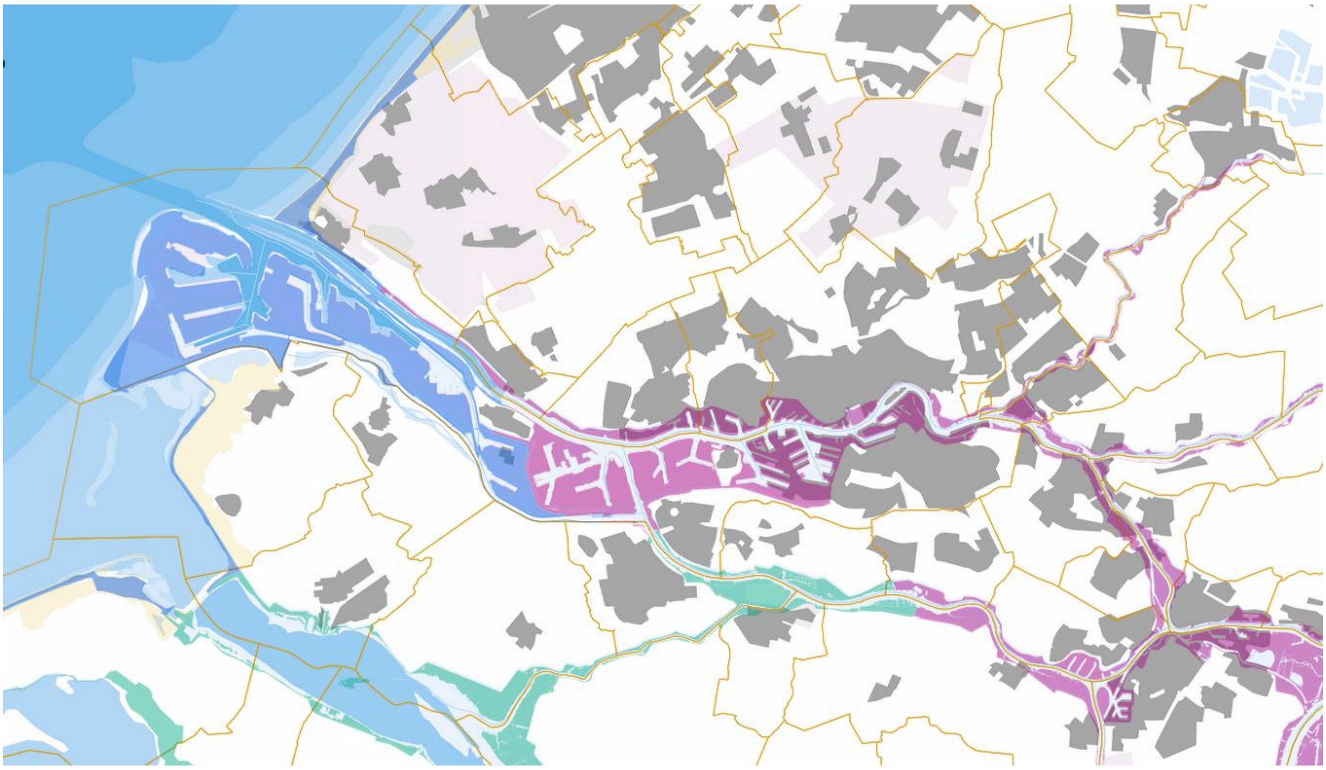
BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

SEVENTH FRAMEWORK PROGRAMME



Subgroup: Cities

Case-study: Rotterdam

(Deltares, The Netherlands)

Date: 7 September 2016

Document prepared by: Mark Zandvoort & Femke Schasfoort

Name of Researcher responsible for the case study: Mark Zandvoort

Partner: Deltares

Project:

FP7/ Project BASE [2012-2016]

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Purpose of this document:

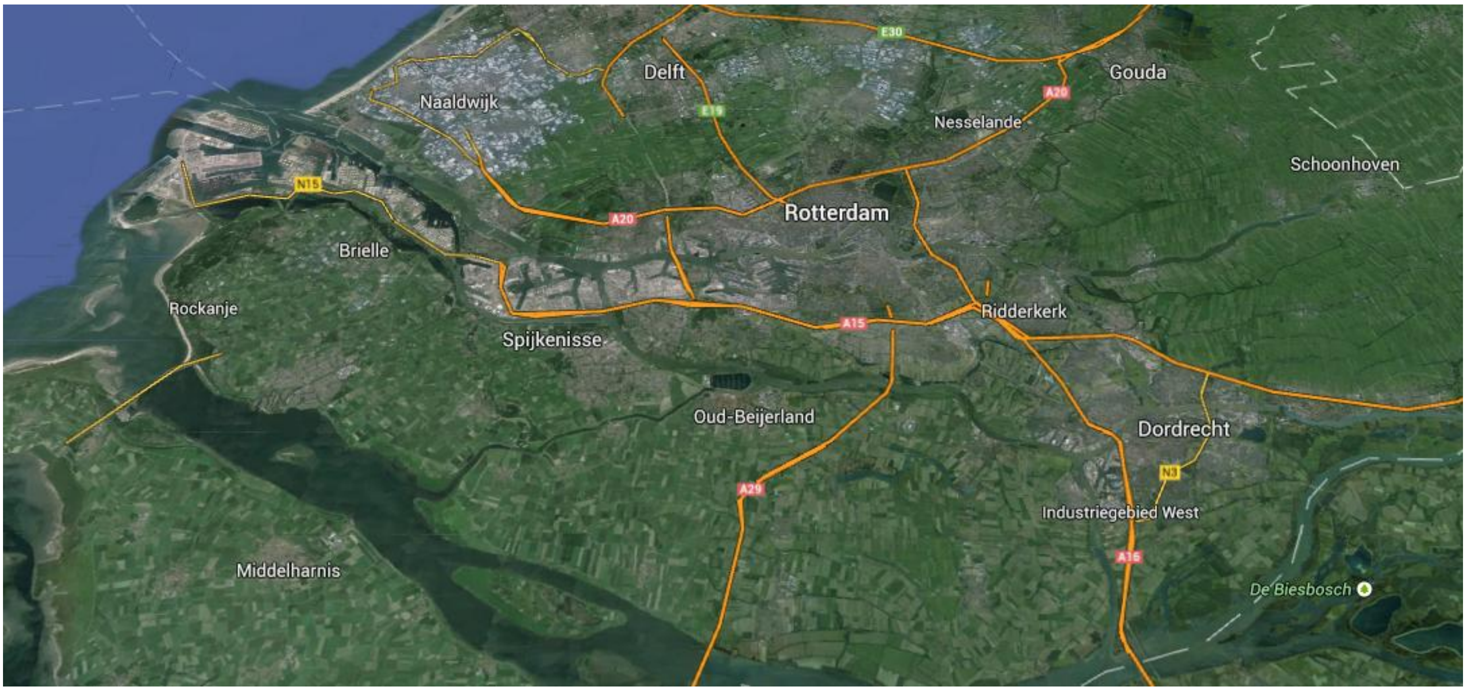
"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

Index

1. General Case Study Description

Location

GPS: N 51°55’N 4°30’E / W 51.917°N 4.500°E
Area: 2147 km^2



Case Study Summary

The Rotterdam case constitutes four types of areas with different characteristics regarding climate change effects. These effects also indicate the necessity and characteristics of adaptation to climate change. First, the river foreshores, which have large build-up parts and include major harbour areas. Second, the urban build-up area behind the dikes, constituting the normal city activities such as houses, business, real estate, etc. Third, the critical (infrastructural) components in the city behind the flood defences, including hospitals, electricity supply, risky locations due to heavy industry, roads, sewage- and waste treatment, etc. These critical components need extra attention from a climate adaptation perspective, since they are critical for the functioning of the current system. Fourth, and last, are the agricultural areas and rural structures adjacent to the outskirts of the urban area.

