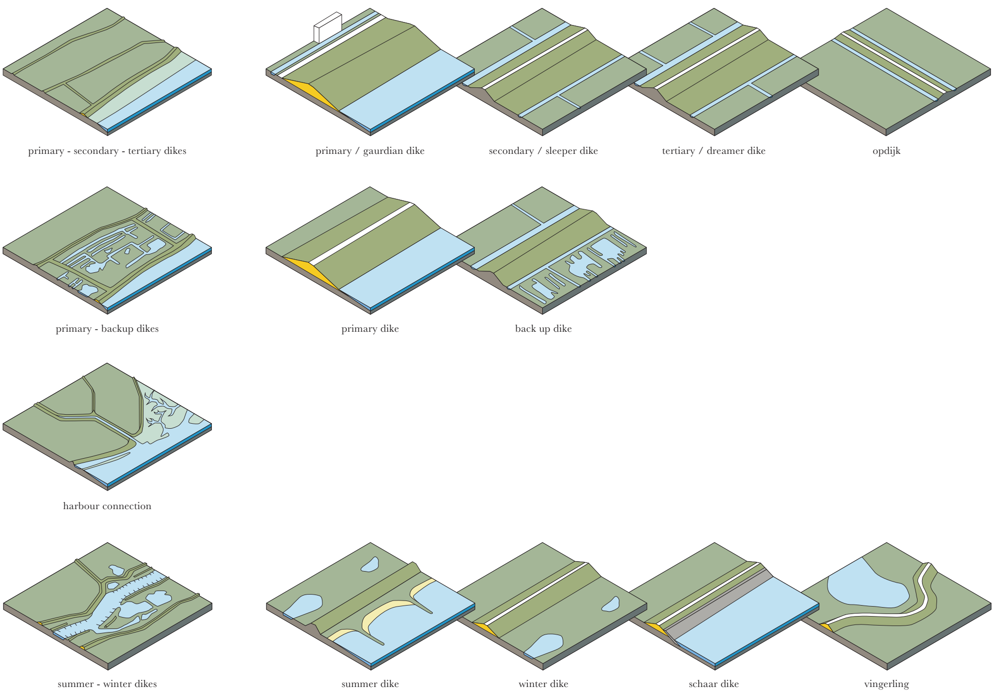


4.24

guardian (primary), sleeper (secondary) and dreamer (tertiary and more) and are sometimes accompanied by a so-called ‘opdijk’ in between them.

Primary - backup dikes

The combination of a primary and backup dike has a defence character and can be found in the Southwest Delta of the Netherlands. Compared to the north of the Netherlands, the fight against water was harder here (LOLA Landscape Architects 2014). For this reason, also before but especially after the 1953 North Sea flood, a backup dike was placed behind the primary dike in case this dike would succumb with storm surges.

Harbour connections

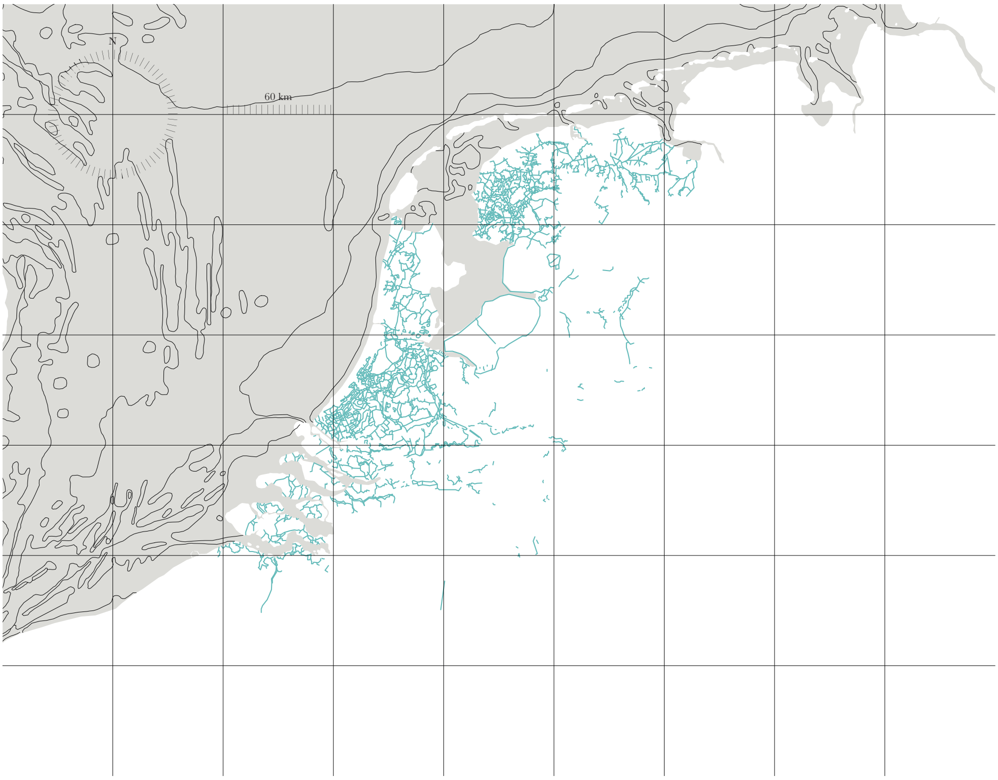
For a harbour to function an interruption of the sea dike or dune is required. Depending on the scale of the harbour, this can be securely realised with either a diked harbour with or without a canal connection or a system of locks. A diked harbour implies a tidal harbour with an open connection to sea. A harbour with a lock system is dependant of the tides and the required protection. In the case of particularly large harbours, the lock system can be upscaled to the category of a dam, like the harbour of Rotterdam.

River dikes

Summer - winter dikes

This set of dikes follows the fluctuating river discharge and can be found in the inlands of the Netherlands. Summer dikes keep rivers within their flow profiles. Winter dikes demarc the floodplains behind the summer dike and safeguard the land when summer dikes are overtopped with high discharge. So-called ‘schaar’ dikes can be found in places where the summer dike is missing and the winter dike runs straight along the river, schaar dikes are reinforced with stone revetment to prevent the washing away of soil (LOLA Landscape Architects 2014). In cases of a dike breach the dike is often reconstructed around the pitch shaped by the powerful flow of water through the breach, these special shaped dikes are called ‘vingerling’ (LOLA Landscape Architects 2014).

4.25 The distribution of secondary dikes over the Netherlands.
4.26 A categorisation of secondary dikes in the Netherlands.



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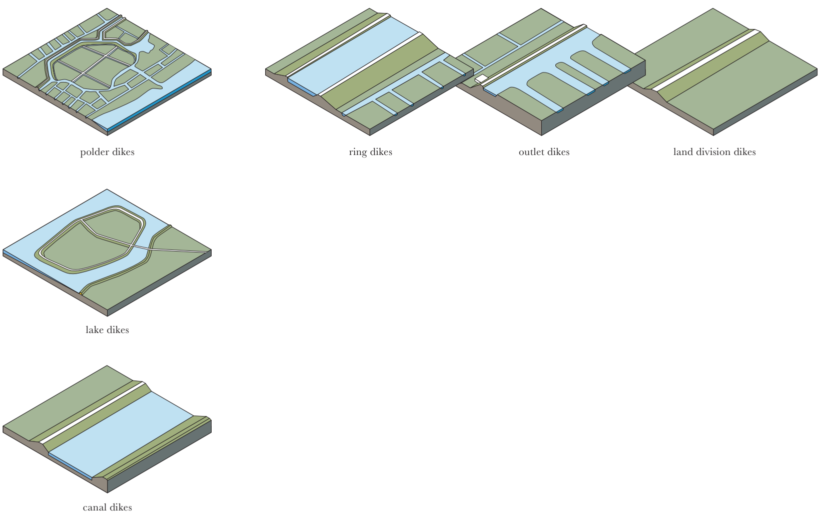


4.26

Secondary dike systems
The category of secondary dikes includes all regional flood defences, which are subservient to the primary dike systems. Just like the primary dikes, the secondary dike systems are an important part of the Dutch dike culture but they are mostly located landinwards where they protect or divide areas within or outside of the dike rings.

Polder dikes
Polders are an unique part of the western Dutch landscape and cultural heritage and so are their accompanying dikes. Polder dikes started as a frame around a system of watercourses through which water could be pumped away from the first polders. With the advancement of pumping and draining technology, possibilities grew and polder dikes were set up to drain growing stretches of land or even lakes. Polder dikes consist of ring dikes around the area of reclaimed land, outlet dikes around the water storage basin and land division dikes as a boundary between the land of water boards (LOLA Landscape Architects 2014).

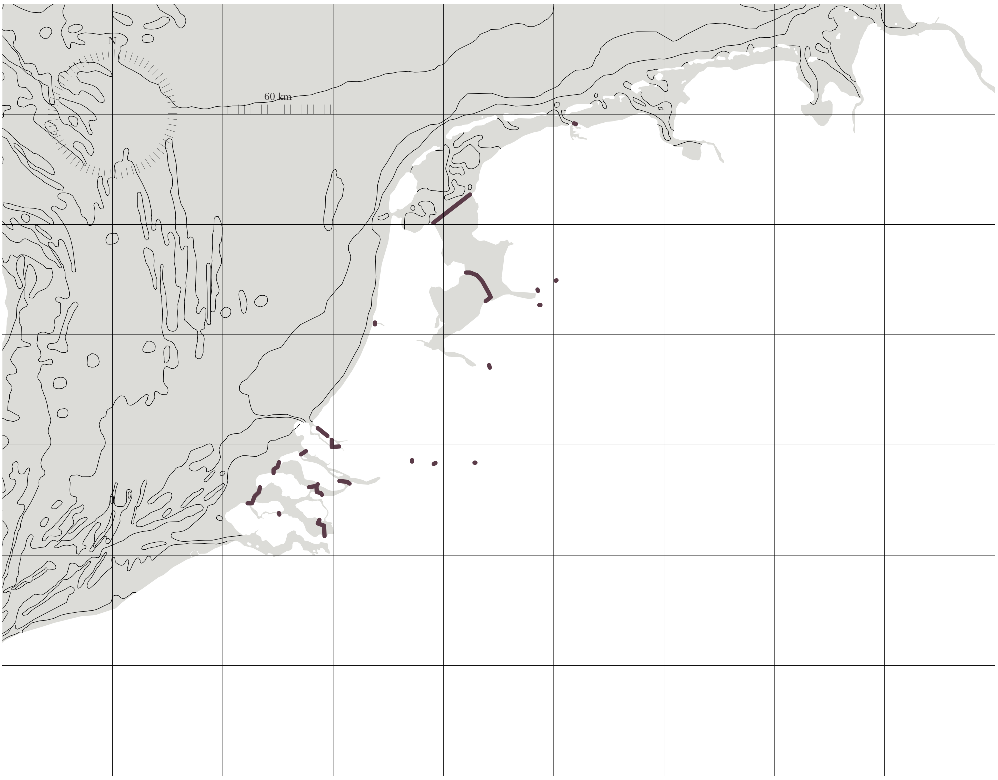
Lake dikes
With the growing possibilities of creating polders and the land reclamation to continue on lakes, the lake dike was born. This dike system consists of the dikes necessary for the construction of land on the bottom of a former lake. They are recognisable by their straight shapes and lines.

Canal dikes
Canal dikes are not constructed for the risk from natural water but to facilitate the construction of a artificial water way, the canal, which often lays higher than the neighboring lands.

Dams

Open dam
These dams are commonly in their opened position and only closed in times of storm surges and high water. Open dams are often applied for the major shipping routes.

4.27 The distribution of dams over the Netherlands.
4.28 A categorisation of dams in the Netherlands.



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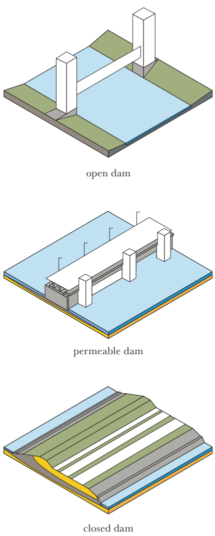


4.28

Permeable dam

These dams can be partially opened and closed in events of high water and storm surges and only facilitate shipping routes when a lock element is included.

Closed dam

In contrary to the previous dams, this dam is permanently closed and shuts off the natural flow channel completely. In order to discharge water, sluices or pumps have to be included.

The set of dunes, dikes and dams facilitate protection levels which are formulated in a report (RWS 2016) analysing flood risk in the Netherlands. Risk is expressed in potential economic damage and the number of potential victims. Based on the risk and the consequences of flooding, every desired protection level is translated into safety norms for primary flood defences, expressed in the chance of flooding per dike element, ranging from 1:300 to 1:100.000, to secure the chance of death because of flooding to be no less than 1:100.000 per year (Deltacommissaris 2014; 2016). A distinction in safety norms can be seen between the dikes in the coastal region and dikes inland. Higher protection levels are in operation for the dikes near the coast and lower levels for the dikes inland. However, even within the coastal region a division is made with higher safety norms for the most urbanised areas of the Netherlands, emphasising prioritised areas.

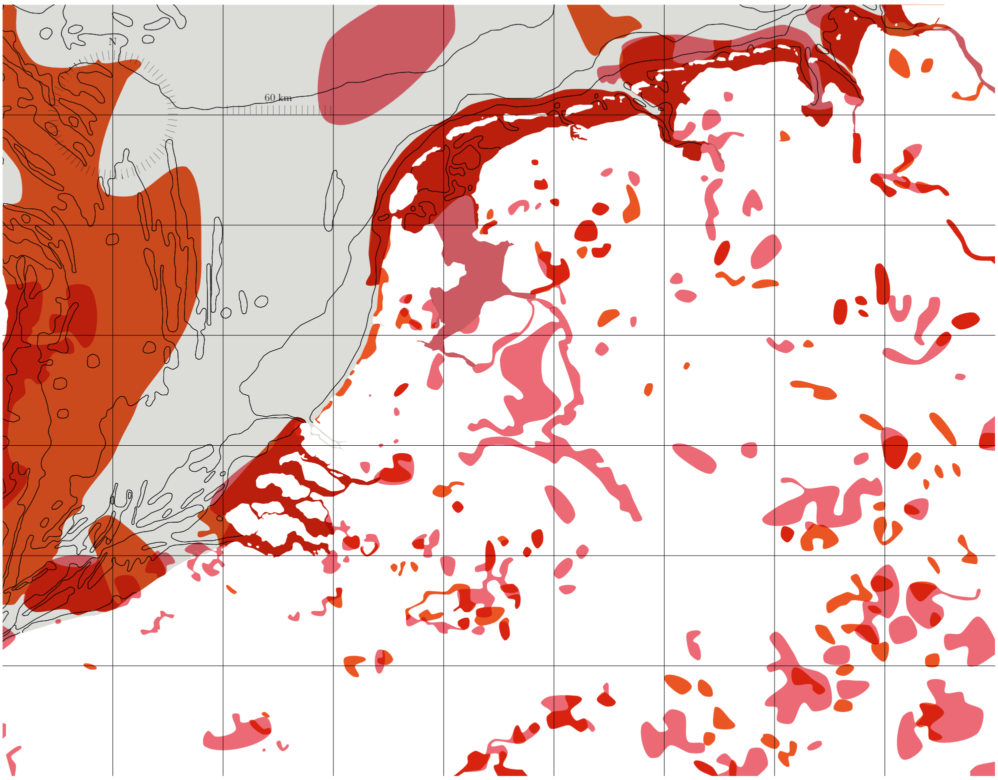
4.3.2 NATURE

The natural layer is important for a prioritization of the Netherlands as it contains unique conservation areas and essential natural elements of the water cycle and topography influencing flood risk and the natural functioning of the country. When looking at the distribution of nature in the Netherlands, therefore, the protected nature is distinguished from the water elements related to flood risk. For the distribution of protected nature in the Netherlands, the assigned Natura 2000 areas are used. Natura 2000 is a European network of nature reserves in which the protection and conservation of flora and fauna are key. The species and areas to include are defined in the bird directive (CUE 2009) and habitats