In the Rotterdam Area, two initiatives have a role in adapting to climate change. The first is the Rijnmond-Drechtsteden subprogramme of the Dutch delta programme which addresses primarily water related climate change adaptation, with emphasis on flood risk. The second is the municipal adaptation strategy, and related activities within the Rotterdam Climate Initiative. The Rotterdam Adaptation Strategy distinguishes four key focal themes:

water safety, urban water system, city climate and mobility & infrastructure. This case, however, is specifically about the first initiative, the Rijnmond-Drechtsteden subprogramme of the Dutch delta programme. The case specifically studies the flood risk related measures and strategies developed in this programme.

The prime focus in this case will be on flood risk management from the main river tributaries in the Rotterdam area. The current system can be divided in the main water system and the urban water system. The main water system's emphasis is on safety measures including the prime defences such as dikes, storm surge barriers 'the Maeslantkering' and 'the Hartelkering' and pumping and drainage systems in the polder areas behind the prime defence system. The urban water system consists out of the main sewage system, local retention possibilities on roofs, squares and parks, and other objects related to urban water management. Adaptation measures aim at providing sufficient flood prevention for the coming decades with respect to both the local situation, effects of climate change on sea level, storm setup and river discharge, and socio-economic development affecting the city and harbour of Rotterdam and the larger area with agriculture and small urban agglomerations. This report specifically deals with the main water system, while the urban area is slightly touched upon and mainly included for identification of the main impacts.

Historical flood risk context

Rotterdam is located in the densely populated area in the western part of the Netherlands. The western Netherlands has a long history of flooding and flood risk management. The most prominent flooding is the disaster of 1953, mainly affecting the Rhine-Meuse-Scheldt delta south of Rotterdam. This led to the building of the so-called Dutch Deltaworks, whereof the Hartelkering and the Maeslantkering are components. Also norms for risk were established for the first time, based on a risk approach outlined in the 1960's. Recent climate change projections, near floods in the riverine area in the hinterland of Rotterdam in 1995 and 1997, and a growing awareness of susceptability to higher consequences of flooding due to economic development, led the Minister to install a delta committee in 2008 to advice parliament about flood risk managemengt for the decades and centuries ahead. The result of this advice (Delta committee 2008) and several research programmes in the first decade of the 21st century led to the creation of the Delta Programme. This is a hybrid institutional programme running for four years and aimed to provide a detailed strategy until 2100. The case Rotterdam falls under the umbrella of this nation-wide program and is, thus, influenced by developments ongoing in the whole nation (regarding amongst others the concept of Adaptive Delta Management (van Rhee 2012), Multi Layered Safety (I&M 2008) and the related discussion regarding flood risk norms based on a full risk approach constituting probability of a flood times the exposure and vulnerability to a flood (Zandvoort & Van der Vlist 2014).

Urban planning context

Another part of Rotterdam's history is its urban development. Since centuries this harbour is located in the northern part of the Rhine-Meuse delta. This location grew, since industrialization, due to a sharp increase in harbour-bound activities. The prospering city was heavily bombed at the start of WWII and its city centre was destroyed. In the decades after the war, Rotterdam was quickly rebuild and grew quickly to become the largest deep sea port of the world and is still in the top ten of largest ports in the world. This led to four important developments from the perspective of flood risk relevant for this case:

- Seaward port extension; Maasvlakte 1 (realised) and Maasvlakte 2 (in realisation);
- Degeneration of urban and port areas along the Rhine due to shifting facilities and seawards
- Large economic investments in the city centre, and;
- High cultural diversity and urban sprawl due to muchemployment possibilities.

Thus, next to flood risk, the city is currently confronted with a multitude of urban planning challenges including keeping its attractiveness as port for economic activities, managing a high cultural urban diversity, and necessity to redevelop old, urban and port areas.

Institutional context

The institutional system regarding flood risk management is divided among different governmental actors, including the national government, water boards, and municipalities. The river tributaries and the coastal zone are the prime responsibility of the National government, with involvement of several ministries. The urban water system is the prime responsibility of the municipality and partially of the water boards in the area, although national actors also have a role. In both systems other stakeholders like the port authority, large companies and civil organisations have stakes in water, and decisions made by these stakeholders influence the state of the system. To the lowest level individual decisions of citizens can influence the effectiveness of public adaptation policy.

Brief General Information on climate change and related issues

Rotterdam is located adjacent to the North Sea. Thus, the general climate is dominated by the sea and is rather mild due to the Atlantic gulf stream (Rotterdam has a Cfb climate in the Köppen-Geiger classification). Located in the Rhine-Meuse delta and adjacent to the North sea, the topography is flat and the soil mainly consist out of old clay and peat layers. This made the area very fertile, which in the larger Rotterdam area is visible in high revenue agriculture activities and horticulture (see map with land use, Figure 1). The water system in the area and the whole tributaries of the Dutch Rhine and Meuse are dominated by human alterations and are today a highly managed system. The human alterations include the creation of polder areas by pumping out the water. This intensive pumping led to soil subsidence, which enforces the natural soil subsidence processes due isostatic rebounce of Scandinavia after the last ice age. Thus, there is a gross sea level rise due to climate (see next section for the scenarios) but also an increased effect on the probability of flooding in Rotterdam due to glacial and human induced soil subsidence.

Scenarios used in Rotterdam

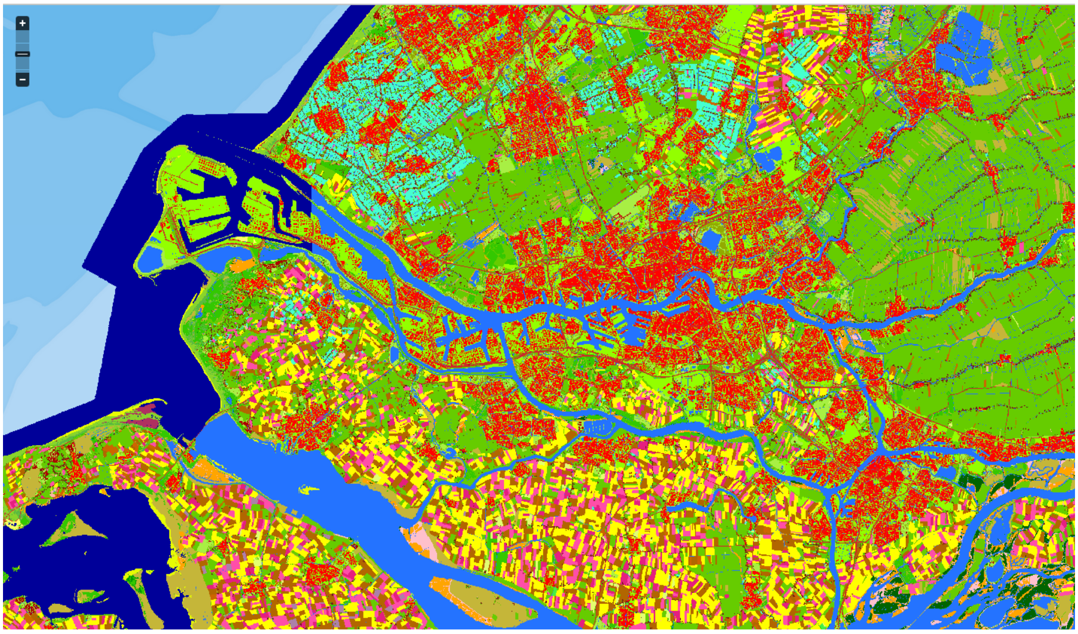


Figure 1: Land use in the larger Rotterdam Area (The red colour represents built-up area).

There are several climate change scenarios studies in the Rotterdam area. These build on each other, with the main climate scenarios beng those from the Royal Meteorological Services, in Dutch the KNMI, in 2006 (Van den Hurk et al. 2006) and updated in 2009 (Klein Tank & Lenderink 2009). These were for example used for the latest municipal strategy. For the Deltaprogramme the 2009 KNMI scenarios were updated into four discrete scenarios, based on two of the extreme scenarios developed by the Dutch meteorological institute (KNMI) in 2009 (G and W+), which were coupled to two socio-economic scenarios (Global Economy and Regional Communities). The Deltaprogramme Rijnmond Drechtsteden and the municipality of Rotterdam, for the Rotterdam Adaptation Strategy, used these Deltascenarios. The four scenarios are depicted in figure 2.

The most important study is the translation of the deltascenario's for the Rijnmond Drechtsteden by the Deltaprogramme in 2011 (DPRD 2011). This study gives a regional image of the national four extremes as indicated above. The main numbers are included in table 1. These scenarios are used to assess the different alternative strategies (see chapter 5).

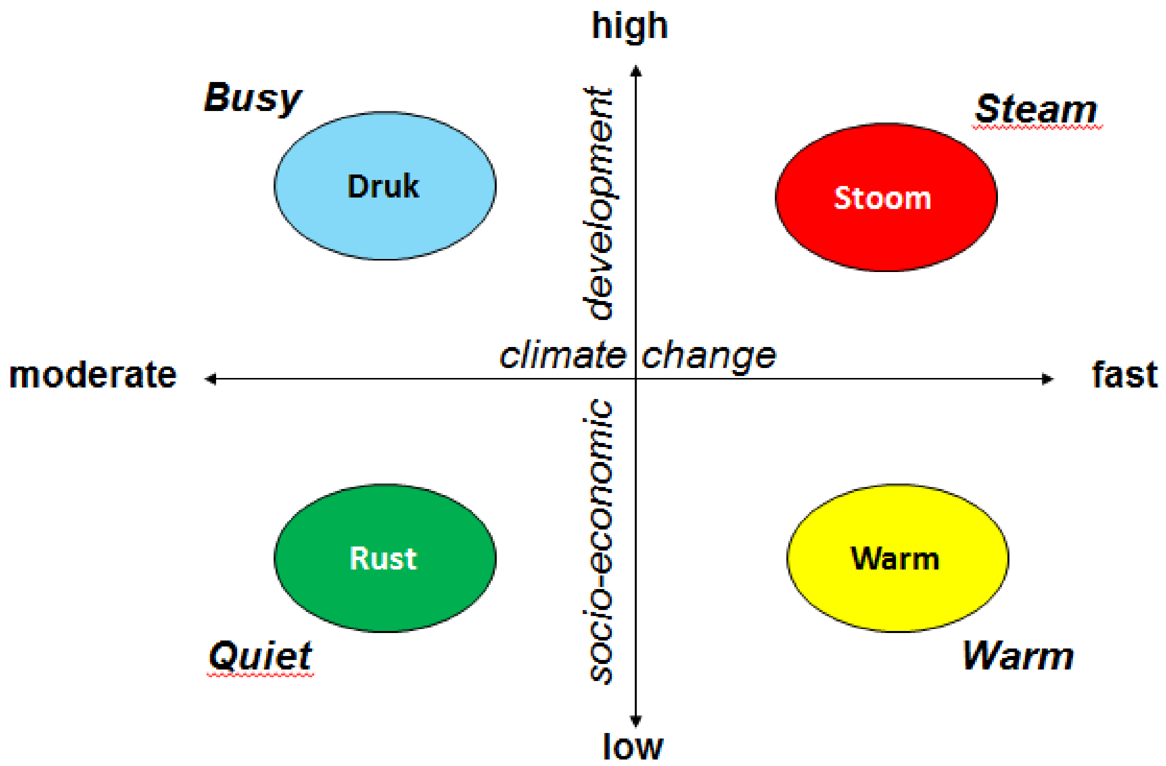


Figure 2: horizontal axis intensity of climate change (left to right is increasing change) and socio-economic development (growth on top, decline below). The four scenarios are indicated with their Dutch names: pressure, steam, quiet, warm.

Table 1: Regional climate change and socioeconomic scenarios for the larger Rotterdam area (derived from DPRD 2011: table 2a & 2b)

Climate Change Scenarios		*G*		*W+*	
	Reference year	**Pressure and Rest**		**Steam and Warm**	
Year	2000	2050	2100	2050	2100
Av. Rhine discharge Februari (Q)	2900	3100	3200	3400	4000
Av. Rhine discharge September (Q)	1800	2000	2100	1300	900
Av. Meuse discharge Februari (Q)	480	500	520	530	590
Av. Meuse discharge September (Q)	89	92	94	48	30
Sea level rise (cm)	-	15	35	35	85
Extreme high Rhine discharge 1/100 year (Q)	12000	13000	14000	14000	17000

Extreme high Meuse discharge 1/100 year (Q)	2900	3000	3200	3200	3600
Extreme low Rhine discharge 1/10 year (Q)	630	650	670	520	420
Extreme low Meuse discharge 1/10 year (Q)	18	18	18	10	6
Average precipitation in winter		↑4%	↑7%	↑14%	↑28%
Average precipitation in summer		↑3%	↑6%	↓19%	↓38%
Socio-economic scenarios	**Reference year**	**Pressure and Steam**		**Rest and Warm**	
Year	2000	2050	2100	2050	2100
Inhabitants NL ($*10^6$)	16	20	24	15	12
Economic growth (% a year)		2.6	2.0-2.6	0.7	0-0.5
Urbanization (% land surface)	16	20	25	17	10
Agricultural landuse (% land surface)	67	59	70	62	67
Nature (% Land surface)	17	21	5	21	23

Relation delta scenarios - EU and IPCC scenarios

The delta scenarios used for the assessment of the Rotterdam case study are comparable with the RCP 4.5 and RCP 8.5 pathways adopted by te IPCC for its fifth Assessment Report (2011). RCP stands for representative concentrations pathways representing greenhouse gas concentration trajectories. Four RCP's are adopted RCP 2.6, RCP4.5, RCP6.5 and RCP8.5 (Table 2), which are named after the possible range of radiative forcing values in the year 2100 relative to pre-industrial values. The climatic part of the two extreme deltascenarios is comparable with the RCP4.5 and RCP8.5 pathways. Although the average sea level rise projections are lower for the IPCC scenarios, both the temperature change and CO_2 concentrations are comparable. Regional sea level rise projections of the Netherlands are in general higher due to oceanographic differences and the role of the North sea basin in the larger set of interacting oceanic basins. The Deltascenarios can also be related to the IPCC SRES scenarios B1 (for the pressure and rest scenarios), being a low emission scenario, and A1F1 (for the steam and warm scenarios) being a high emission scenario.

Table 2: Effects on CO2, temperature and Sea level rise in each of the representative concentration pathways (derived from IPCC 2011)

	RCP 2.6		RCP 4.5		RCP 6.5		RCP 8.5	
Climate Change	2050	2050	2050	2100	2050	2100	2050	2100
CO2 concentrations (ppm)		421		630		800		1313
Temperature change (°C)	1	1	1.4	1.8	1.3	2.2	2	3.7
Sea level rise (cm)	24	40	26	47	25	48	30	63

Main identified impacts in literature

Wardekker et al. (2010) and De Moel et al. (2013) indicated the disturbances and challenges the Rotterdam area faces due to climate change. Together with the Rotterdam Adaptation Strategy these studies give a good overview of the main effects and the related impact of climate change effects. One of the main effects is a temperature increase in the summer resulting in: more warm days, more heat waves, reduced air quality and drought. Drought can induce problems with warm river water which reduces the possibility to cool power plants, leading to a reduction in energy production. Also water supply could be limited. Sea level rise will increase flood risk. This will cause an increased closure of the storm surge barrier Maeslantkering limiting shipping traffic. Some meteorological scenarios foresee an increase in storm surges with north western winds. Since these projections are ambiguous, they are not taken into account. Altered river discharge due to increasing precipitation and melting water from the Alps, will affect the closing regime of the Maeslantkering and lead to a decrease of discharges due to drought, hampering inland shipping and increasing concentrations of pollutants and salinity. However, the main impact is an increase in flood risk due to higher mean discharge and higher peak discharges (see table 1). Additionally, an important effect are possible precipitation extremes, leading to increased surface flooding and sewage problems which is amplified by a lack of storage capacity. De Moel et al. (2013) do not specifically translate the climate change scenarios for the local unembanked river foreshore, nor do they calibrate for future change in socio-demographics or economic development in the local unembanked area.