4.29 The distribution of Natura 2000 areas in the Netherlands.

habitats directive site
birds directive site
habitats and birds directive site

modified from European Environmental Agency 2016



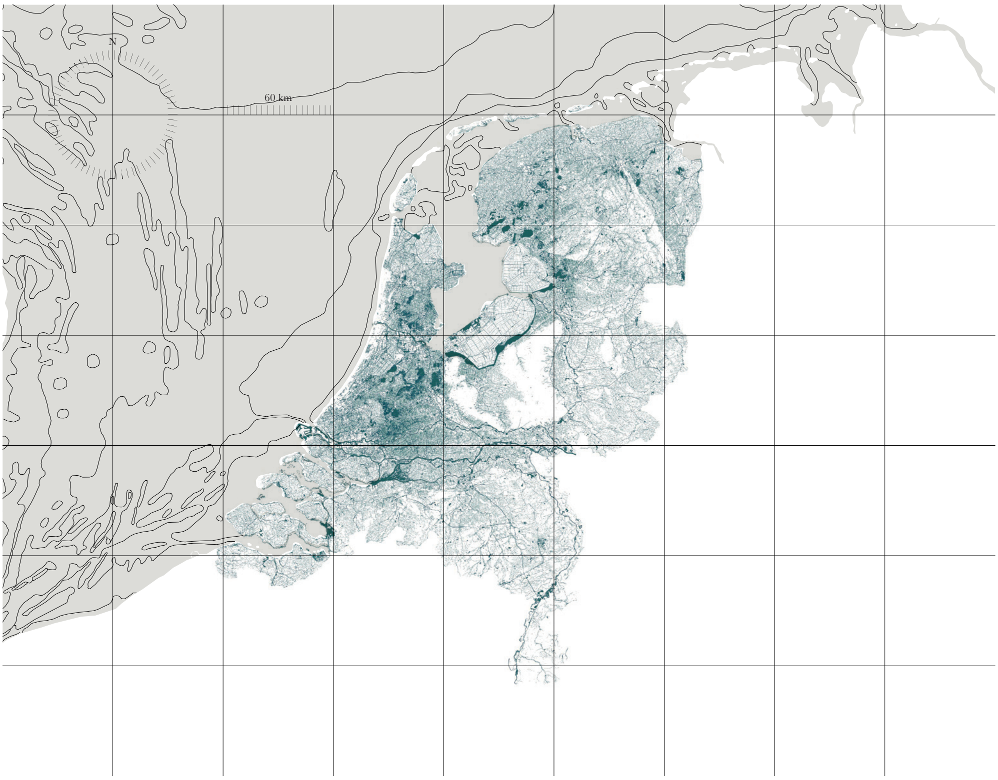
4.29

directive (CUE 2007) and mapped in figure 4.29. A lot of scattered smaller areas can be recognized but for coastal region of the Netherlands, several large Natura 2000 areas stand out. The different parts of the Southwest Delta, Biesbosch, Veluwe and the Wadden Sea are both bird and habitats directive sites, the IJsselmeer and rivers are mostly only bird directive sites and the dunes are habitats directive sites.

In order to visualise the natural elements related to flood risk in the Netherlands, water and topography are mapped. In figure 4.30, all water bodies wider than 0,50 m are shown and the Netherlands as a water nation is affirmed. The rivers are a particularly crucial water element in the Netherlands, their location demarcs regional and national territories, they are of great importance for the Dutch economy and they connect the Netherlands to rivers reaching into Belgium, Luxembourg, France, Germany and Switzerland and a catchment with a surface of 219.500 km2 spread through Europe. The flow path of the rivers but also the distribution of river discharge coming from the Meuse and the Rhine show a concentration in central Netherlands and the largest share of the river discharge is reaching the North Sea at a concentrated point via the Nieuwe Waterweg and the Haringvliet [4.14]. These discharge points are located at only 12 km distance from each other.

The topography of the Netherlands is shown in figure 4.31 and emphasises the extent of the country that is located below sea level and at highest risk for flooding. Behind a small stretch of flood defence by elevation, shaped by the dunes, the islands and the Wadden Sea together with the Delta Works, big parts of Zeeland, Noord- and Zuid-Holland, Flevoland, Friesland and Groningen are located below current sea levels. In the province of Drenthe, Utrecht and Gelderland the altitude increases to above 10 m quickly with the presence of the higher sand grounds, like the glacial deposition of the Veluwe. However, as sea levels rise to extreme scenarios, the whole Netherlands are at risk. A crucial point at risk with extreme sea level rise is the 15 m high elevation called the Hoge Berg at the island Texel. Flooding of this topographical element is predicted to cause the coastal foundation to be pushed back from the current

4.30 The distribution of all water bodies
wider than 0,50 m in the Netherlands.

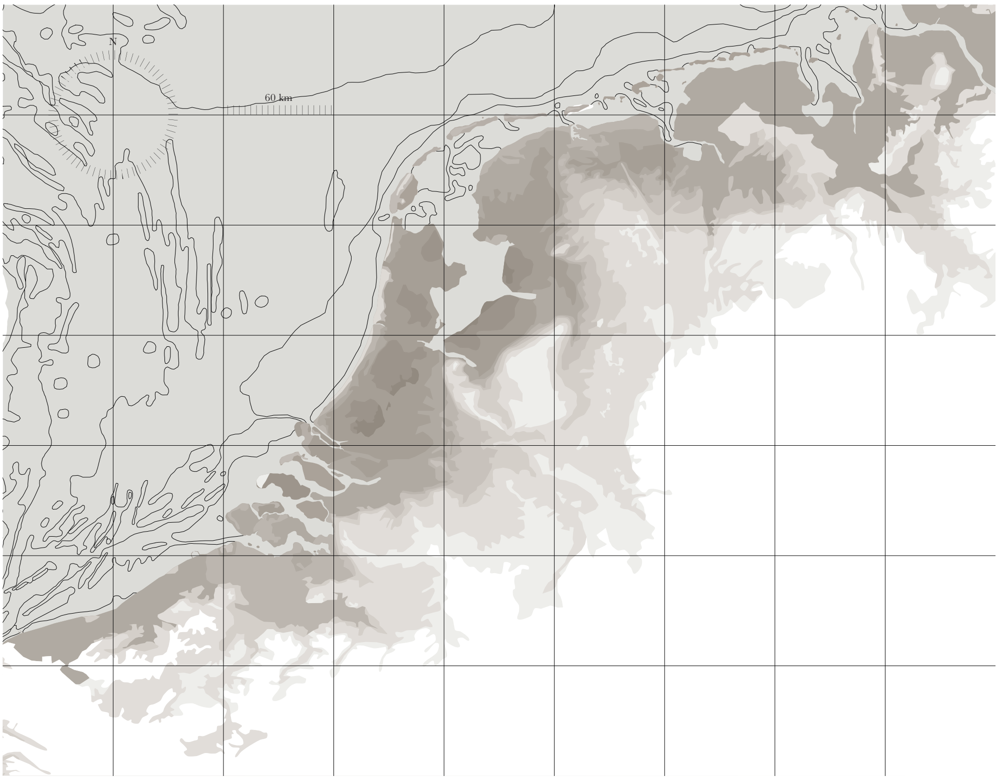


4.30

4.31 The topography of the Netherlands.

30 m
20 m
10 m
5 m
2 m
1 m
0 m
- 3 m
-5 m

modified from Publieke Dienstverlening op de Kaart 2018

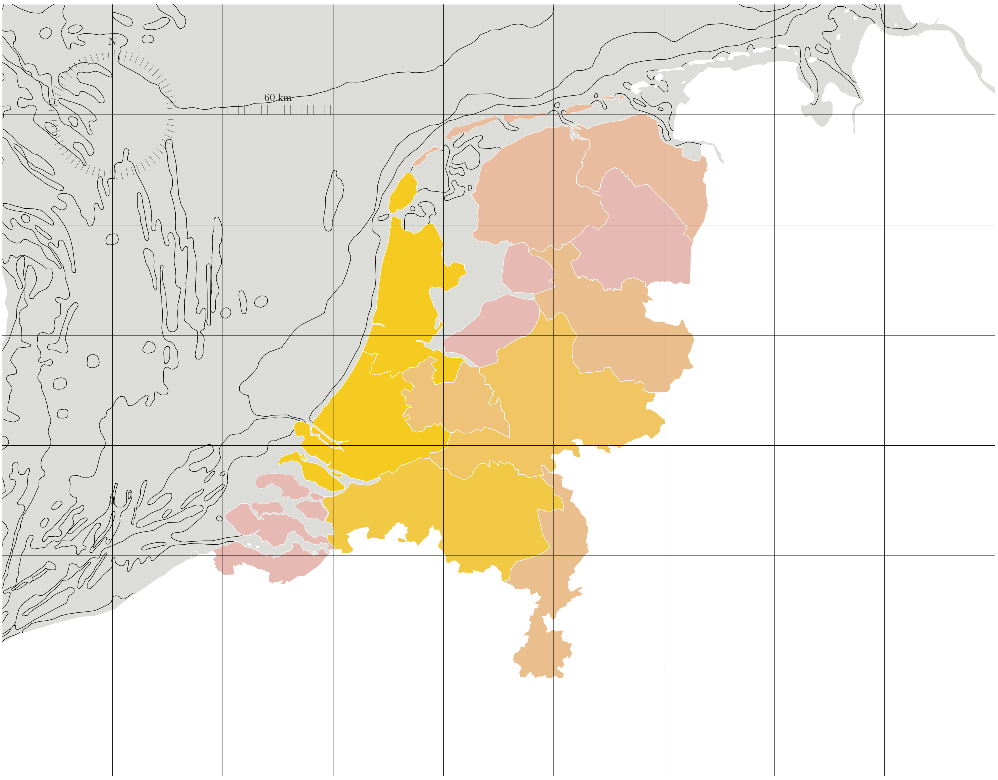


4.31

4.32 The distribution of the contribution to the Dutch GDP per province, 2018.

■	Zuid-Holland / Noord-Holland	21 %
■	Noord-Brabant	15 %
■	Gelderland	10 %
■	Utrecht	9 %
■	Limburg / Overijssel	6 %
■	Groningen / Friesland	3 %
■	Zeeland / Flevoland / Drenthe	2 %

modified from CBS 2018



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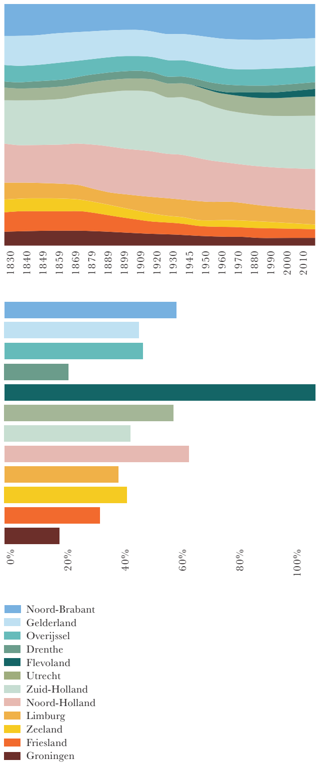


4.33a The contribution to the Dutch GDP per province, 1830 - 2013.

modified from Oevering 2013

4.33b The economic development per province, 1995 - 2015.

modified from CBS 2015

line between Belgium and the Hoge Berg towards the line between Belgium and Gaasterland in the south of Friesland (Haasnoot et al. 2017).

4.3.3 ECONOMY

The distribution of regional contribution to the Dutch economy, the gross domestic product (GDP), is shown in figure 4.32. It shows that the provinces of Noord-Brabant and Noord- and Zuid-Holland account for more than half of the Dutch GDP. This figure however is a picture of the current situation and needs also to be explored over time. Graph 4.33a shows how the contribution of the GDP per province in the Netherlands changed over time. Here, the upcoming contribution of the province of Flevoland after completion of its land reclamation is striking. Graph 4.33b shows the economic development per province over the period between 1995 and 2015. Where in figure 4.32 and graph 4.33a for the reclaimed land of the province of Flevoland show a small contribution to the Dutch GDP, graph 4.33b shows how the economy of the relatively new province doubled in the period of 1995 - 2015. Flevolands increasing economic development goes together with its population growth (CBS 2015).

4.3.4 POPULATION

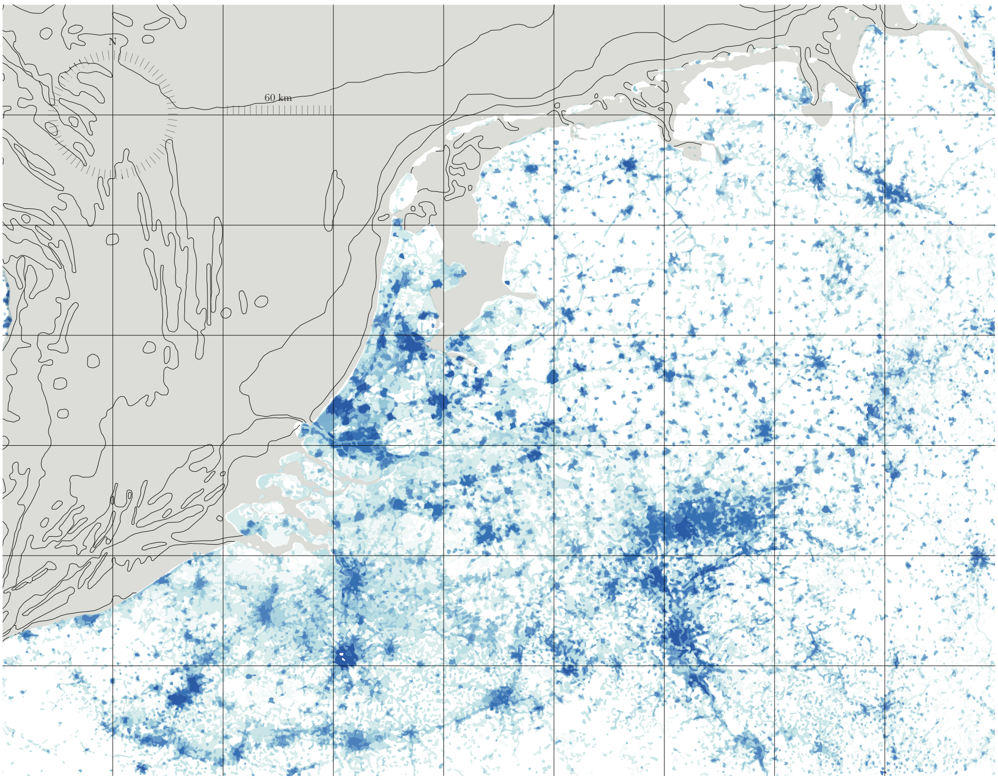
The example of Flevoland showed how the distribution of economy in the Netherlands is interrelated to the distribution of its population. Economic development can only be partially be evaluated without the consideration of population. Figure 4.34 (GEOstata and EU 2017) shows the distribution of population densities in the Netherlands. A distinction can be seen between the densely populated Randstad region, a transition zone south of the Randstad with cities and average densely populated areas in between and sparsely populated areas in the northeast of the country.

Figure 4.34 again is only a picture of the current situation and need to be seen over time. Hence, the Dutch Planning Agency for the Living Environment (PBL) in collaboration with the Central Statistics Office (CBS) update the regional population and household prognoses every three years. Figure 4.35 (Kooiman et al. 2016) shows the most recent projection. Per municipality the expected shrinking or increase of population is shown between

4.34 The distribution of population densities in the Netherlands.

residents per km²
0 - 99
100 - 399
400 - 1 000
1 000 - 2 000
2 000 - 3 500
3 500 - 5 500
5 500 - 7 500
7 500 - 9 500
9 500 - 12 000

modified from GEOstata and European Union 2017

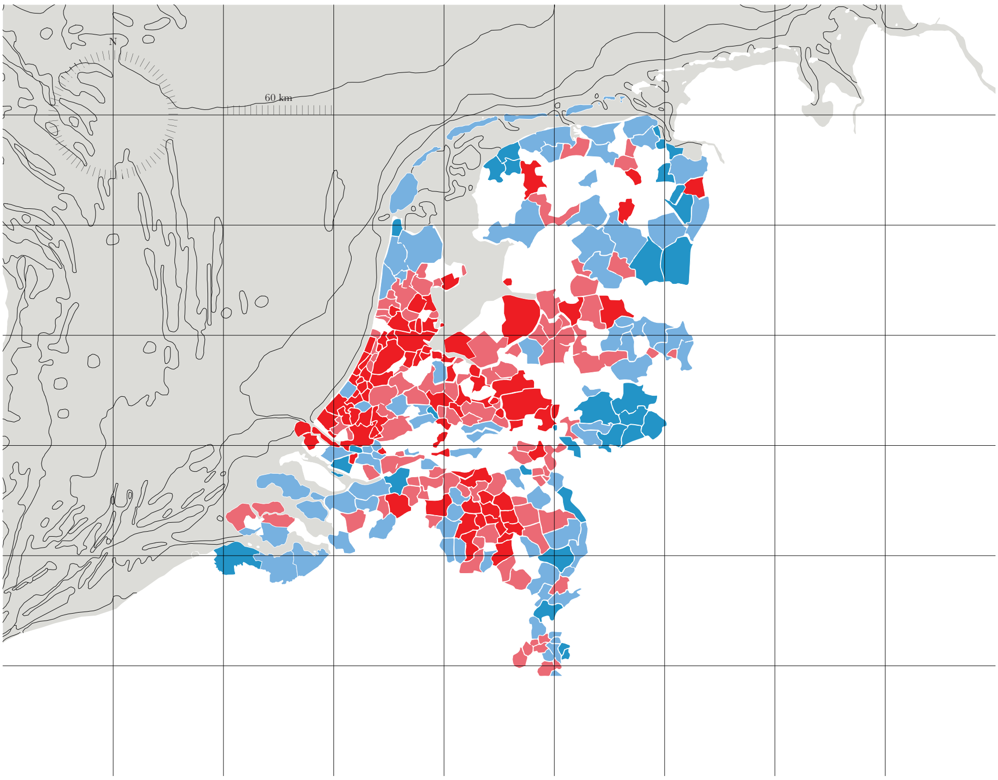


4.34

4.35 The population development projection for the Netherlands, 2016 - 2040.

	strong growth	> 10 %
	growth	2,5 % - 10 %
	stable	-2,5 % - 2,5 %
	crimp	-2,5 % - -10 %
	strong crimp	< - 10 %

modified from Publieke Dienstverlening op de Kaart 2018



4.35

2016 and 2040. A concentration of municipalities with a population expected to grow strongly can be seen around the Randstad and stretches further out to the Flevopolder, Arnhem and Zwolle. Divided from the Randstad by the rivers, a second cluster of population growth can be seen around Eindhoven. Scattered population development can be seen around the cities of Leeuwarden, Groningen and Assen in the north of the Netherlands and to a lesser extent for the municipalities of Veere, Noord-Beveland and Goes (Walcheren) in the province of Zeeland and Maastricht in Limburg. This scattered population growth shows parallels with the population crimp in the surrounding municipalities. Clusters of the strongest population decline can be seen in the islands, northern parts of the provinces of Noord-Holland, Friesland and Groningen, Drenthe, Twente (East Overijssel), the Achterhoek (East Gelderland) and the south of the province of Zeeland.

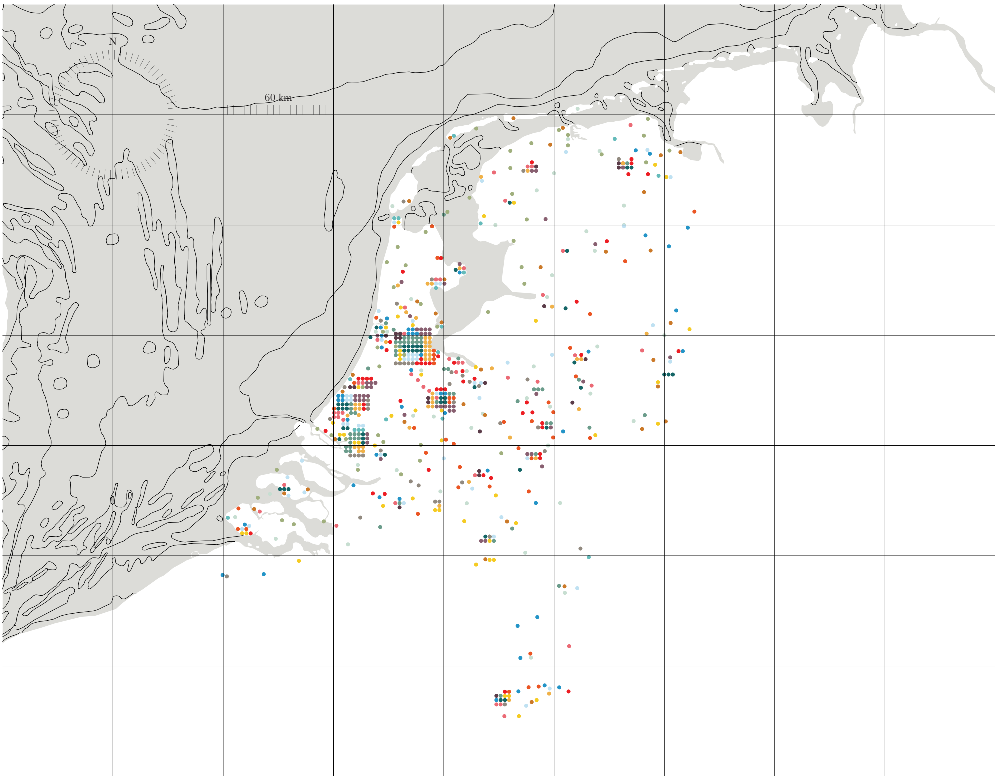
4.3.5 HERITAGE

An, at first sight, element of lesser importance is the dispersion of heritage in the Netherlands. Complex national structures are not depending on its distribution. However, the idea of distinguishing priorities in regions is likely to cause resistance based on the presence of heritage as it, partially conscious and partially unconscious, represents the Dutch identity. Research on societies has shown that the sunk-cost effect, where irreversible prior investments irrationally influence behavioral choice, increases the vulnerability of a society (Scheffer and Westley 2007) and is the basis of one of the psychological limitations in climate change mitigation and adaptation (Gifford 2011). The sunk-cost effect has manifested itself over time and throughout scales. Examples can both be found in the fall of seemingly indestructible civilisations like Angkor in Cambodia but also the management of soccer teams who let it’s most expensive player play most regardless of its performance in the competition season.

To allow the option of retreat to happen requires the making of space for natural bodies to coexist with rising sea levels. Here the sunk-cost effect offers restrictions to the possibility of prioritising a dynamic coastline over the present heritage resulting from centuries of ‘investments’. To localise and make a relevant selection of the various

4.36 The distribution of cultural heritage in the Netherlands.

- natural
- water
- cultural
- urban
- transport
- religious
- memorial
- power / authority
- industrial
- trade
- agricultural
- defence
- collected
- healthcare
- educational
- utility



4.36

manifestations of cultural heritage, a categorisation is made. The categories in the inventory can be seen in figure 4.36 and the accompanying maps in appendix II [25 - 40]. In figure 4.36 all the different heritage maps have been merged and gives and strongly abstracted image of the dispersion of heritage in the Netherlands as statues, buildings, neighborhoods and nature reserves all have been represented with only a dot. This exercise however points out the disparity of heritage present per region. The concluding merged image shows a strong accumulation of heritage in the cities of the Randstad.

4.4 THE DUTCH LAYERS APPROACH AND THE CASCO CONCEPT

The exploration of Dutch dispersions provides us with a set of interconnected systems related to the threat of flood and flood risk management. The presented interconnected systems are on their turn again related to a range of systems, patterns and traditions embedded in the Netherlands and its culture. The overlay of the dispersion of systems facilitate the Dutch layers approach (DLA) (De Hoog et al. 1998a) and the casco concept (Sijmons 1991).

The DLA originates from a model created as a response to the Metropolitan Debate which accentuated the need for the establishment of a base for the strategic choices that had to be made regarding the future spatial development of the Netherlands in the light of climate change, water management, the economic position of the Netherlands in international networks, urban dynamics in relation to the values and attractiveness of the landscape and the need for integral planning (De Hoog et al. 1998a, De Hoog et al. 1998b).

A stratified model was proposed which connected planning tasks to spatial dynamics on a regional scale by differentiating the substratum, the layer of networks and the layer with occupation patterns. In addition to the three layers, the element of coherence is considered as the domain of spatial planning between the layers and interventions (De Hoog et al. 1998a). The division of layers facilitated a strategic organisation of the multitude of spatial tasks and projects. This ordering, in which not everything was equally important, allowed a new logic of prioritising one project or task over another (Sijmons

4.37 Plan Ooievaar (Stork), the Dutch layers approach applied on the river region in the Netherlands.

4.38 layers

substratum	
design and planning tasks	~ dealing with physical effects of climate change ~ modernising the water management system
approach	~ nature engineering ~ civil engineering
networks layer	
design and planning tasks	~ strengthening the position of the Netherlands in international networks ~ control and steer the growth of mobility
approach	~ complexes approach (developing nodes for exchange of information and knowledge) ~ corridor approach (developing mainports and hinterland connections)
occupation layer	
design and planning tasks	~ accomodating spatial claims and shrinkage in relation to values and attractivity
approach	~ ecology approach (ecology defined as a locally characteristic life-style envrionment) ~ mold-contramold approach (city vs. landscape)

modified from De Hoog et al. 1998b

2002). The stratified model developed into an approach to spatial planning and design and gained popularity as the DLA in the last two decades of the Dutch planning praxis in which the layers stand for aspects of concern in the domain of urban and regional design and planning (Van Schaick and Klaasen 2011). The visualisation of the approach which illustrates the layers of the approach plays an important role in its success.

Table 4.38 (De Hoog et al. 1998a) shows the trichotomy of layers of the DLA to be characterized by particular design and planning tasks and a specific pace of transition. The importance of the transition-pace and dynamics is introduced by the a predecessor of the DLA, the casco concept. This is an integrated approach for the design of frameworks in the urban landscape (Hooimeijer 2014). A framework that can be conceived as a critical set of essential and robust natural and manmade structures which give boundaries to a more flexible supportive urban and landscape development in the long term which, on its turn, accommodates different and emerging programmes (Lafleur 2017). An important difference of the casco concept from the DLA is its projection of the distinction between a crucial robust network and the supportive flexible patches only to the third occupation layer (Hajer et al. 2006).

When regarding the dynamics of layers for scenarios of extreme sea level rise, the gap between the multiple transition-paces is decreasing. The Dutch Delta Commissioners advisor on strategics and knowledge, Pieter Bloemen (personal communication, April 18, 2018), justly questioned the allocation of general transition-pace to the layers of the DLA. When it comes to extreme sea level rise, he believes the substratum to be most dynamic and the layers of networks and occupation to be unfortunately static. Firstly, because of the lack of adaptability in the layers of networks and occupation. Secondly, because of the relatively small magnitude of change ahead the layers of networks and occupation will face in comparison to the radical changes within the substratum subject to the accelerated rising of sea levels.

To evaluate the dispersions of flood risk sensitive systems in the Netherlands, the two perceptions of dynamism are important to be considered. Therefore, in making a prioritisation based on these dispersions, the allocation of the different discussed systems to one of the layers of the DLA is considered to be of lesser concern than to examine their transition-pace. The more simplistic distinction of the preceding casco concept is leading, focussing on distinguishing a critical, essential and robust framework from the flexible and supportive patches.

For this exercise all layers of the spatial analysis of the Dutch dispersions mapping exercise are superimposed, resulting in the concluding image in figure 4.39.
Many of the dispersions show overlap. Most striking is the resemblance between the distribution of strong population growth, the distribution of contribution to the GDP, the distribution of heritage sites and the safety norms for the dike rings. It is, however, self-evident that these systems show overlap. Aside from the IJsselmeer region, the Natura 2000 areas show overlap with the projections of population decline. The area around the Wadden Sea shows a predicted crimp of population on the islands and the adjacent municipalities in Friesland and Groningen. The Southwest Delta coincides with the population decline of the province of Zeeland and the region bordered by the Rhine, Meuse and Biesbosch, below the Randstad and in the north of Noord-Brabant, corresponds with municipalities with a stagnant population development. Furthermore, the natural flood defence of dunes show overlap with the Natura 2000 areas. Likewise do the man made primary flood risk management match with the network of the main Dutch rivers. Additionally noteworthy is the overlap of areas with relatively little sites of heritage and the municipalities of population decline.

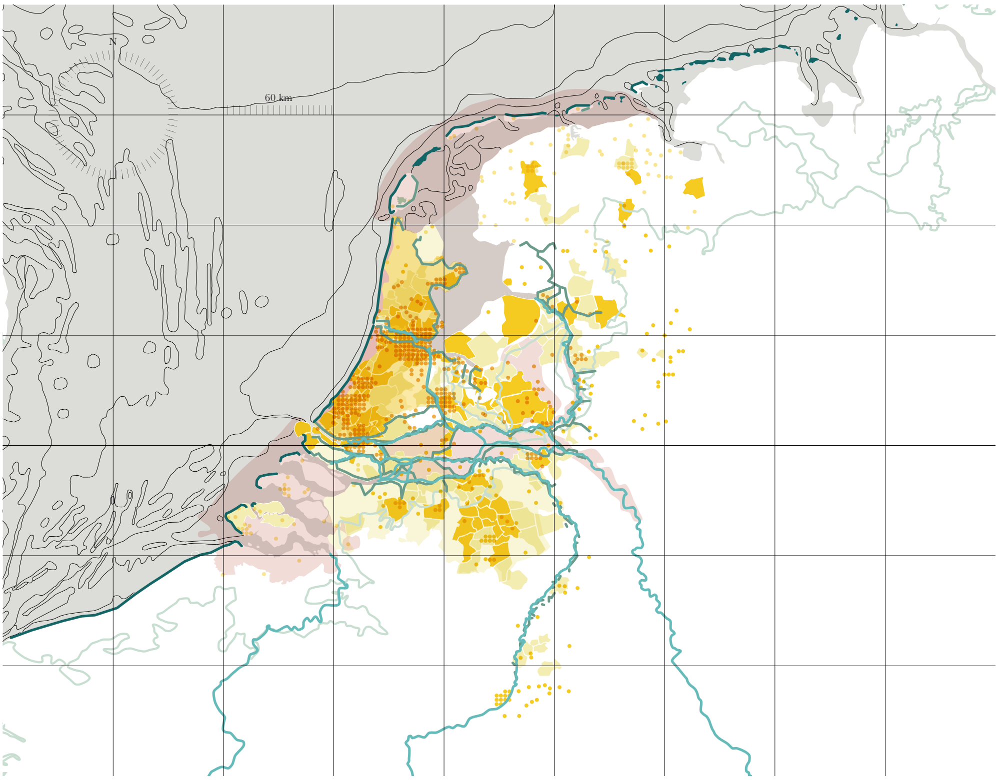
As most of the overlay of the visualisations of the Dutch dispersions show clear parallels, one discrepancy stands out. The topography of the Netherlands includes a large area which is located below current sea levels and aside from the Eindhoven region, this is exactly the area of strong predicted population growth, the highest contribution to the GDP, the biggest amount of heritage site and, therefore, obviously the highest safety norms for the dike rings. This discrepancy confirms the relevance of the research.