Existing Information on Case Study's adaptation history

The relevant case study's adaptation history is included in the participation and implementation chapters of this document. Major adaptation to flooding is embedded in the historical construction of the Netherlands since it is physically located in a subsiding delta. This led to a cultural emphasis on collaborative planning of water systems via water boards, and in most parts of the province South Holland (where Rotterdam is located) to a poldering and diking strategy. Adaptation of these strategies builds on a technocratic institutional paradigm (Wiering & Immink 2006) embedded in structures such as water boards and the Rijkswaterstaat. Major efforts were undertaken after the already mentioned 1953 floods in the southwestern delta, which led to the Delta Works, physical structures to shorten the coast line, a set of norms for increasing dike height and strength, and a cycle of assessing dikes by both national and regional water body's given them hegemony over the Dutch water defense system. The origin of the Delta Programme building on the near floods of 1995 and 1997 is reported in this document elsewhere. However, adaptation in general water management in the Netherlands takes place against the background of these historical developments.

Connection with other research projects:

(Please list and shortly describe previous or ongoing research projects directly related with the Case Study) Please write the name and summary of the project, relevant partner institutions, year of beginning and end of project)

- Deltaprogramma Rijnmond-Drechtsteden (Different governments and research institutes including Deltares)
- Rotterdam Climate Program (Municipality)
- Cost benefit analysis adaptation strategy Rotterdam (Deltares)
- Research on adaptive planning in delta areas (Wageningen UR)

Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES
1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES
A. Public administration (municipality, regional, national, european)

B. Research and education Centres (universities, research centres, projects and groups, schools)
C. Public companies
D. Companies (farms, SMEs, big businesses)
E. Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F. Consortiums (partnerships, campaigns),
G. NGOs (environmental NGO, local development NGO, charities, etc)
H. Transition Initiative
I. Ecovillage
J. Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[1]
	[x] Objective 1 [ ] Objective 2 [ ] Objective 3 [x] Objective 4 [ ] Objective 5 [ ] Objective 6 [x] Objective 7	Example: [B] Companies (Farms)	[ ] Rural [x] Urban [x] Coastal [x] River Basin	[x] Local [x] Regional [ ] National [ ] Transnational [ ] European /Global	[ ] Bottom-Up [ ] Top-Down	[x] Retrospective [ ] Prospective	2015 - 2100

Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[2]	Phase of Implementation[2]

[1] Please insert year of start and year of end of case study.
[2] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

☐ Extreme Temperatures ☐ Water Scarcity ☒ Flooding ☒ Sea level Rise ☐ Droughts ☒ Storms ☐ Ice and Snow	☐ Extreme temperatures ☐ Water scarcity ☒ Flooding ☐ Coastal Erosion ☐ Droughts ☐ Soil Erosion ☐ Vector Borne Diseases ☒ Damages from extreme weather related events (storms, ice and snow)	☐ Agriculture and forest ☐ Biodiversity ☐ Coastal Areas 1 Disaster risk reduction ☐ Financial ☐ Health ☐ Infrastructure ☐ Marine and Fisheries ☐ Water Management 2 Urban	☐ Agriculture ☐ Biodiversity & Ecosystems ☒ Coastal and Marine systems ☐ Energy ☐ Health and Social Policies ☐ Transport ☒ Production Systems and Physical Infrastructures ☐ Water resources ☐ Tourism	☐ Yes ☒ Ongoing ☐ No	☐ Assessment ☒ Planning ☒ Implementation ☐ Monitoring ☐ Evaluation

Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

☒ Case developed and implemented as a climate change adaptation measure

☐ Case developed and implemented and partially funded as a climate change adaptation measure

☐ Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

2. Case study research Methodology

a) Research Goals

(Máx 500 words) *Please insert which are the General Goals for the case study as well as how will the case study contribute for BASE projects and BASE key research questions.*

The main goal is to derive pathways based on the costs and benefits of the different adaptation measures for different scenarios to reduce uncertainty for decision makers. These measures aim at a reduction of the flood risk in the Rotterdam area. To reach the goal, we take several steps. The first step is collecting the different possible adaptation measures in the Rotterdam area. The most important ones are chosen to derive information about the cost, benefits and effectiveness of the measures. The second step is obtaining information about the costs, benefits and effectiveness through estimations in the Planning Kit DPRD. With the results benefit/cost ratios and net present values can be estimated. This will be the input to take the third step, creation of efficient pathways.

Our goal is in line with the goal of WP5: 'examining sectoral and spatial multi-sector case studies of planned and autonomous adaptation to climate change, in order to draw bottom-up lessons on the planning, *impacts, costs, benefits* and implementation of adaptation measures in Europe'. One way of doing this is by extracting qualitative information on costs, benefits and effectiveness of adaptation measures, within BASE we want to upscale this information. Although our results will probably not deliver input to top-down models within BASE, such as Ad-WITCH, we can compare our findings with the case studies Leeds, Copenhagen and Prague to derive some general lessons.

A further goal is to increase our understanding of the functioning of adaptive planning to deal with uncertainty. To this goal three objectives are formulated: understand the role of participatory design in the context strategic planning by means of adaptive delta management (ADM), which is the principal structuring strategic planning approach in the Delta Programme (van Rhee 2012). Second, the functioning of ADM in processes confronted with a multitude of uncertainties. More specific, how does ADM function in the face of the state's altering hegemony due to increased technological advancement, increased recognition of a need for participation in strategy formulation, and difficulties with future uncertainty and possible (avoidance) of lock in by choosing specific strategies. Third, the more specific functioning of pathways as basic method underlying ADM and the strategizing processes in the Dutch Delta Programme, but also abroad. These three aims are strongly interlinked but will be addressed separately in the Dutch cases (so including the Ijssel Lake case) and in a comparative case study with other BASE cases.

b) Stakeholders involved

(Máx 2000 words) *Please insert any information about the stakeholders involved in the adaptation process with which you will relate to, namely their nature, involvement in the process, etc. If possible highlight the decision-making process as well as the leadership process for Climate Adaptation Strategies. Do Mention if there exists any kind of public engagement and participation within the Adaptation process.*

See for the stakeholders involved the extended description in the participation chapter.

c) Methodology

(Máx 2000 words) *Please insert what will be your research approach regarding this case study, how did you define it (did it include participatory sessions or not) and how you will implement it during the BASE Project period.*

During the BASE project the Dutch Delta Program will be completed. Therefore the Rotterdam case study is neither retrospective nor prospective, but somewhere in between. Our case study will correspond as closely as possible with developments in the program. Hence, we will choose to include all possible adaptation measures to reduce flood risk that are considered in the Delta Program. The Planning Kit model will estimate the costs, benefits and effectiveness of these measures for different scenarios. This will be followed by an analysis of the results and a construction of pathways.

Participation in the Rotterdam case is looked at in a retrospective manner, based on policy analysis, interviews and minutes of participatory meetings. With regard to the larger strategy development process in the Netherlands, interviews will be conducted with several policy makers in the sub-programmes of the Delta Programme, involved staff of the so-called-Delta commissioner and the initiators of the 'Adaptive Delta Management' – strategic planning approach used in Delta Programme. For the design component, interviews and documents analysis will be executed.