4.39 Mapping spatial prioritisation in the Netherlands.

crucial / essential framework
river
natural flood defence
man made primary flood defence
Hoge Berg, Texel
topography

static / supportive patches
economic importance
level of protection
population growth
heritage

flexible / supportive patches
preserved nature



4.39

Independently of either the perception of the DLA or the Delta Commissioner on the dynamism and flexibility of the layers, the layers are set apart to assist the progress of prioritisation. Figure 4.39 illustrates a framework shaped by the linear elements and contains the rivers, primary flood defences, dunes and contour lines of topography whose structure appears to be clustered in central Netherlands. Here the framework occurs to unite the patches of strong predicted population growth, highest GDP contributions, dike ring safety norms and even heritage sites. The patches defined by natural elements reach out from the core of the framework but are interwoven within the framework with the river region and follow the network of dunes. The concluding image emphasises accentuates the detachment of provinces of Friesland, Groningen, Drenthe, Limburg and parts of Overijssel and Gelderland and a clear dichotomy of prominence for either nature and water and the Dutch population and culture on the other hand.

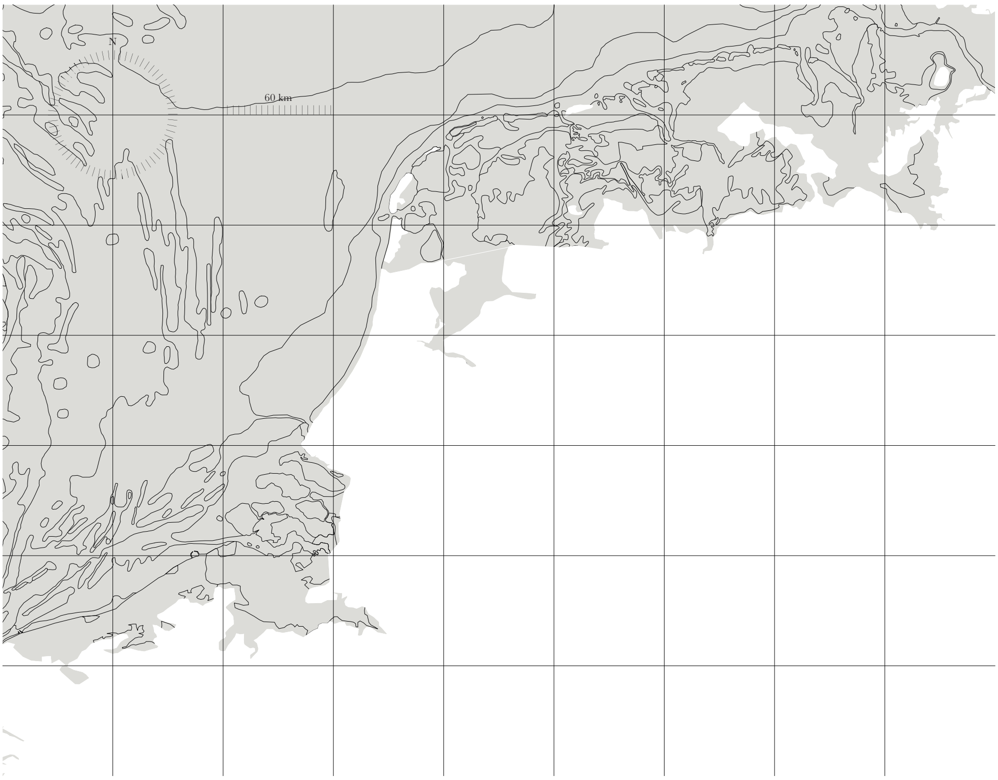
5. THE NEW NETHERLANDS

The system analysis resulted in a visualisation of regional priorities in the Netherlands. In scenarios of extreme sea level rise, this mapping exercise facilitates the continuance of the process of coastline shortening besides the application of a gradual transition between land and the high water levels. The concluding image of figure 4.39 served as an underlay for the blueprint of the New Netherlands.

The New Netherlands [5.1] is shaped for the efficient securing of delta stability for the country to coexist as a prosperous nation living with water, rather than struggling to defeat it. The emphasis on either the Dutch population and its traditions and habits or natural bodies and the Dutch natural system structures the country's new contour by harmoniously applying a superimposed coastline and coastline remediation respectively. The dichotomy results from analysis of reasonable and beneficial investments for interventions and the importance of existing and underlying functions, systems and patterns in the country.

The New Netherlands is capable of providing safety with a GMSL rise of 2 to 10 m, by transforming the Dutch coastline from a length of 880 km to 580 km, decreasing the flood risk management challenge. By doing so it offers space to the Wadden Sea and the Southwest Delta and their behaviour under sea level rise. With help of a revised dredging policy for the North Sea, sand suppletion can continue to enhance the Dutch dunes and dikes, maintain some of the remaining Wadden Islands and control sedimentation mechanisms to provide safety for the Randstad and reduce wave energy in the Wadden Sea and the Southwest Delta. An enhanced regulation mechanism in the west of the country controls the division of discharge of river water and works together with the storage capacities of the Markermeer, Biesbosch and river region as a buffer before water is discharged to sea with newly implemented pumps. The new coastlines, the Randstad and higher parts of the Netherlands can gradually anticipate to the relocation of population, in total an estimate of 1,7 million.

5.1 The New Netherlands.



5.1

5.1 DELTA PROGRAMME REVISED

Whether or not the proposal for the New Netherlands is sufficient, the new contour of the country and the relocation of a population of 1,7 million is difficult to process. The biggest problem posed for certain transitional measures drastically changing the system is the established standard giving resistance to change. In an attempt to make the transition towards the New Netherlands more tangible, the regions of the current Delta Programme are translated to a division of regions applicable for the New Netherlands under scenarios of extreme sea level rise.

Reactions to the New Netherlands showing perceptions, priorities and levels of acceptance.

‘You don’t like Friesland?’
‘It’s a nice picture but everything is flooded.’
‘But the country looks really ugly like this.’
‘This is not possible.’
‘Where am I supposed to live?’
‘Luckily Texel remains.’
‘I never really had a connection with Friesland either.’
‘I’m happy those sea level rise scenarios will never come true.’

5.2 Leo Belgicus - Michael Aitzinger, 1583.

The propasal for the New Netherlands requires the acceptance of a new territorial outline, the beheading of the lion.

The current Delta Programme is divided into three generic subprograms; safety, sweet water and new constructions and restructuring, and six site specific subprograms, the IJsselmeer region, the Rhine debouchment region and its Drecht cities, the Southwest Delta, the rivers, the coast and the Wadden Sea region [5.3]. For every region, the Delta Programme distinguishes a set of topics of concern, required improvements, research and policy making, regarding water management. The regions of the current Delta Programme were the basis for the new division of regions [5.4]. The current and future topics related to flood risk and sea level rise management are listed below and in figures 5.5 - 5.10.

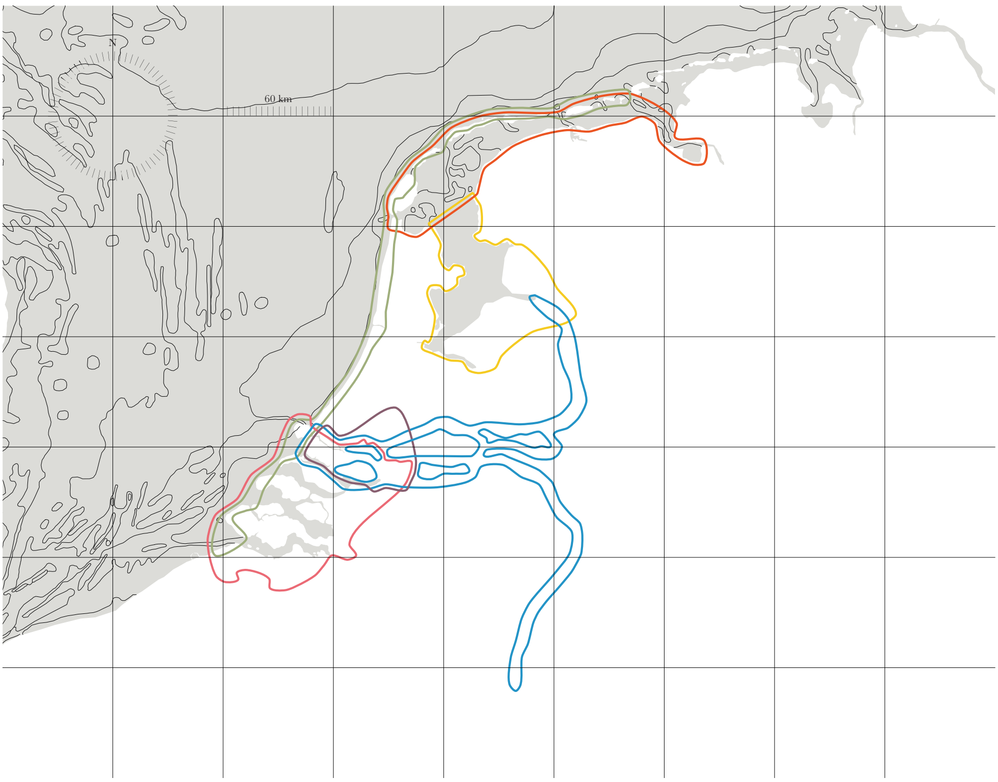
<u>IJsselmeer / Markermeer</u>
Where the IJsselmeer region focuses on the maintenance, improvement and standardisation of flood defences and the control of lake water level, for the Markermeer region [5.5] these actions will be extended with the innovation and integration of dikes facilitating an enlargement of the storage capacity of the buffer function of the lake. Besides dike innovation the pumps and their capacity are a topic of concern. The most radical and different intervention of the New Netherlands is the relocation of the Afsluitdijk.

<u>Wadden Sea / Greater Wadden Sea</u>
The current flood risk management of the Wadden Sea is occupied with the assessment of increasing security norms, climate change consequences and climate resiliency of outerdike regions. The current works include wave energy reduction, coastal- and island management, dike innovation, sedimentation

5.3 The current regions of the Delta Programme.

- IJsselmeer
- Wadden Sea
- Southwest Delta
- Rhine debouchment / Drecht cities
- rivers
- coast

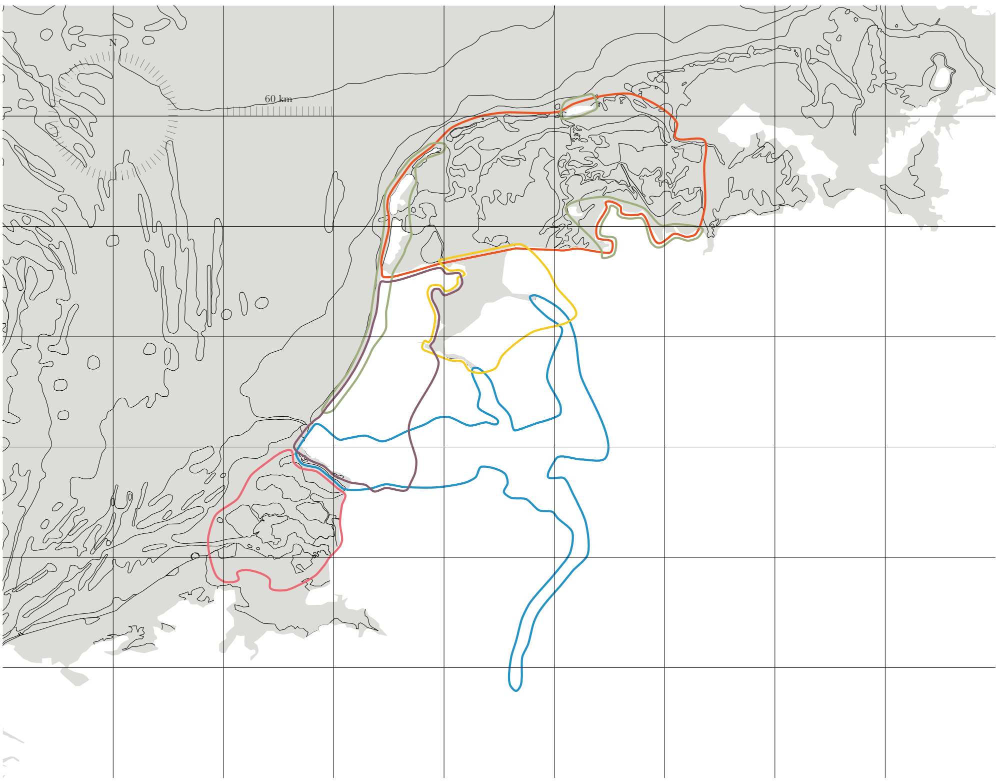
modified from Van Vuren et al. 2013



5.3

5.4 The revised regions of the Delta Programme for the New Netherlands.

- Markermeer
- Greater Wadden Sea
- Southwest Estuary
- urban peninsula
- river region
- coast



5.4

control and management and the maintenance of natural system. For the Greater Wadden Sea [5.6] the assessments continue but will be extended with the assessment of decreasing security norms in order to initiate the program of Room for the Wadden Sea. The Room for the Wadden Sea results in a shifting coastline and retreat which needs to be controlled and facilitated and requires alignment with German flood risk management and planning.

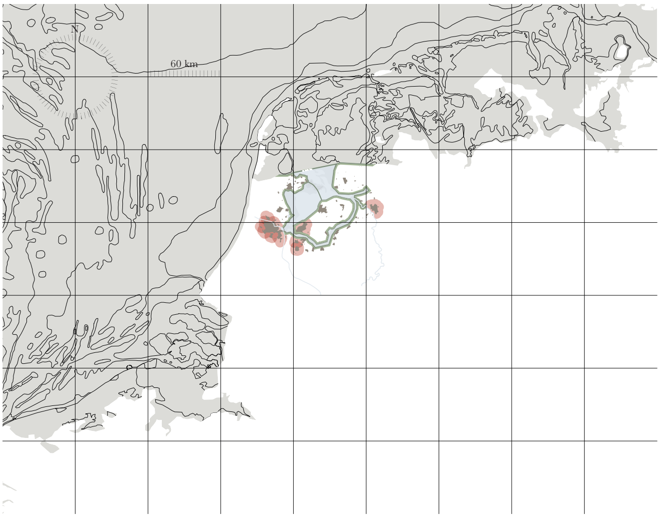
Southwest Delta / Southwest Estuary
The Southwest Delta is a region subject to works of maintenance, improvement and standardisation of flood defences with a focus on spatial and economic development and the natural system, besides the control of salt intrusion. Towards the New Netherlands the concerns will focus fully on the natural aspect and become an estuary [5.7]. The maintenance of the natural system, the control of salt intrusion, wave energy reduction and sedimentation control and management is key and goes together with dike innovation, relocation and integration and the facilitation of the replaced coastline and retreat. Alignment with Belgian flood risk management is important for the accessibility of the Port of Antwerp and collective coastal management.

Rhine debouchment and Drecht cities / Urban Peninsula
Flood risk management of the Rhine debouchment and the surrounding cities currently focuses on the maintenance, improvement and standardisation of flood defences with a focus on spatial and economical development, international positioning, urban water management besides the anticipation to river discharge fluctuations. As in the New Netherlands this region will form an urban peninsula [5.8] superimposed to the natural future outline of the country, the focus on flood defence and spatial and economical development and international positioning remains. The superimposition makes the innovation and integration of extreme dikes a concern, together with extreme urban water management to address the increasing ground and river water fluctuations and nuisance and

the maintenace of the accessibility of the Port of Rotterdam. The urban peninsula is most likely to facilitate the retreat of population from the Southwest Estuary and the Greater Wadden Sea and therefore increasing population densities become a topic of concern.

Rivers / River region
In the current Delta Programme the focus for this region is on the maintenance, improvement and standardisation of flood defences to anticipate to fluctuating river discharges and to maintain the natural system with a strong focus on spatial development and spatial quality. In the New Netherlands the Room for the River program remains and gets enhanced which implies the enlargement of the retention capacity, the innovation, relocation and integration of enforced dikes and the redesign of the river discharge division with a higher discharge via the Markermeer, for this the Gelderse Valley flow path needs to be facilitated [5.9].

Coast / Coast
With the proposal for the New Netherlands the coastal stretch decreases but as sea levels increase the focus points grow. The current Delta Programme only states the indication of weak links and beach nourishment. This will continue in the future but requires upscaling and an emphasis on the management of dunes. The New Netherlands will also result in new shore lines which will become a new part of this region [5.10].



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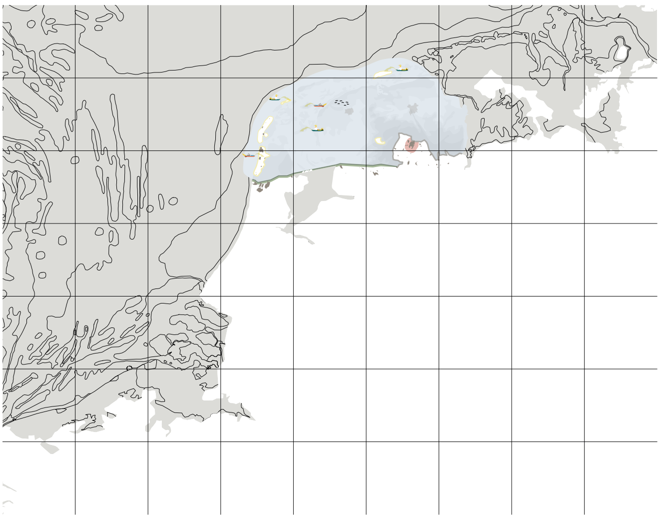

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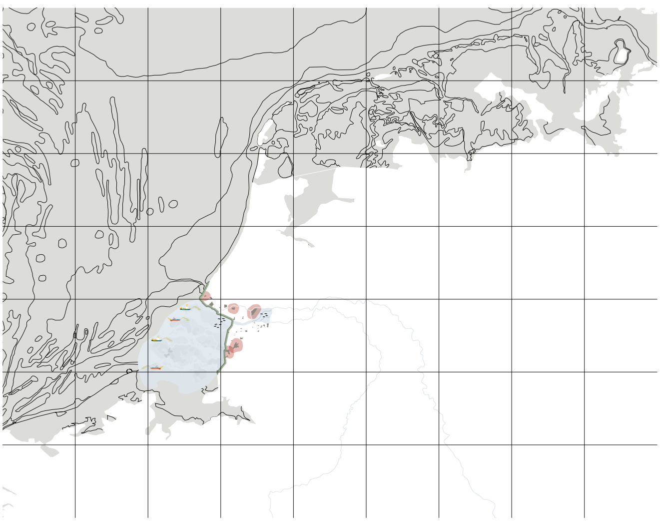

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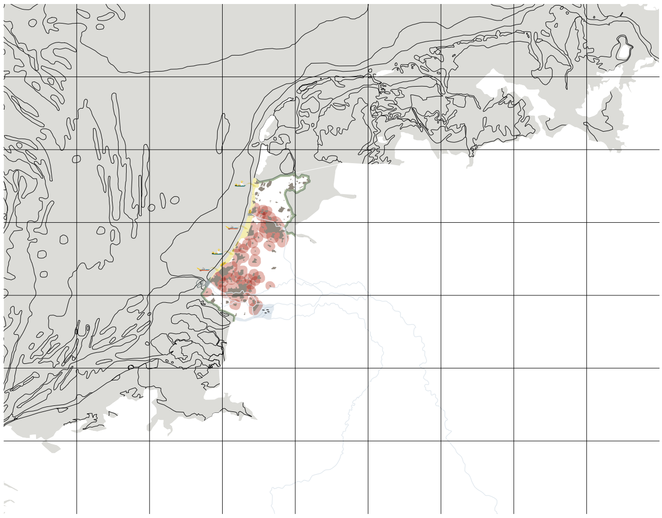
5.5 The Markermeer region in the New Netherlands.
5.6 The Greater Wadden Sea region in the New Netherlands.
5.7 The Southwest Estuary region in the New Netherlands.
5.8 The Urban Peninsula region in the New Netherlands.
5.9 The river region in the New Netherlands.
5.10 The coastal region in the New Netherlands.



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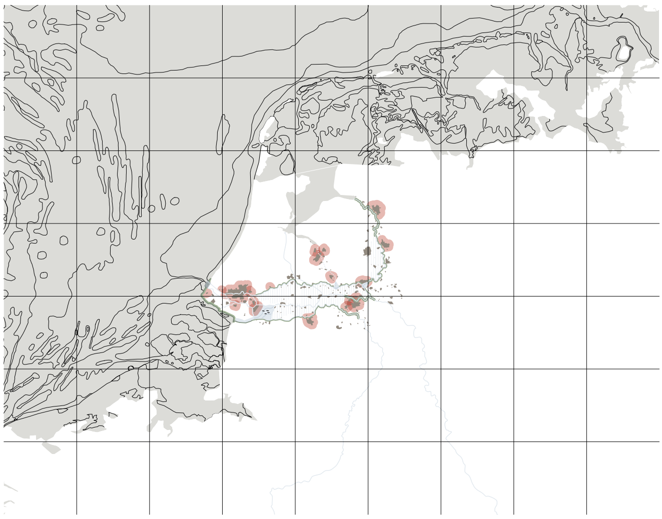

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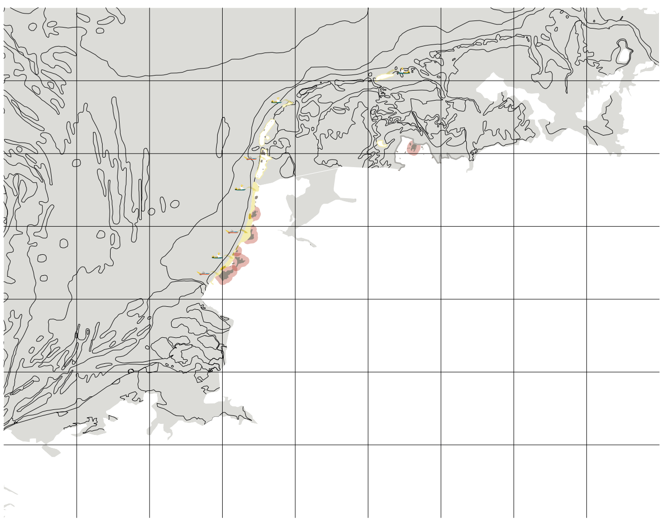


5.10

5.2 MAPPING THRESHOLDS

Figure 5.11 decomposes the transition towards the New Netherlands in steps and assesses the extents of sea level rise some of the crucial measures of the current system are capable to cope with. At the moment these extents of sea level rise are going to be crossed, the point is reached where to choose for enhancing the current system or changing the system. In order to point out urgencies, lead times and delineate the dependency of the current system on the magnitude of change in sea level rise, the thresholds are disconnected from a time scale but plotted on a scenario scale following rising sea levels. However assumption-based, figure 5.11 is an attempt to stepwise visualise and shape the process on how to concretely reach the realisation of the system of the New Netherlands.

Although the Dutch Delta Programme acknowledges sea level rise scenarios ranging upto 0,4 m in 2050 and upto 1,0 m in 2100 (Deltacommissaris 2014), the crucial flood defences are not capable of securing safety with these magnitudes of sea level rise. Figure 5.11 kicks off with the current GMSL and a selection of exemplary elements used in the current system: sand suppletion, sea dikes and dunes, the Afsluitdijk, the storage capacity of the IJsselmeer, the Maeslantkering, the dikes neighboring the Wadden Sea, the Delta Works in the province of Zeeland and river dikes.

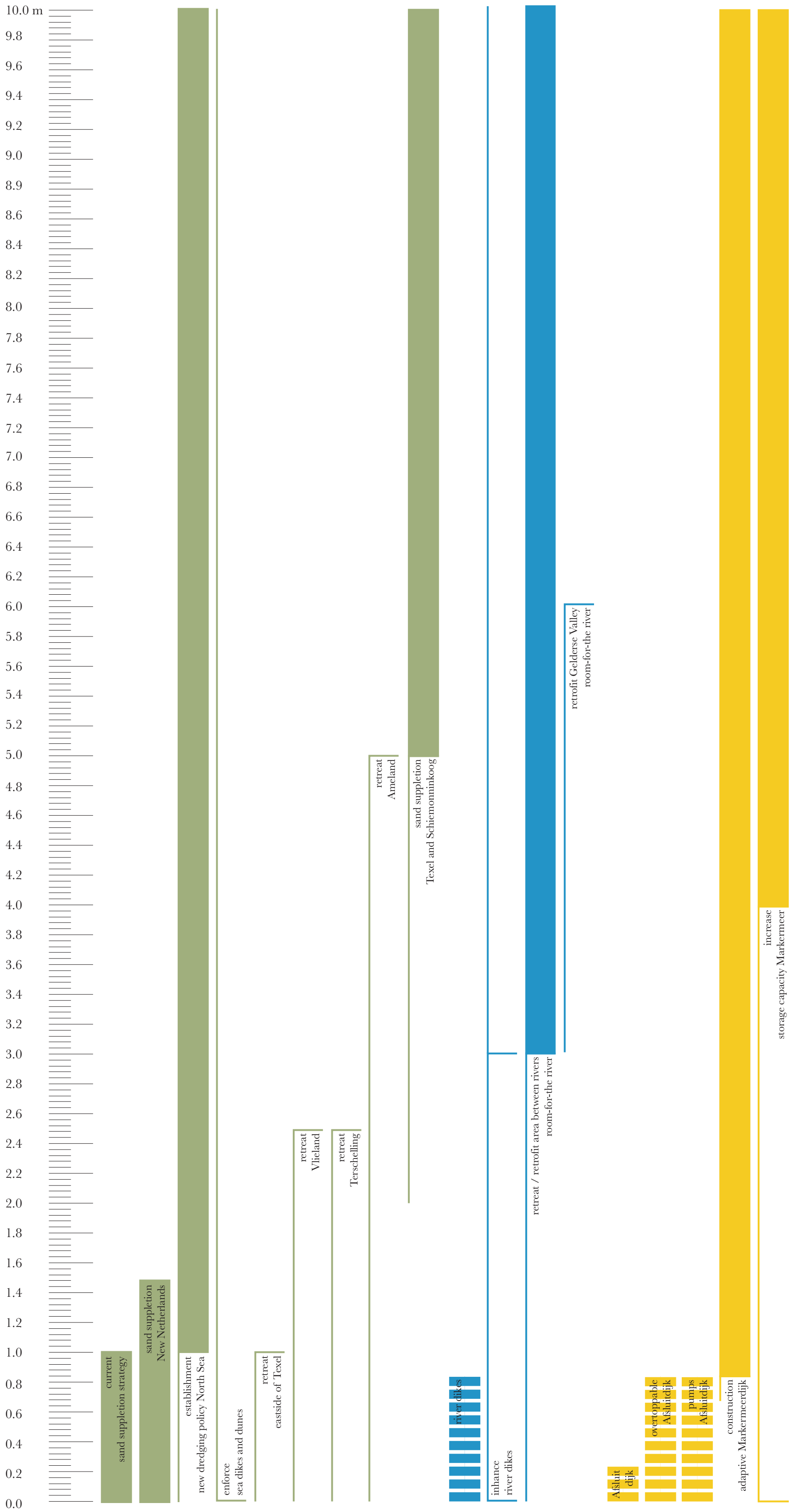
In case of accelerated sea level rise, the current dredging policies for the North Sea are forecasted to provide sand for the current sand suppletion strategy until 1.0 m GMSL rise (Noordzeeloket 2018) as long as we maintain the current coastline of the Netherlands. The gradual implementation of the New Netherlands' coastline will push its expiration date forward a bit, however, not sufficient to cover all extreme sea level rise scenarios. The exploration of an adaptation of the sand extraction strategy should start now, to research the applicability of sand further out at sea, the limitations by Natura 2000 areas and other activities and structures present in the North Sea like fishing, windmills and pipelines but also the ecologic effects under increased sand dredging (Haasnoot et al. 2017). A new dredging policy for the North Sea should be a high agenda point because of the need for sand in many flood risk management interventions, the availability of sand is interconnected with the possibility of beach nourishment, additional sedimentation in the Wadden Sea and the Southwest Delta and reinforcement of river and sea dikes and dunes.

Continuously enforcing sea and river dikes and dunes is a task which will be crucial both in the current and in the proposed flood risk management strategy. However, the dike enhancement in the New Netherlands takes extreme future scenarios in to consideration in an attempt to optimise efficiency and investments. When reviewing the examples of the Afsluitdijk, the sea dikes neighboring the Wadden Sea in Friesland and Groningen, the Delta Works and the Maeslantkering, multiple pathways are considerable. Besides a transitional adjustment there is the option of incrementally heightening the mentioned objects after every tipping point, pushing the original interventions further within one pathway until the dead end of a pathway is reached.

The Afsluitdijk is already subject to improvements within its original pathway by making it resistant to overtopping waves and adding pumps to the sluices which now naturally discharge water from the IJsselmeer with the tidal range (De Ingenieur 2015; Deltacommissaris 2017). As an alternative there is the enforcement of the Houtribdijk or/and the construction of a new 'Markermeerdijk', allowing ascending safety levels and a phasing out of the Afsluitdijk. This development goes connected with an increase of the storage capacity of the IJsselmeer and Markermeer.

On the topic of the Maeslantkering, the Delta Programme is more in line with the transitional approach of the New Netherlands proposal. The 2016 Delta Programme expects the lifespan of the Maeslantkering to reach up to 2070 (Deltacommissaris 2015) and therefore the 2017 Delta Programme proposes the research for replacement of the Maeslantkering to start in 2040, including the statement that the radically different variant for locks will be a full-fledged alternative (Deltacommissaris 2016).

The thresholds of the Wadden Sea dikes in Friesland and Groningen, the Delta Works in Zeeland and the river dikes in the centre of the Netherlands are



5.11 Tipping points towards the New Netherlands as sea level rises.


Maeslantkering
completion adaptive sluices Port of Rotterdam
Delta Works Zeeland
retreat Schouwen-Duivenland
dike inhancement southside of Zuid-Holland
retreat Goeree-Overflakkee
retreat Tholen
retreat Noord-Beveland
completion Noord-Brabant coastline
retreat Walcheren
retreat Zuid-Beveland
retreat Zeeuws-Vlaanderen
sand suppletion Southwest Delta
Wadden Sea dikes Friesland and Groningen
room-for-the Wadden Sea
retreat southside of Friesland
dike enclosement northside Noordoostpolder
retreat northside of Friesland
retreat northside of Groningen
sand suppletion Wadden Sea
retreat southside of Groningen
completion Drenthe coastline

inextricably linked to the most radical pathway of the New Netherlands: the pathway of retreat. The phased retreat follows the gradual inundation of rising sea levels and can profit of the population decline in the regions. To facilitate the stepwise retreat presented in figure 5.4 the Room for the River concept is extended. As the Room for the River project provides more room for high river discharges, the additional Room for the Southwest Delta and Room for the Wadden Sea will provide space for rising sea levels. Room for the River was developed and implemented between 2000 and 2015 and fundamentally changed the water management culture by connecting nature-engineering with civil engineering and hydraulic infrastructure with spatial development (Meyer 2017) by emphasising the importance of spatial quality to allow large scale transition to happen (Sijmons et al. 2012). Where spatial development is mostly driven by economic and social priorities (Wolsink 2006), Room for the River considered water as a structuring principle for spatial development (Valk and Wolsink 2001). Although the scale difference, Room for the River is an exemplary project showing that transitional change is possible (Rijke et al. 2012).