Analysis of the qualitative data will be executed by means of a coding procedure in Atlas.ti. These give coding procedures will substantiate the findings in the case, and direction for the case narrative.

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

METHODS to be used in Case Studies[3]	YES // NO
A) Methods for prioritizing adaptation options	

[3] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

Cost-Benefit Analysis (CBA)	YES
Cost-Effectiveness Analysis (CEA)	NO
Multi-criteria Analysis (MCA)	NO
Analytic Hierarchy Process (AHP)	NO
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	
Influence Diagrams	
Process-based Modelling	
Welfare variation analysis under restrictions	
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	
Monte Carlo simulations (PRIMATE uses this method)	
Real option analysis	
Climate risk management process	
D) Participatory Methods	
Scenario Workshop	
Participatory Cost Benefit Analysis (PCBA)	
Participatory add-ons to CBA	
Participatory add-ons to Multi Criteria Decision Analysis	
Participatory add-ons to Adaptation Pathways	
Other (add extra lines if necessary):	

(Máx 500 words) *Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.*

d) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Case: IJsselmeer ; Person: Rutger van der Brugge

Case: Ilhavo & Vagos ; Person: Inês Campos

Case: Prague ; Person: Eliška Krkoška Lorencová

Case: ____________________________; Person: _____________________

Case: ____________________________; Person: _____________________

Case: ____________________________; Person: _____________________

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: Volker Meijer & Oliver Gebhardt ; Partner: UFZ

Name: ______________________________; Partner: _____________________

Name: ______________________________; Partner: _____________________

Name: ______________________________; Partner: _____________________

Name: ______________________________; Partner: _____________________

Name: ______________________________; Partner: _____________________

Name: ______________________________; Partner: _____________________

e) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: 3

Provisional Title: Design in adaptive planning under uncertainty

Concept ready by; Month/Year: May/2015

Provisional Title: Adaptation pathways in planning for uncertain climate change

Concept ready by; Month/Year: January/2016

Provisional Title: Dealing with uncertainty in collaborative settings

Concept ready by; Month/Year: June/2015

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: ____

____; Month/Year: ___/_______

c. Other

- Scientific conferences: # ___

Provisional Title: Understanding adaptive planning approaches for dealing with uncertainty

________________________ Conference: Month/Year: July / 2015

Provisional Title: ____

________________________ Conference: _________________________________ Month/Year: ____/______

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

a) Process overview

(Please describe the use of Participatory Methodologies within your case study, namely its integration in the overall Research Methodology explained earlier in the CSLD, the rational behind it and key expected outcomes – Máx 1000 words)

Participation in the Rotterdam case is looked at in a retrospective manner, based on policy analysis, interviews and minutes of participatory meetings. With regard to the larger strategy development process in the Netherlands, ten interviews were conducted with several directors of the sub-programmes of the Delta Programme, involved staff of the so-called-Delta commissioner and the initiators of the 'Adaptive Delta Management' – strategic planning approach used in Delta Programme. This larger National structure of the Delta Programme formed the context wherein the Rijnmond Drechtsteden Delta programme was executed. The Rijnmond Drechtsteden used the Adaptive Delta Management (ADM) approach to create their strategies, as such ADM structured the way participation was done and how participatory methods were used.

Within the Rijnmond Drechtsteden, so-called delta ateliers or design workshops were used to address climate change adaptation needs, to enable joint fact finding, and to seek for possible solutions together with participants from societal partners. We interviewed the atelier master, and the director of the sub-programme related to these design workshops and the role of this method to let different stakeholders participate in the strategy formulation. Also, a content analysis of the role of especially research by design within the context of ADM was executed, here interviews with the atelier master and two designers within the ateliers were included. Next to the design workshops, stakeholder meetings and other participatory events were organized throughout the process. This already started at a national level by the Dutch Delta Committee (Kabat et al. 2009), who advised to start the Delta Programme. We reflect on the whole process and gained our insights from policy analysis, interviews and analysis of the different minutes of the participatory meetings by means of content analysis. In this chapter we will explicitly focus on a retrospective description of:

a) Participation within the process of the Rijnmond Drechtsteden sub-programme
b) The use of design workshops as participatory method within the Delta programme, emphasising its use in the Rijnmond-Drechtsteden sub-programme

The data is used to reconstruct the process of how the adaptation strategy for Rijnmond Drechtsteden came into being. This whole process was a four year long participation process of all the relevant stakeholders: Ministry of Infrastructure and Environment, Rijkswaterstaat, Waterboards, Provinces, Municipalities and NGO's.

b) Participation in the Process Phases

Process phases:

1. *Initiative/decision to act*

The Delta program was originally initiated as a result of the delta committee, who in 2008 argued that a new Delta Plan was needed in order to meet the challenges of climate change. That committee involved people (predominantly experts, but some with a political background) with a wide variety of disciplinary background. For making their report (Delta Committee 2008) they used a national participatory process involving stakeholders, interested citizens, experts and officials in collecting different perspectives and visions on the development of the Netherlands regarding water in a broad sense. Their advice resulted in the parliamentary acceptation of their recommendations to install the Delta Programme, with as judicial backbone the Delta Act and a fund to provide for financial resources. The Delta Programme was created to further advance the visionary view of the Delta Committee, by executing research and doing strategic planning across the multiple institutions involved in Dutch water management and spatial planning (including the national, regional and local authorities) (See also: Boezeman et al. 2013; Kabat et al. 2009; Verduijn et al. 2012). The way the Delta Programme was launched reflected the interdisciplinary advice: it became a National programme. As such, it was not to be considered as a national government program, but was assumed to be executed in a joint effort by the relevant national, local and regional authorities.

In the initial stage, each regional Delta programme, whereof the Rotterdam region became one, was responsible for its own organisation and process architecture, although some general guidelines were provided in the existing use of programme management principles throughout the Dutch government and in the new Delta Act. This initially existed out of the 'Projectbureau' consisting out of employees from all Governmental layers (Municipality of Rotterdam and Dordrecht, Waterboards, Provinces, Ministry of Economic affairs, Rijkswaterstaat (executive body of the Ministry of Infrastructure and the Environment) and the port Authority).

Because of the complex situation in the delta of the Rhine, with the confluence of sea and river water, and the historical emphasis on large scale infrastructure, the programme set out to explore a broad range of strategies in conjunction with the upstream measures and the measures within the delta to the south of the Rijnmond-Drechtsteden area. The complex situation and the necessity of a broad scope regarding the strategies was acknowledged at the start of the programme in 2010. Therefore, at that time, the range of stakeholders was also defined. This included all governmental levels, companies, NGO's, citizens and scientific experts (DPRD 2010). At that time, the goal was to execute the strategy-making process in co-production with these stakeholders, with as core values transparency of the steps, involvement in, and commitment to the process. Thereby expertise and knowledge from all stakeholders should be included within the process via joint fact finding. Participation was seen as a necessity for good decision making (DPRD 2010: 6). This was organized via a societal advisory board consisting of representatives of each stakeholder group, including representatives of different groups of citizens (youth, elderly, etc.) and economic sectors (maritime, recreation, industry, etc.) (and via two governmental collaborative efforts, see below).

2. *Development of potential adaptation options*

For the development of the potential adaptation options, several participatory processes were used. These can be divided among the phases of developing the adaptation options, as described in the overall strategic planning approach Adaptive Delta Management, and among the involved groups within society.

The process of the Delta Programme, based on ADM (Van Rhee 2012; Van der Brugge et al. 2012; Vlieg & Zandvoort 2013) existed out of 4 phases, each lasting a year: from preliminary assessment, via possible strategies, to making a choice for a preferred strategy (which was proposed to Dutch parliament in September 2014 in the report called Delta programme 2015). The first phases of the Delta programme were devoted to problem analysis based on long term delta scenarios, and subsequent refinement by assessing the (im)possibilities and cost-effectiveness of possible strategies. Dutch knowledge institutes such as Deltares and the KNMI (the Dutch meteorological institute) played an important role throughout the different phases wherein the development of the delta scenarios and impact assessments were important aspects. These institutes also played an important role in the identification of solutions and the assessment of proposed strategies and measures. This was done in commission of the various subprograms.

The Delta Committee, in 2008, already laid out several possible strategies which formed the starting point for the Rijnmond-Drechtsteden strategizing process. There were 4 different strategies in 2010 to start analysis and collaboration. Experts did an economic effectiveness study of these 4 strategies, on a range of different criteria (Jeuken et al. 2013). Meanwhile, a design workshop with a set of stakeholders was used under the title 'From possible strategies to narratives' (DPRD 2011), to come to a first line of reasoning and consensus about the (im)possibilities of the different strategies. The main aim of these narratives was to communicate the (im)possibilities and technical knowhow to the general public and to provide possible storylines to discuss the different possible strategies.

Each of the steps within the Delta Programme were on a yearly basis reported to parliament, together with the national budget in September of each year. Local politicians were involved via their contributing officials in the smaller governmental steering board (the 'Bestuurlijke Stuurgroep') and within the larger regional collaboration efforts structured around conferences for politicians and consultation sessions with both officials and politicians (respectively 'Bestuurdersconferenties' and 'ambtelijke & bestuurlijke consultatierondes'). The participation of different governmental layers within the national programme started with a conference attended by politicians from municipalities, provinces, and water boards. This resulted in a round of interviews among the regional governmental coordination bodies and conversations with the responsible politicians at the different governmental bodies. All representatives indicated they wanted to be involved, even if the regional strategies didn't have large effects on their respective constitutive areas. As such, the participatory process was to a certain extent created in a participatory way.

Next to the involvement of the specific governmental layers, also existing intergovernmental platforms were used to create some participatory efforts. The main construction was based out of the initial round of consultation. This led to a division of the full region into in 7 smaller sub-regions, each having its own specific characteristics from a water management and urban constellation perspective. Each of these regions had its specific intergovernmental body which was informed and to a certain extent involved in the process. Several of these regions became very important in the latter half of the four year programme. Within the regions the main effects of the strategy and hence, the major efforts regarding execution and overcoming barriers to implementation are located. As such, the design workshops were mainly focussed on, and used in these regions.

From 2013 onwards, another important intergovernmental body was deemed to be important to involve, this is the governing board of the so-called safety region. This governing board is responsible for emergencies of all kinds within a specific region and consists out of different representatives of the government but also from the emergency organisation responsible for first response in case of for example a chemical disaster or a flood. As such this governing board was regarded as being important to inform and to participate with to align the strategy with the functioning of the safety region.

The societal actors were involved via a societal advisory board (Maatschappelijke Adviesgroep) consisting out of 11 members, each representing a different stake. This included all major economic sectors, and societal values regarding nature and landscape. The societal advisory board advised the steering board of the Rijnmond-Drechtsteden. This was the main set-up to involve different stakeholders from society. Twice a year a large stakeholder meeting with amongst others the representatives for the stakes within the societal advisory board were conducted to both inform stakeholders and provide input for the strategizing process. The programme bureau deliberately choose not to actively involve citizens in these phases in the Rijnmond-Drechtsteden programme, since it was deemed sufficient to incorporate societal organisations from different relevant domains, and let the citizens be represented by the municipalities. However, the programme was open to citizens who took action themselves to be incorporated in the process, the programme bureau was open to these private initiatives (DPRD 2014).

3. Decision-making

Final decision-making about the broader national strategies is formally arranged in parliament as the primary democratic institution. The local and regional measures and implications of the total strategy as proposed and made official by parliament have to be decided upon by the local and regional democratically legitimate authorities. Within the Dutch law, citizens can give their opinion, for example in advance via letters, or at the local level via public hearings. There is a more elaborate democratic mechanism in place if the strategy implies infrastructural projects or alteration of law. In that case there are also hearings but also the right to proceed via legal ways to influence or stop a decision. This latter does also count for local or regional authorities who object against national decisions to alter legal prohibitions for lower tier institutions. Water related issues, however, are normally not subject to such types of legal mechanisms. Within the actual decision-making, participation is thus very formalized via legal procedures and only parliament is responsible for decisions, with other stakeholders and governmental bodies only participating in the development of possible options. The advice of different stakeholders, however, is seen as important and parliament will normally not alter course regarding the proposed strategies (which was indeed not the case).

4. Implementation

The implementation is currently under way. The intention is to keep the different discussion and participation platforms alive during the implementation process. Therein the role of the stakeholders will be crucial for the implementation and the evaluation of the effects. There remains to be a steering board of wherein local politicians will actively participate and discuss all matters relation to the implementation of both the strategy and resulting measures. Next to this steering board there is a ‘community of practice’ wherein different parties come together twice a year to discuss implementation matters. Most important parties in the implementation of the strategy are Rijkswaterstaat, the Waterboards, the different Provinces and Municipalities, with the Ministry of Infrastructure and Environment as

the supervisor or the total implementation. Experts will remain to be involved on the same basis as they did in the earlier phases: by means of commissioning for specific projects on regional or local scale.

Parts of the implementation of options (regarding safety, water resource issues) are integrated in the national implementation scheme. This means that experience in other parts of the Netherlands need to be shared, and can influence the Rijnmond-Drechtsteden situation. While most of the measures build on the already used types of measures practiced in the Netherlands, some do not have a historical background (such as multi-layer safety, which is in a pilot /test phase in amongst others the city of Dordrecht). For example for dike reinforcement, the role of different actors are clearly defined and codified in law. How participation turns out for new measures remains to be seen.

In a letter to parliament (MinI&M 2014) the minister indicated that the implementation of all strategies will be executed via the existing process for implementing spatial and infrastructure projects. A remark the minister made is that most of the projects will be executed in the context of larger scale programmes, amongst others for dike reinforcement. Thus, the participation will take place within the already institutionalized legal descriptions for project and programme planning. This also means that contribution of new methods, and alteration of the participatory structures for specific climate adaptation actions can be hindered in both a legal and customary way. There is, however, a transition visible especially in the Dutch water management context of more control on participation, citizens involvement, and quality of designs (Klijn et al. 2013). The design workshops can be positioned in this trend, since their application for specific projects along the rivers took flight within this Room for the River programme. As such, there are opportunities for participation by design workshops for the Rijnmond-Drechtsteden area but how this will evolve in the future remains to be seen.

c) Participation Experience

(Please report with regards to your case study and the implementation of Participatory Methodologies using a traditional SWOT analysis – Strengths; Weaknesses; Opportunities and Threats)

We reflect here on the use of the Design workshops as part of the DP Rijnmond-Drechtsteden, based on the executed interviews with responsible people for the design workshops.

Table 3: A swot for the Design workshops as part of the Rijnmond-Drechtsteden deltaprogramme

Strenghts	Weaknesses
• Integrated approach • Possible to involve all relevant participants • Emphasises quality of options • Practical and hands-on approach • Imagining quantitative data • Creates strong relation between designers and modellers/experts	• Necessity of design specialists to execute the design component • Necessity of sufficient detailed information as input for the design and sufficient resource to collect data and material to disseminate within the workshop • The group size is limited • Only relevant for physical options, not for governance/legal/institutional adaptation

Opportunities	Threats
• **Relevant for all local and regional scale participatory planning processes** • **Attractive form of participation due to visuals and instant interaction about forms** • **Connecting quantitative data with qualitative design solutions** • **Functioning as a knowledge broker**	• **Large focus on how it looks on a local detail, risk of leaving out larger scale perspectives** • **Focus on what works, so very pragmatic which can conflict with tacit or expert knowledge, it can possibly open a box of pandora regarding the myriad of visions and knowledge claims if not executed properly** • **Possible imbalance between form (easthetics) of an adaptation option and function (effectiveness) of options**

d) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

a) Your view whether and how participation influenced the strategies and measures decided in your case?