6. DIRECTIONS TO THE NEW NETHERLANDS

The proposed adaptations to cope with scenarios of sea level rise implies a radical transition in Dutch flood risk management. The adaptive capacity of the Netherlands as a system could potentially be overstretched. However, to enable transition, the investment gap between current flood risk management and the further development of this approach needs to be closed (Bloemen et al. 2017) and social limits of adaptation need to be pushed forward.

The discourse around limits of adaptation is mostly constructed around economic, technological and ecological and physical limits as they have been used in the assessment of the layers and systems of the Netherlands in this research. These limits are supposedly binding and beyond them adaptation is alleged not to be possible. However, when approaching limits to adaptation from the point of view of the organisation of societies and their values, knowledge and the relations between individuals and institutions within them, limits of adaptation seem to emerge from inside the society (Adger et al. 2009). Therefore, adaptation to climate change is confined by the attitude of a specific society to ethics (how and what is valued), knowledge (how and what is known), risk (how and what is perceived) and culture (how and why is lived). Which implies that the limits of adaptation are society-dependant and mutable. The question how to stretch the societal limits of adaptation to extreme sea level rise scenarios, however, remains. In the Netherlands, the possibility of transitional change in flood risk management is proven. The implementation of hydraulic structures after the 1953 North Sea Flood drastically transformed the Southwest Delta region.

This chapter looks into the implementation of transition. By means of a brief historical analysis of flooding and its perception, the risk management behaviour over time is explored alongside the research of flood and flood risk management represented in visual arts [appendix I]. By extending this flood risk management discourse, the opportunities and challenges of a future transition of the current Dutch flood risk management strategy is examined.

6.1 FROM THE DELUGE TO NON-ANTLOPHOBIA

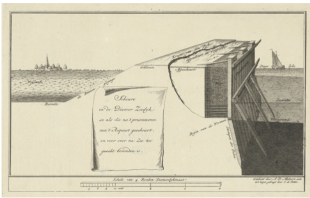
Fear of floods is defined as antlophobia. This definition describes an extreme or irrational fear of property damage or loss and injury or death of oneself or loved ones caused by floods. Nomather how extreme, irrational or natural the degree of fear, the origin of fear for floods can be found in either, a fear of drowning, trauma from previous experiences or the coverage of flood events elsewhere in the world via numerous media channels. Fear of floods can be experienced both as an individual or as a collective. Collective fear never reaches the extreme degrees an individual's fear can reach (Doctor et al. 2008) but it is the collective regard of flood risk management that will be discussed.

The consideration of flood is something of all times. The oldest dike related structures found, date back to the prehistoric era (LOLA Landscape Architects 2014). The best known ancient representation of flood, however, is the deluge in Genesis 6:9-9:17, and dates back to the 6th and 5th century BC (Van Seters 1998). Similar flood narratives appeared in ancient Greek, Mayan, Mesopotamian, Islamic and many other ancient cultures and religions, but they all tell a story comparable to the Hebrew flood myth where the flood is considered as the reversal of creation. Seeing the world was corrupt and violent, God instructed Patriarch Noah to build an ark for his family and one male and female of all living creatures, after which it rained until all mountains were overtopped with water and all life on earth perished except for Noah and his companions on the ark.

Throughout history the religious point of view towards flooding, as a deluge, was leading. Even though flooding was seen as a sign from God, this didn't mean there were no dikes [6.1]. The construction and maintenance of dikes was throughout most of history considered to be the responsibility of individuals living in close proximity of the dikes (Hage 2015). With the growth of prosperity and political stability in the Western world, flood risk and water management technologies started developing after the 14th century (LOLA Landscape Architects 2014). A change of perspective was initiated and flooding again started to be also attributed as a natural phenomenon. Especially in the Netherlands, where flood risk was

6.1 The Saint Elizabeth's Day Flood Panels, 1490 - 1495.

interconnected to the polder culture and its position below sea level. This, however, did not mean an abandonment of faith.



6.2 Coenraad de Putter - Profile of the Diemer Sea Dike with crack, 1729 - 1737.

Over the centuries, this change of perspective kept shifting. The book press and the growing possibilities of international communication facilitated the sharing of news, experiences and knowledge on flood events and flood defences [6.2]. In the 18th and 19th century, it was not the starting trend of atheism that changed the way we perceive flood risk management but the growing understanding of the functioning of our planet and the continuous accumulation of knowledge on flood disadvantages that made flood risk management become a collective concern, mainly in the Netherlands. The maintenance of flood defences went from an individual responsibility until gradually cooperation arose and private dikes were connected. With complaints of unfair responsibility distribution, the control of maintenance became a task for landowners and nobility. From here national regulations were set up and eventually water authorities were established and flood risk management became a national scaled concern (Hage 2015). From this moment in history onwards, flood risk management was no longer just a merely functional defence mechanism. Dikes became heritage sites and flood risk management became a part of the Dutch culture (LOLA Landscape Architects 2014).

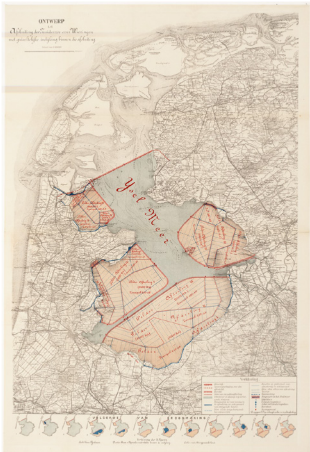
The high rate of globalisation in the 20th century and the continuous development of technologies on communication, like photography and television, followed by social media, made the importance of flood risk management increase. Flood events started to be covered on global news media as natural disasters. Many people however, still sought to explain floods in religious terms (Rooijendijk 2009), up to the 1953 North Sea Flood in the Netherlands, when a rare combination of a spring tide, north-northwest storm and high water levels in the rivers caused a catastrophe which took the lives of 1.836 people. Also for flood risk management the disaster was an important turning point. In the very same month as the flood event, the Delta Commission was appointed and the Delta Programme was established. A large number of drastic and large-scale reinforcement and hydraulic works would protect the Netherlands from suffering any repeat of the catastrophe in the future and the country became fully water managed (Deltacommissie 2008). In the Netherlands, no lives were lost ever since but worldwide flood events still happen on an annual basis and images of flooding after tsunamis or hurricanes haunt us [6.3]. Water and flood risk management became one of the Dutch national export products (Kimmelman 2017) and however learning to swim with clothes on is still obliged for every kid to prepare for flood events, the fear and awareness of flood risk in the Netherlands faded (LOLA Landscape Architects 2014).

6.3 Joy Garnett - Flood 2, New Orleans on fire after Katrina, 2005.

6.2 REBUILDING IN RESPONSE TO FLOOD / RESILIENCE IN RESPONSE TO PREDICTIONS

All throughout history flood risk management strategies have been initiated after events of flooding. Perspectives change due to these 'surprising' events (Valkering et al. 2008). Such surprises can be considered as events which show that the day-to-day reality deviates from the expectations (Offermans et al. 2011). When confronted with a surprise like flooding, its occurence will be tried to be ignore or explained in a way that it still fits with the former expectations (Thompson et al. 1990). This ignorance, however, is only possible up to a certain extent after which reality can no longer be denied (Offermans et al. 2011) and actions need to be taken.

In the Netherlands this process dates back to the period between 500 BC and 700 AD when farmers in the northern parts of the country placed themselves on artificial dwelling hills, so-called terpen, to provide safe ground from high water, followed by the extensive diking culture. More concretely are the Dutch examples of the Zuiderzee Works after the Zuiderzee Flood of 1916, the 1953 North Sea Flood prompting the Delta Works. Recent examples can be found in the United States with the New Orleans Urban Water Plan after the flood caused by hurricane Katrina in 2005 [6.3] and the Hurricane Sandy Rebuilding Task Force after the floods in 2012. Through this history of flooding two lines of reasoning can be distinguished, the line of catastrophes and the line of knowledge. Where in the times of the terpen and the initial dikes the line of catastrophes was obviously above the line of knowledge and the flood risk management happened after the flood, the last decades the two lines are coinciding and knowledge is getting potentially ahead of the catastrophes.



6.4 Cornelis Lely's 1891 design for the enclosure and land reclamation of the Zuiderzee commissioned by the Zuiderzee Association.

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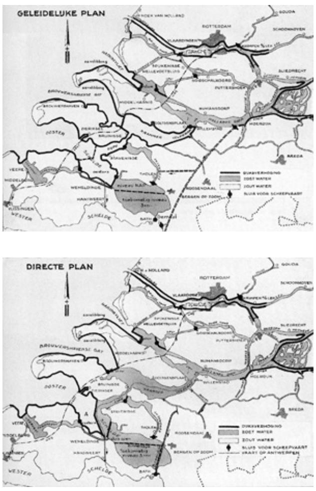

6.5 Johan van Veen's 1953 design (3 days before the 1953 North Sea Flood) for the Delta Works, divided in a gradual plan (geleidelijk plan) and a direct plan.

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The Zuiderzee Works

The Zuiderzee Association was set up already in 1886 with the idea of sealing off the Zuiderzee, having the insight that this would facilitate extensive land reclamation [6.4] to create new agricultural land, would make shipping routes safer and above all would reduce flood risk for cities like Amsterdam and villages and rural areas around the water body (Ten Horn-van Nispen et al. 1994). However, engineering, organisational, financial but mainly political problems prevented the plan from being carried out until the catastrophe of the Zuiderzee Flood of 1916, which became the decisive event for the Zuiderzee Works to be executed (Meyer 2017).

The Delta Works

The flood protection of the Southwest Delta, an area equally sensitive to flooding as the Zuiderzee region, was subject of discussion and research since the 1930s. In these years, hydraulic engineers Johan van Veen, among others, posed radical plans improving the flood safety of the delta region. Because of great disagreements between national and provincial water management organisations as to what should be done about the delta (Meyer 2017), only small scale interventions were carried out. Only in 1952 Van Veen was instructed to propose possible improvements for the Southwest Delta. His report, proposing the damming of parts of the delta, was handed in three days before the 1953 North Sea Flood [6.5]. Seven days later the Delta Commision was set up with the mission to draw up a flood protection Delta Plan (Meyer 2017).

The brief histories of the flood risk management discourse around the Zuiderzee Flood of 1916 and the 1953 North Sea Flood proof the state of the art of flood risk research to be capable to foresee possible catastrophes. Recent major flood events after hurricane Katrina and Sandy in the United States, demonstrated that flood events can still happen in a modern Western metropolis (Meyer 2017) and re-induced the importance of up-to-date flood risk management. Hurricane Katrina and the subsequent New Orleans Urban Water Plan preceded the establishment of the Second Delta Commission in the Netherlands and the launch of the interdisciplinary planning and design competition, Rebuild by Design, by the Hurricane Sandy Rebuilding Task Force, to cultivate innovative proposals for recovery and to increase long-term resiliency for the states of New Jersey, New York and Connecticut in the United States (Shapiro-Kline 2014), inspired a spin-off on the other side of the country. The San Francisco Bay Area Resilient by Design competition, recognises the areas changing environment and vulnerability (Chen 2017) to floods and earthquakes and therefore focuses on resilience instead of having to focus on rebuilding.

The successful exemplary position of the New Orleans Urban Water Plan and the Rebuild by Design competition, with a strong focus around New Orleans and New York City, is attributed to the concept of cities as first responders to climate change (Rosenzweig and Solecki 2014). Especially metropolitan cities are emerging as first responders because of their longer-standing experience in addressing multiple environmental challenges, their recognition of the need for services for vulnerable and disadvantaged citizens and their understanding of the science of urban climate and its impacts and the integration of scientific knowledge with adaptation investments. A benefit of this exemplary role of cities in addressing climate change is their function as cultural leaders and media centers to conveniently communicate the issue of climate change both with other levels of government and the world.

Initiator of the Rebuild by Design contest and Director General for Planning and Water Affairs of the Netherlands, Henk Ovink, emphasises the required change from response to preparedness. The current generation is the first experiencing climate change in these extreme and evident extents and at the same time the current generation is the last to act and make a change. No further disaster should be necessary to generate further action as the capability to meet the current challenges has never been bigger. The knowledge and understanding of the future and capacity to intervene and act has never been greater and never have the facts been this clear, as they are now (Ovink and Boeijenga 2018). Pieter Bloemen (Dutch Delta Commissioners advisor on strategics and knowledge) (personal communication, April 18, 2018) however stresses that setting in motion transitional strategies and the actual implementation of transitional interventions like the Delta Works, is impossible without a disastrous event which regenerates awareness for the need of transition. This does not imply waiting for the worst to happen but emphasises the need for the Netherlands to maintain control in unfortunate events of flooding in terms of prevention, planned inundation and evacuation. Only a catastrophe, like a hurricane or a flood, serves as the final major tipping point leading to transitional adaptation (Rosenzweig and Solecki 2014) for the affected area. Outside of this area, the catastrophe is merely sufficient as a reality check but is not capable of (re-) generating the need for transitional adaptation.

6.3 TOWARDS A TRANSITIONAL STRATEGY

The current flood risk management of the Netherlands is structured by a Delta Commission, Delta Programmes, Delta Plans, Delta Decisions, Delta Scenarios, Delta Commissioner and so on. After the wake up call of hurricane Katrina, the Second Delta Commission was established in 2007 in succession to the 1953 Delta Commission with the task of advising on how the Netherlands can be climate resistant on the long term, protected against floods and remain an attractive environment to live, work, recreate and invest (Deltacommissie 2008). With the completion of their advisory report a year later, the commission was brought to an end. The report presents a future vision of water management in the Netherlands until 2100 and an initial comprehensive Delta Programme to develop strategies facilitating execution. The programme would be renewed annually in the years to follow until 2015, after which the phase of implementation started and the Delta Programmes would elaborate on that aspect of the strategy.

The 2015 Delta Programme (Deltacommissaris 2014) consists of Delta Decisions, forming the basis of the work, and two Delta Plans, on flood risk management and freshwater supply, and drew attention to various tasks. A new task is dealing with the magnitude of uncertainty of the extent and speed of climate change, sea level rise and socio-economic conditions. The magnitude of uncertainty was addressed by developing Delta Scenarios to guide the process of formulating the Delta Decisions and constructing regional strategies (Bloemen et al. 2017). These scenarios have been applied for the yearly proposals of the Delta Programmes which are now centred around the principle of adaptive delta management (Delta Commissaris 2014; 2015; 2016; 2017) and are structured by adopting the DAPP approach (Haasnoot 2013).

To facilitate decision making and secure coherence and progress for the Delta Programmes and maintain their upward momentum, a Delta Commissioner and staff is assigned. The first year of the Delta Commissioners activities, however, coincided with rumorous events both nationally, with an unstable government, and internationally, with the controversial Climategate and the global financial crises. For the Delta Commissioners this consequenced to a reserved attitude, not causing panic and accordingly excluding large scale and transitional interventions from their agenda (P. Bloemen, personal communication, April 18, 2018). However ambitious the Delta Programmes are and effective they have proven to be, societal limitations to adaptation remain binding.