This question can be answered on three levels: At the level of the Delta program: This was a four year national program, which means that it was a shared program of the relevant institutions: Ministry of Transport and Public Works, Regional Water management authorities, Provincial authorities and Municipalities. In addition knowledge institutes and universities were involved as well as private companies, predominantly consultants. All these parties have co-created the strategies.

Participation among governmental layers, principal stakeholder groups and members of the scientific community has influenced the strategies to a large extent. There was large emphasis on getting different societal partners on board, and the resulting strategies are to a large extent influenced by the regular meetings with stakeholders and also underwritten by the different governmental bodies involved. Although the focus on participation was primarily via democratic representatives of the public in lower tiers governmental layers, it was highly influential in taking the local aspects into account and, based on the localities of places, alter the main strategies. This mainly resulted in flexibility for the implementation (between space for the river versus hardening the dikes), and possibly the resistance against room for the river, which have enormous local implications influenced to some extent the strategies for dike reinforcement and only where possible seek for spatial solutions. Also, some actors were influential in bringing local spatial measures within the Multi-layer Safety Approach (Zandvoort & Van der Vlist 2014) to the fore, amongst others the municipal of Dordrecht did a lot with this newly establish paradigm (which still knows cultural resistance since it seems to challenge the hegemony of engineers and water boards vis-à-vis spatial planning).

To what extent the lobby and influence of companies such as the harbour based industry and transport interests is not has altered the strategies is not clear. The stakes are however clearly factored in (which is for example also visible with the high revenue horticulture which is dependent on both specific quantity and quality of the water supply and the transport stakes regarding possible alternatives including closing the harbour entrance with a sluice complex, these latter possibilities are discarded). As visible from the cost-benefit analysis, the primary rationale are the high costs for these market parties.

b) How you think the participatory process in your case could be/have been improved?
An important aspect lacking in the current participatory process is the inclusion of direct citizen involvement. Via delegates participation is to some extent useful, because the local and site specific interests can be taken into account. However, fuller inclusion of societal parties including interested citizens could deliver new perspectives and insights for the strategy making process. Although the large geographical scale of the Delta Programme, the Delta Committee (which advised the instalment of the programme) did do such a participatory process on a national scale. For the regional and local implementation and exemplar projects probably the participation will be extended to the citizens and fuller involvement of also smaller companies and NGO's. The already used participatory method of design ateliers shows the necessity of including citizens at least at a local and supra-local scale.

c) Any novel (use of) participatory methods observed in the case studies
In the Delta Programme, and especially in the Rijnmond-Drechtsteden design charrettes or design workshops were used as a novel participatory method. These design workshops had overall two functions: research-by-design (Lenzholzer et al. 2013) and codesign based on joint fact finding (Howard & Somerville 2014). While for the first the research component is important, the second emphasizes the participation or 'codesign' wherein different stakeholders sit together in the form of a scenario workshop but with a strong design focus. Taking such a design focus can inform sustainable, context-dependent interventions and is very effective for collaborative decision-making if executed in a proper way (Howard & Somerville 2014; Palmer et al. 2013). It could be argued that design workshops are a participatory method which can establish a better spatial quality of measures resulting out of a strategy while it can also be used to explore ex ante the resulting effects of strategies on the current spatial configuration. This last use was the main aim of design in the Rijnmond Drechtsteden, as reported upon in the cost-benefit analysis in Jeuken et al. (2013) and by Nillesen (2012; 2014). Further use of design in strategy making and climate change adaptation planning, should be informed by the (im)possibilities for feasible integration in the existing planning system from the different existing perspectives on the link between design and spatial planning (Kempenaar et al. 2016; Van Assche et al. 2012; Van Dijk 2011). This could be done from the angle of planning but also from the possible roles of research by design (Lenzholzer et al. 2013) and existing typologies of design workshops (for example Palmer et al. (2013) indicate at least five: visionary, consultation, project based, research and testing charrettes).

Regarding design workshops as participatory methods comparable to shared vision planning and scenario workshops, first studies are done by Sanders & Stappers (2014) and Howard & Somerville (2014). They divide design charrettes in 'designing for' versus 'designing with' and structure these in the role of design in decision making: predesign, generative phase of design, evaluative and post-design. The participation in the delta programme were mainly policy-makers collaborated with scientists and designers can be seen as either predesign (so prob-

ing for alternative solutions within the range of climate change scenarios) and generative design (specifying water management and adaptation strategies by searching for increased spatial quality by design).

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

The economic analysis focuses on regional adaptation measures proposed for the Rijnmond-Estuary area. These are the following adaptation measure(s):

1) Dike reinforcement
2) Water storage Grevelingen
3) Room for the River measures
4) Channel deepening
5) Full closure with dams and sluices

Although, we studied measures such as adaptive building and preventive evacuation, these measures are not included in the economic analysis.

Dike reinforcement

Rijnmond Drechtsteden will face an increased flood risk. Reinforcement of the dikes will lower this risk.

Water storage Grevelingen

The adaptation measure consists of opening of the Volkerak locks in case of high water levels (up to 2.6 meter above sea level). Additionally, the Volkerak-Zoommeer & Grevelingen will be filled with water, which will slow down the rise of the water levels in other areas (see the green area, figure 3). This measure can only be taken when the Measlant barrier is closed.

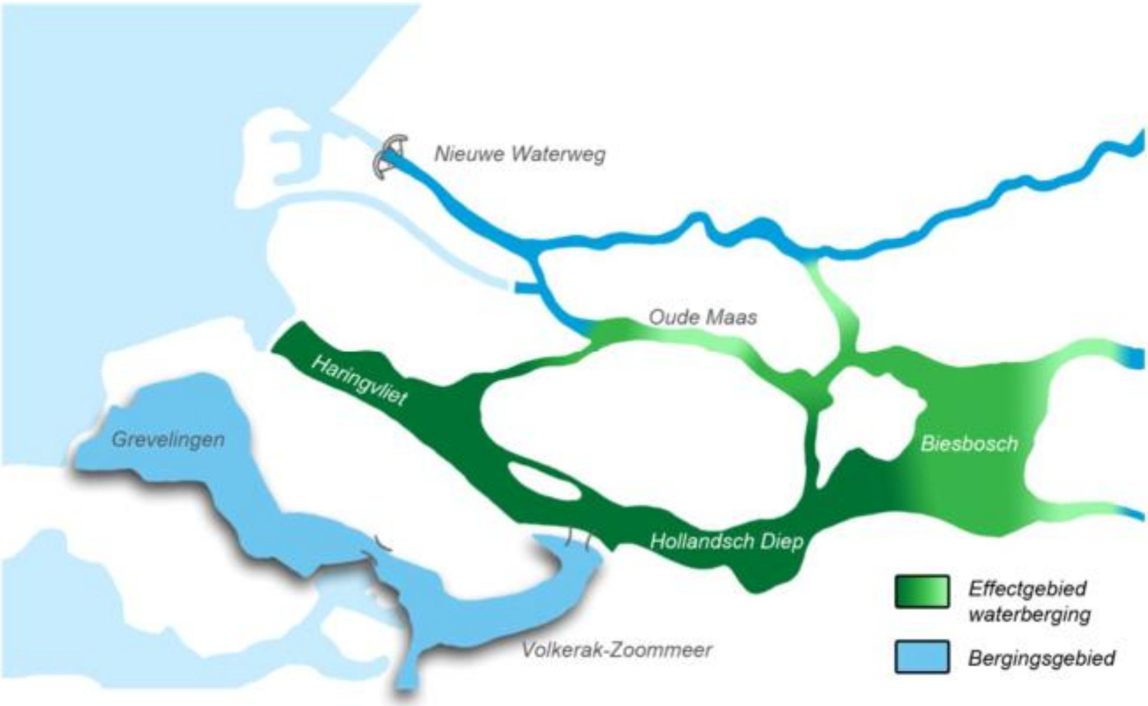


Figure 3: Water storage areas (bleu) and affected areas (green) where water level rise will slow down.