Despite the reserved character of the Delta Commissioner, adaptive delta management and the incorporation of DAPP in the Delta Programme has proven to be effective. Particularly, the approach helped to provide political support for keeping decision processes going forward and options open in the future (Bloemen et al. 2017). Its visual component and usage of transient scenarios at least links short-term decisions to long-term tasks and furthermore supports the development of additional alternative pathways and facilitates to choose these pathways (Haasnoot et al. 2012c). When it comes to the implementation of the interventions proposed by the DAPP, there are again challenges yet to be addressed (Bloemen et al. 2017). Firstly, the crossing of a tipping point is difficult to recognise in situations with large natural variability and complicates the decision when to initiate an intervention. In the case of flood risk management, the crossing of a tipping point does not happen gradually but is depending on observations of extreme events, as only these are hazardous, yet by definition rare (Klijn et al. 2012). Second, the simultaneous implementation of parallel trajectories of the DAPP can result in mutual strengthening but also weakening. In practice a set of pathways can be followed and implemented which complicates the assessment of their efficiency and interdependency. At last, the complicating gap between incremental and transitional interventions is stated again. DAPP and adaptive delta management in practice have shown to lack measures which prepare for the shift from incremental measures to a transitional strategy. Problematic are the increasing transfer costs after continuous incremental improvement of the system which increases path dependency and the difficulty to shift to transitional strategies.

It is this last challenge of adaptive delta management that complicates future flood risk management in scenarios of extreme sea level rise and the transition challenge of the New Netherlands. In practice, the adaptive delta management of the consecutive Delta Programmes have shown to prefer strategies including short-term incremental measures over long-term and transitional measures (Bloemen et al. 2017). This allows the Delta Programme to be discussed as an example of incrementalism. Incrementalism is a theory of public policy making which argues that a policy choice at a particular time is a marginal adjustment of a previous policy choice, relying in the status quo and adjusting from that point. Translating this to the case of the Delta Programme this implies that its yearly flood risk management strategy is an adjustment of last years strategy. An incremental Delta Programme supposedly works for the same reasons incremental decision rules are used, because of its relative ease of reversing mistakes following incremental changes and the possibility to create stable expectations and compromise while dealing with complex and deeply uncertain climate change (Jones and Baumgartner 2005).

A shift from incremental measures to a transitional strategy requires the acknowledgement of the need for a theory like transition management (Rotmans et al. 2001). Transition management focuses on radical innovation and the societal resistance this will initiate and is therefore potentially suitable to address the transitional strategy to manage flood risk with extreme sea level rise in the Netherlands. Transition management facilitates the development of a long-term sustainability perspective, linked to desired societal transitions, to guide accelerated social innovation in the short term. Developing this long-term sustainability perspective requires approaches which focus on learning, interaction, integration and experimentation on the levels of both society and policy. This accelerates social innovation as every action will lead to changes in the societal structures which initially shaped the problem, in turn transforming the problem itself (Loorbach 2010).

In an attempt to translate the transition management theory into an practical management framework, table 6.6 (Loorbach 2004) presents a framework differentiating types of governance activities influencing long-term change and of relevance to societal transitions. Within transition management, instruments are developed to guide the activities in the desired direction. One of them is the transition arena, a central element in which a group of frontrunners, with different backgrounds, perceptions on the issue and possible directions for the solution, reach a joint sustainable perspective. The participants of the transitions arena are innovators and relative outsiders selected on their type of actor (government, companies, NGOs, academia and intermediaries), competencies (strategic and system thinking, communication and ability to sell the message) and role and network (opinion-makers, networkers, visionaries and leaders) and are capable of leading to a bigger impact on complex and uncertain social problems than if the problem would be tackled by the usual policy makers (Van Buuren and Loorbach 2009), the Delta Commissioner. For that reason, the transition arena would start autonomously in the shadow of the regular policy makers with merely a certain representation of the existing policy makers in order to set the legitimacy and financing (Loorbach 2010).

6.6 transition management types

strategic	
focus	~ culture
problem scope	~ abstract ~ societal system
time scale	~ long term (30 years)
activities	~ problem structuring ~ envisioning ~ establishing transition arena
tactical	
focus	~ structures
problem scope	~ institutions ~ regime
time scale	~ mid term (5 - 15 years)
activities	~ developing coalitions ~ developing images ~ developing transition agenda
operational	
focus	~ practices
problem scope	~ concrete ~ project
time scale	~ short term (0 - 5 years)
activities	~ mobilizing actors ~ executing projects ~ executing experiments
reflexive	
activities	~ evaluating ~ monitoring ~ learning

modified from Loorbach 2004

6.4 TRANSITION DESIGN

The concept of the transition arena is considered a useful tool in guiding the shift from the current incremental measures for Dutch flood risk management to a transitional strategy. The transition challenge stated by the New Netherlands calls for innovative group, embraced by the Delta Commissioner, with a radical yet sustainable perspective on flood risk management for extreme sea level rise scenarios, willing to push their idea forward which requires the ability to communicate.

A powerful asset to accomplish this is transition design. Design has the power to solve problems by inspirationally and aspirationally thinking across scales and time. It assists the transition challenge as it creates a narrative and is capable of convincing, informing and uniting people around complex decisions leading to action and opposing the established standard which will give resistance (Ovink and Boeijenga 2018). The strength of design and imagination can succeed in initiating a collective behavioral change (Brugmans 2018) and to accelerate the necessary change and visualise futures that successfully mobilize the longing for change are the most relevant tasks we can formulate for the current generation (Alkemade et al. 2018).

The New Netherlands does this by addressing a scenario which initially is considered to be the worst-case. From that perspective the projection is visionary and succeeds in visualising what the future can be and showing it is not a shock regardless of the sacrifices required. The project shows the potentials of the worst-case scenario and explores what kinds of living can unfold. This exploration by design gives people the opportunity to think about and reconsider what is of importance. This research by design is facilitated by the instrumental characteristic of design is its evolvement as the process of envisioning and discussing change is equally important to the final change (Loorbach 2010). Especially in the case of facilitating transitional flood risk management for extreme sea level rise scenarios.

7. TRANSITION OR A CATASTROPHE

The previous chapters presented a transitional approach to confront extreme sea level rise scenarios and the future of flood risk management. To optimally answer the research question, the transitional approach focussed on the Netherlands, a country with an established and renowned flood defence system but also challenging conditions and characteristics when it comes to rising sea levels due to its positioning in one of the lowest-lying deltas in the world. Based on the hypothesis that a multidisciplinary approach, combining engineering, design and policy can support transition, applying the approach on the Netherlands resulted in a transitional design of the New Netherlands. This concluding vision of an extensive spatial analysis facilitated the assessment of its applicability and feasibility. The research of the applicability and feasibility is two sided. Firstly, the transition to the New Netherlands was dissected in steps depending on the passing of physical acceptability thresholds as sea level rise unrolls. Secondly, the research assessed the societal change required to enable transition. In this chapter the research question is answered, envisioned and discussed.

7.1 FACILITATING TRANSITION

How best can the shift to transitional flood risk management strategies be facilitated to anticipate to extreme sea level rise scenarios? In order to allow transitional approaches dealing with extreme sea level rise to be implemented, a shift away from the established and renowned flood defences and flood risk management is required. Managing transition requires constant influence and adjustments in governance systems and societal patterns (Rijke et al. 2012). Crucial is the emphasis on prioritising preparedness above responding to floods, on acting before flood events instead of after and stretching or crossing the limits of adaptation and climate mitigation. Herein the theory of transition management (Rotmans et al. 2001) provides. Transition management calls for the development of a long-term sustainability perspective linked to a desired societal change, to guide accelerated social innovation in the short term, leading to changes in the societal structures which initially shaped the problem, in turn transforming the problem itself (Loorbach 2010).

Within the theory of transition management the transition arena is one of the initial directional elements. The transition arena would consist of a innovative group of frontrunners with a radical yet sustainable perspective on flood risk management for extreme sea level rise scenarios. A certain group is capable of leading to a big impact on complex social problems, like the sunk-cost effect (Scheffer and Westley 2007) and the societal limits to adaptation (Adger et al. 2009). More than if they were confronted by the usual policy maker (Van Buuren and Loorbach 2009). For that purpose it is important for the transition group to work autonomously.

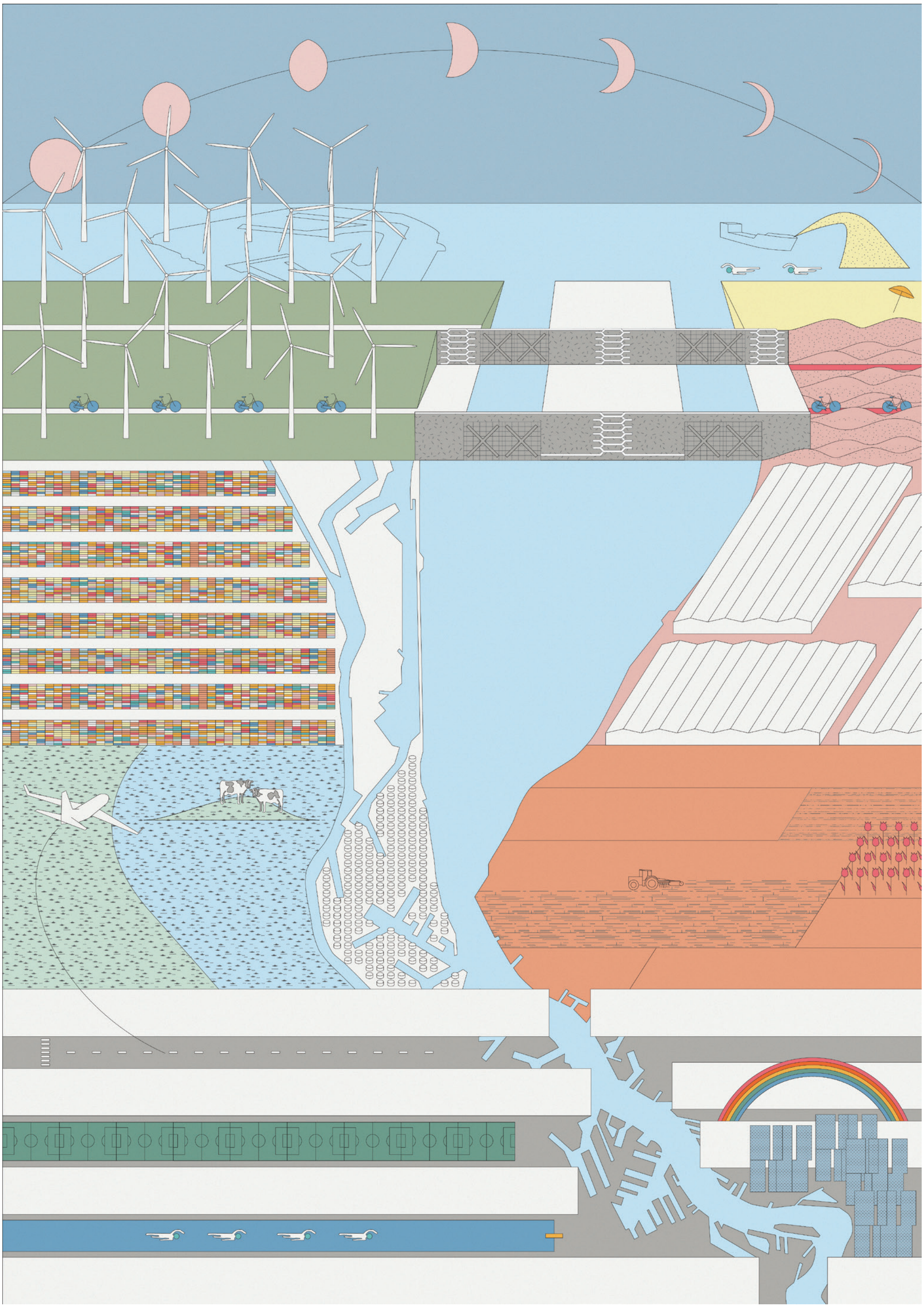
Where the transition management method has an agenda formulating what is important, design complies in giving people the opportunity to think about what they consider to be important and therefore facilitates transition.
A transition image is created to serve as a tool of communication for the transition arena (Loorbach 2010). The creation of a transition image requires site specific research to establish a design exercise which concretises the issue of flood risk management in a spatial context.

As the complexity of future climate change conditions has never been bigger, the capacity to intervene and act has never been greater and the facts have never been this clear, the challenge arises to seek innovation and set aside the established standard, existing frameworks and agreements based on assumptions made in the past. Design embodies the power to address the new complexity of a future with extreme sea level rise by crossing through spatial and time scales and creating a narrative capable of convincing, informing and uniting people around complex decisions leading to action and opposing the resistance-giving standard (Ovink and Boeijenga 2018). Design has the strength to facilitate ones imaginations and to initiate a collective behavioral change (Brugmans 2018). The acceleration of the necessity of change and the visualisation of futures that successfully mobilize the longing for change are the most relevant tasks we can formulate for the current generation (Alkemade et al. 2018). As the current generation is the first to experience climate change in these extents and at the same time the last able to act, this is to moment to use that power and strength of design and for the Dutch to maintain their position as pioneers in addressing the water management challenges.

7.2 IMAGINING TRANSITION

In this research first steps towards the initiation of transition have been made by translating the understanding of transitional flood risk management to a concrete design exercise. The Netherlands was selected to analyse under conditions of extreme sea level rise. A mapping exercise explored different systems at risk by sea level rise in order to assess possible transitional flood defence measures like the historical process of coastline shortening and coastal remediation, going back to a gradual transition zones between land and water (Meyer 2017). By means of the Dutch layers approach (De Hoog et al. 1998a) and the casco concept (Sijmons 1991) a framework was established [4.39], differentiating a critical and robust network and flexible and supportive patches based on multiple transition paces. The concluding image [5.1] presents the new territorial outline of the Netherlands, the New Netherlands.

To translate the image of the country's new contour into a transition image, capable of communicating and selling the transition, the key features of the transitional design are to be addressed. These features include the transitional flood defence measures and the effect they have on the country. A triptych of images present the visionary New Netherlands. Figure 7.1 makes use of the theory of city as first responders (Rosenzweig and Solecki 2014) and in an attempt to make the drastic change tangible, by making the city of Rotterdam recognisable. Transitional flood risk managing measures to be recognised are the enhanced dikes and dunes and the implementation of a system of locks to connect the harbour to the sea. The adjusted dredging policy for the North Sea is represented with a dredging boat and the flexible transition zone between land and (river) water represents the programs of Room for the River and its extension with its followers Room for the Southwest Delta and Room for the Wadden Sea. The consequences of transition are retreat, visualised with a flooded Maasvlakte and an increased pressure on



7.1

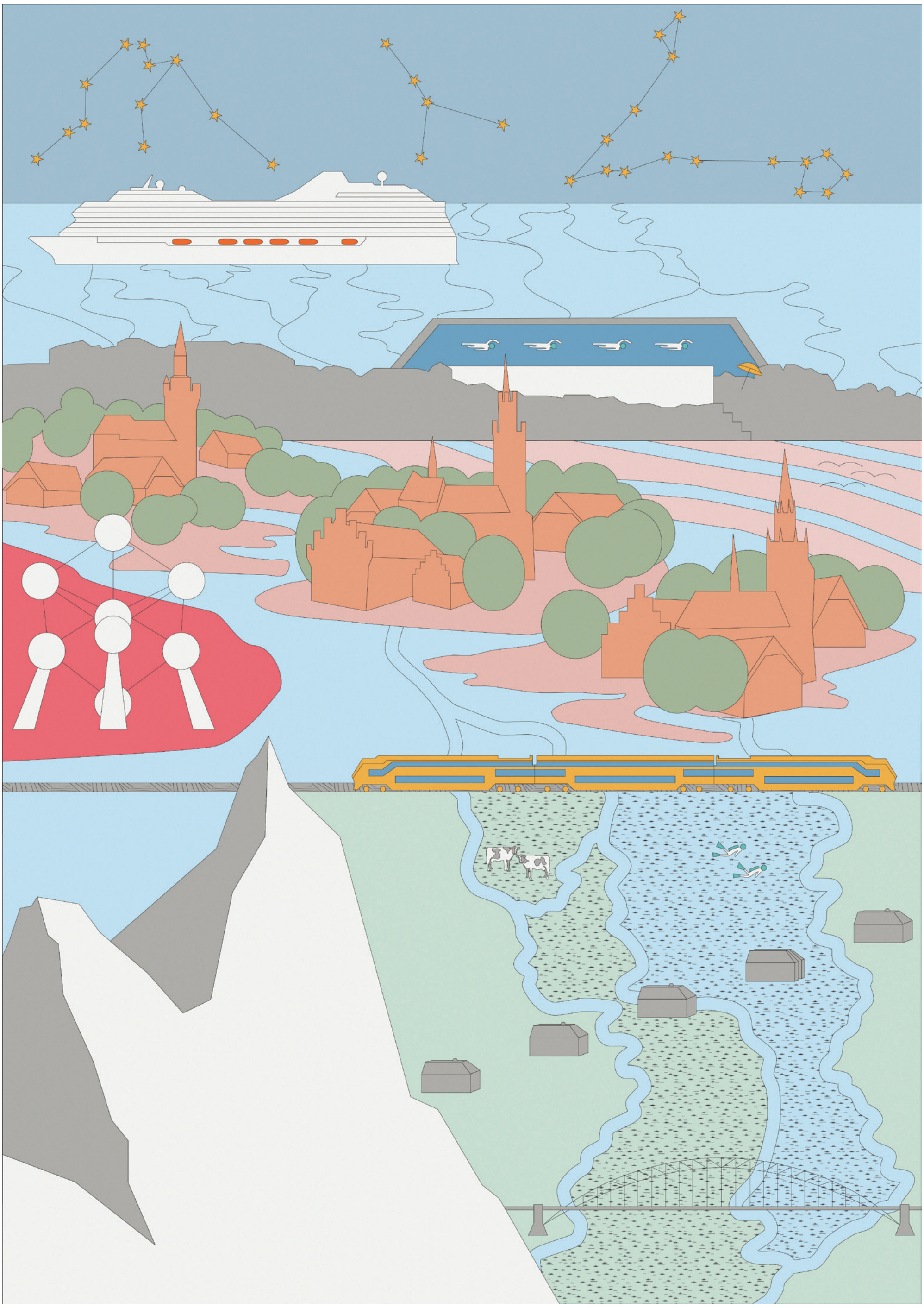
the remaining system, like nature, economy, agriculture, infrastructures and urbanisation. At the same time the transitional flood risk management provides safety for this nature, economy, agriculture, infrastructures, urbanisation and facilitates their growth, but also secures the Dutch population and their cultures, like architecture, sports, tulips, bikes, tolerance and even obliged swimming lessons with clothes on for children.

The transition vision continues in figure 7.2 which subtly represents the prioritisation made. Wadden Sea islands are missing and the biggest accumulation of cultural heritage in Amsterdam confronts the inundated city of Leeuwarden in Friesland. Alongside Amsterdam, the fisherman's village of Volendam and the Flevopolder, Noordoostpolder (and the reclaimed island of Schokland) and Beemster Polder continue to exist, as does the Veluwe region due to its position above the rising sea levels and the Frisian sailing culture regardless of sea level rise. Richard Serra's Sea Level (1996) is a reminder of long gone days with sea levels metres lower.

Figure 7.3 closes the triptych by showing the possibilities of a new beach culture which took the example of a tidal pool in addition to a coastline executed in concrete. On one side of this solid line the Southwest Delta is inundated and on the other side three churches from the Saint Elizabeths Day's Flood Panels can be recognised but this time subject to controlled inundation instead of a flood. The Waal Bridge makes the connection between the showpiece of the current Room for the River program in Nijmegen and the required upscaling. In this image the national boundaries are crossed. The mountains represent both the cause of the fluctuating river discharge, the Alps, and the cause of rising sea levels, the ice caps. The Atomium emphasises the collectiveness of the climate change challenges and the need to collaborate both with neighbouring countries, like Belgium, and the European Union, seated in Brussels.

The representation style of the transition image is inspired by OMA's (Office for Metropolitan Architecture) proposal for Parc de la Villette in Paris from 1982. The project is renowned for its clear manifestation and shows similarities with the design exercise of the New Netherlands. The

7.2



7.3

listed program requirements for the park were too large for the site, leaving no space for a park. In order to meet all requirements, the proposal was not for a definitive park but for a method that combines programmatic instability with architectural specificity, eventually generating a park (OMA et al. 1995). The parallels, regardless of the different scales, of the two design challenges justify the usage of the visual language of OMA's project.

7.3 DISCUSSING TRANSITION

The research presented a comprehensive approach to facilitate transition towards transitional flood risk management strategies in anticipation to extreme sea level rise scenarios. Throughout history disastrous floods have occurred, bringing awareness and facilitating transitional flood risk management in response. For that, the research discussed the line of catastrophes and the line of knowledge. Whereas the line of catastrophes always was ahead of the line of knowledge, they are now reaching a point of coinciding which potentially facilitates the acceptability of transition.

In answering the research questions the research aims at emphasising the necessity to not let the line of catastrophes lead. However, the difficulty of accomplishing transition should be underlined. Firstly, it can be argued that the line of knowledge is already ahead of the line of catastrophes, regardless of the deep uncertainties faced. When the required shift is too radical, the only event decisive enough to initiate transitional change in flood risk management strategies is a catastrophe. However, the Dutch Delta Commissioners advisor on strategics and knowledge, Pieter Bloemen (personal communication, April 18, 2018), acknowledges the need for transition to transitional strategies, his take on the possibility of transition includes a flood event. Bloemen envisions the future of the Delta Programme to gradually allow more transitional decisions with, for instance, future IPCC assessments presenting the growing importance and sparking awareness. This will enable more resolute interventions after ten to twenty years, resulting in a changing water system by 2050. However, as the water system is still derived from an outdated system, a few decades later the need for transition is still there, yet more difficult as transfer costs and path dependency increased (Bloemen et al. 2017). If not now, then definitely in the future, only a disaster can put transition processes in motion. Elaborating on these predictions in follow-up studies can emphasise the importance of acting now.

Secondly, if transition does take off, the importance of monitoring the process needs to be stressed. Transition defines a transitional process with a strong non-linear behaviour on the long term fundamentally changing the operating of a society or a system within a society consequently to co-evolution of (socio-)cultural, institutional, economic, ecological and technological processes and developments throughout scales, resulting in a new stable equilibrium (Rotmans et al. 2001). The accomplishment of transition, however, is difficult to evaluate and can be confused with temporary change (Rijke et al. 2012), especially in complex systems like Dutch flood risk management. The ultimate step of transition is to arrive at an equilibrium, the challenge of sustaining the transitional trajectory is to establish continuity.

At last, even though, the assessment of challenges of the Netherlands under scenarios of extreme sea level rise, the spatial prioritisation of the country and the development of the New Netherlands, are embedded in valid reasoning, this part of the research is very much assumption based. To enable a large scale design exercise for the complex system of a whole country, the system was brought to a level of abstraction which facilitates evident prioritisation but therefore interconnected parts of the system were consciously disregarded. Important missing aspects in this research are the infrastructures of mobility, drinking water supply, power supply and national production of any kind, among others. Future work can provide further validation of the assumptions and can facilitate further definition and refinement of conditions, information and data required for the design exercise and decision-making process. For transition to reach a higher level of reality, a more extensive study can elaborate on the model-based assessments of flood risk, sedimentation processes, pumping capacity, dredging, technology development such as the innovation of flood defences, cost-benefits, and the possibilities of large-scale relocation of population.

7.4 NARRATING TRANSITION

To end this study two narrations of the future of flood risk management are set out to envision transition. Or not.

2018

The narratives take off in 2018 with the Netherlands at its ever rising peak of water and flood risk management. Its approach succeeds in protecting, however vulnerable the country's position and prevails in facilitating decision making under the deep uncertain character of the development of sea level rise. However coming of age, the Delta Works still are the showpiece for flood risk management globally. Around the world Dutch flood defence solutions are implemented throughout scales whereas in the Netherlands only the enforcement of the 1932 Afsluitdijk is needed by making the dyke body overtoppable for waves and assessing the addition of pumps.

2018 - 2025

In the years to follow the overtoppable Afsluitdijk with an additional set of pumps is completed and the Netherlands remains safe whereas the rest of the world is plagued by water nuisance. It's a matter of time or a big flood event far from Europe will again spark awareness and the Dutch approach

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will be called upon to integrate resilience into the existing system. With the coming of the next Intergovernmental Panel for Climate Change report and a next United Nations Climate Change Conference the need for transition is for once and for all underlined and in terms of water management the world turns its eyes to the Netherlands.

<u>2025 - 2050</u>

The accumulation of awareness functions as a global tipping point and as sea level rise is finally with certainty predicted to accelerate the new Delta Programme acknowledges the need for upscaling and accelerating enhancements. For the first time the Delta Programme starts to include more resolute water management interventions which fit the society's expectations of Dutch flood risk management. Throughout the country changes are implemented and the plan for a lock system in the Port of Rotterdam, the enhancement or succession of the Delta Works, the Afsluitdijk and other dike systems is assessed. As years and Delta Programmes

will be called upon to integrate resilience into the existing system. With the coming of the next Intergovernmental Panel for Climate Change report and a next United Nations Climate Change Conference the need for transition is for once and for all underlined and in terms of water management the world turns its eyes to the Netherlands.

<u>2025 - 2050</u>

The accumulation of awareness functions as a global tipping point and as sea level rise is finally with certainty predicted to accelerate the new Delta Programme acknowledges the need for new radical transition to follow up the flood risk management of the last decades.
This statement initiates discussions and resistance. Despite the recognition of the statement by a growing group of politicians, economists, engineers, researchers and so on, the resistance slows transition down which can be seen in the continuous cautiousness of the following Delta Programmes. Therefore the Delta Commissioner appoints an independent group to facilitate the start of transition.

pass, the proposed interventions are adjusted to scales acceptable to be implemented and as the year of 2050 approaches, the water system starts changing from its status at the beginning of the century and succeeds in maintaining and improving the existing but failing framework.

2050 - 2100

The new Delta Works, Afsluitdijk and other dike elements maintain the famous lion-shaped territorial outline of the Netherlands. However the Dutch upscaling of enhancements has an exemplary function to flood prone metropolitan areas around the world, the Netherlands is not the only country innovating and exploring new alternatives.
Dutch flood defences remain impressive civil engineering structures but other regions call for different strategies for which the Netherlands can no longer be the only testing zone. Even though battling climate change finally became a global concern and a massive switch was initiated, the climate change challenge still faces many setbacks: sea level rise keeps

The group consists of diverse innovators with a joint sustainable perspective focussing on the radical innovation needed to address the new complexity of the transition and its societal resistance by using the power of design for the shift away from the existing but failing framework.

2050 - 2100

The complex design exercise calls for a re-invention of the Dutch water system and a long term perspective is developed. Design is proven to be the powerful tool uniting people throughout disciplines and leading to action throughout spatial and time scales. Priorities are progressively rearranged, the sand extraction policy is updated, lock systems keep ports accessible and dikes and dike regions are reconsidered, redesigned and replaced. Even though battling climate change finally became a global concern, a switch as massive like in the Netherlands was not considered feasible and globally the Dutch game changing approach is praised and followed. However, the climate change challenge still faces accelerating and flood events remain a frequent topic of international news media. As time passes and sea level rise develops the probability distribution succeed in identifying the most likely future scenarios which, regardless of the global effort, unfortunately do not exclude the worst-case scenarios.

2100 - 2200

As climate change unfolds and accelerates the exemplary Dutch water system feels the window to sustain success closing fast. Weak link assessments again become an important part of the Delta Programmes and they can only be addressed with last resort adjustments. Urbanised areas in the coastal region suffer from the new flood risk management interventions as concrete walls become the standard element on the horizon. As the country adapted its flexibility decreased. The downside of the static attitude of occupation and networks is most felt in the malfunctioning of the natural landscape of the country in order to accommodate the country's production landscape but since the

many setbacks: sea level rise keeps accelerating and flood events remain a frequent topic of international news media. As time passes and sea level rise develops the probability distribution succeed in identifying the most likely future scenarios which, regardless of the global effort, unfortunately do not exclude the worst-case scenarios.

2100 - 2200

As climate change develops and accelerates the new Dutch water system requires big compromises and sacrifices but opportunities and potentials for new ways of living unfold. As the awareness of the importance and need for adaptation grows the continuation of sea level rise allow the Room for the River, Southwest Delta and Wadden Sea programmes to be upscaled with the accompanying retreat of population. The retreat programmes provide space for a dynamic coastline in areas where natural landscapes have priority and in the areas where the focus lies on a more productive landscape, the groundwater nuisance and the changing perception of the coast, sea and beach surrounding water levels are high above the ground levels, the extents to which the Netherlands remains a pleasant place to live become discussion points as the rising sea levels feel imprisoning.

<u>2200 - 2300</u>
After two centuries of not experiencing flood events in the Netherlands, history repeats itself and a rare combination of a spring tide, north-northwest storm brought the sea water levels above heights the flood defences could deal with in the funnel-shaped Southern North Sea. The advancement of weather forecasts had predicted the event and the areas at risk have been successfully evacuated. Evacuation camps in the east and south of the country host families whose properties and possessions were damaged or lost, besides emergency locations for hospitals and businesses. Despite the loss of few lives and billions of damage, the Dutch preparedness to the highest flood risk is rewarded on every media channel around the world. Directly after the game changing flood, the conclusion is reached that the Dutch water system is derived from

results in new directions for the design of buildings, cities and infrastructures. However surrounded by water levels high above the ground level the country remains a pleasant living environment.

<u>2200 - 2300</u>
After two centuries of glorious transition in the Netherlands, history repeats itself and a rare combination of a spring tide, north-northwest storm brought the sea water levels above heights the flood defences could deal with in the funnel-shaped Southern North Sea. The advancement of weather forecasts had predicted the event and the New Netherlands were put to the test. The water system has evolved to a system capable to live with water regardless of its quiet or aggressive manifestations. Even though the enlarged natural bodies of the Southwest Delta and the Wadden Sea were heavily affected by the storm, they succeeded in protecting the behind-lying areas and in the flood prone inhabited areas the transition reached a state of quick recovery. The Dutch preparedness to the highest flood risk is rewarded on every media

an outdated system and requires redesign from scratch. Transition is feasible in small parts of the country for which foreign water management strategies with a highly natural approach are followed. Large parts of the Netherlands, however, have reached a state of being so static and exploited that the shift is financially and physically impossible. In these regions the worst effects of the flood are only felt in the years after as collective reconstruction stagnates and both population and businesses relocate: the Dutch population became natural refugees.

channel around the world. The future of the New Netherlands however is still not certain but most important is the confirmation of the power of design. Design thinking changed a country seemingly stuck between its unfortunate positioning and the limits to the required adaptation which deals with the unfortunate positioning. Design thinking has set aside the old standard and sought for innovation capable of uniting people around complexity and mobilizing transition. Design thinking facilitated a population to be forever pioneers instead of natural refugees.

‘Eens zullen we ons land met een zucht van verlichting aan de golven prijsgeven’

‘One day we shall, with a sigh of relief, give up our country to the waves’

A quote by Johan van Veen, the father of the Dutch Delta Plan and the man who protected us from a repetition of the 1953 North Sea Flood. But until when?

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