Room for the River measures

The core of the room for the river measures is giving more space to the river in order to increase the velocity of the flow or to reduce the water level of excess flows and time of exposition to large floods. Figure 4 gives an overview of eight different types of measures.

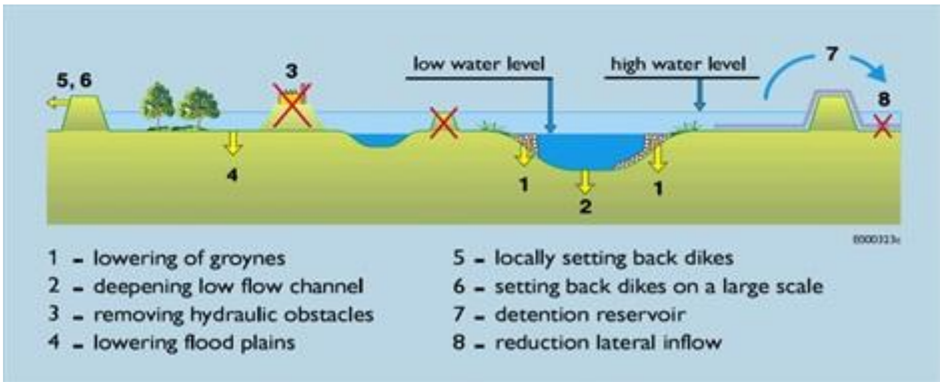


Figure 4: Eight different type of possible measures to take in river management (*Silva et al., 2001*)

In this case study these measures are categorized in four packages:

- Room for the River Small 1
- Room for the River Small 2
- Room for the River 3
- Room for the River 4

All these measures are planned upstream of Rotterdam.

Room for the River Small 1

- Use of channel Steenenhoek, digging a channel through the Biesbosch and excavation of the straight spit of land in Gorinchem.

Room for the River Small 2

- Construction of a side channel close to Sleeuwijk and a flood plain excavation at the left side of the Boven Merwede in combination with the construction of a permeable abutment (bridge A27).
- Flood plain excavation at the right side of the Boven Merwede
- Dike relocation Werkendam along the left floodplain of the Boven Merwede in combination with construction of a side channel and creating a permeable channel (Beatrixport channel).

Room for the River 3

A combination of the measure Room for the River 1 and the following measures:

- Excavation of business area Avelingen along the right floodplain of the Boven Merwede in combination with construction of a permeable abutment (bridge A27) and excavation of the straight spit of land in Gorinchem.

- Construction of a channel through the Sliedrechtse Biesbosch on the left floodplain of the Boven Merwede in combination with a dike relocation in polder Hardinxveld along the right floodplain of the Boven Merwede.

Room for the River 4

A combination of the measures Room for the River 1 and Room for the River 2.

Channel deepening

Deepening of the summer beds of the new Merwede and Boven Merwede (figure 5).

Figure 5: schematic representation of deepening the river bed

Full closure with dams and sluices

This measure consist of full closure of the Nieuwe Waterweg aiming to lower the water levels in the area, resulting in less dike reinforcements and a reduced flood risk. The Nieuwe Waterweg will be closed with a lock complex including sea locks, the Hartelchannel will be closed and extension of the Rozenburgsluice (Figure 6).

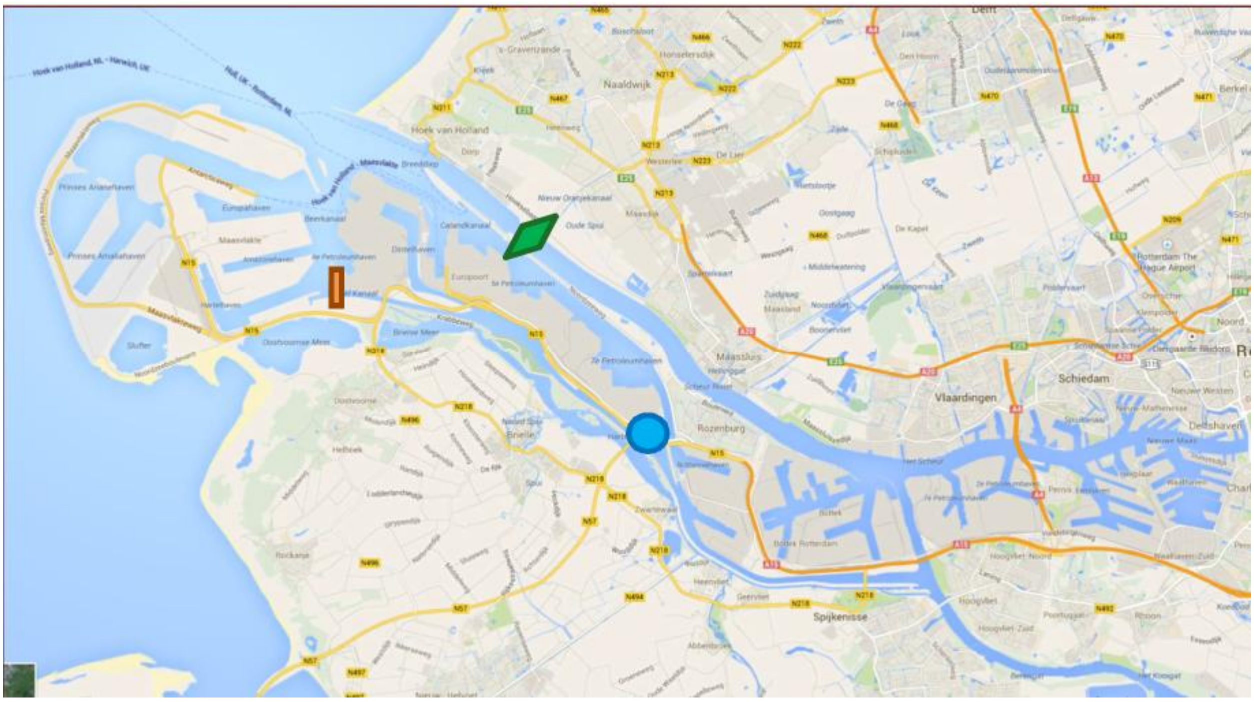


Figure 6: Measures at the Nieuwe Waterweg (green square), the Hartelchannel (red square) and Rozenburgsluice (blue dot).

b) Adaptation Measures selection and data availability prior to BASE

Since the Dutch Delta Program considers the selected measures as promising measures, we decided to include these measures in the analysis. Additionally, there is a considerable variation in the selected measures, varying from 'soft' room for the river measures and 'hard' measures such as closure of the Nieuwe Waterweg.

There is an extensive amount of literature available for almost all measures, especially for water storage in the Grevelingen, dike reinforcement and full closure with dams and sluices. This literature includes a description of the effects of the measures in comparison to the current situation. All these measures are included in the Planning Kit Rijnmond-Drechtsteden, which estimates the costs and damages of these measures.

c) Full description of Adaptation Measures

(Please provide a full description on each of the Adaptation Measures regarding this 21 leading questions under. If more than one Adaptation Measure please copy paste the structure provided.)

Just filled in for Dike reinforcement

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

Probably, institutions will only implement this measure, if the dikes would be disapproved during a regular dike assessment. Since this will be a reactive reaction (adjustment when water levels are already high), this cannot be seen as autonomously adaptation to climate change . However, currently a prediction of conditions is part of the assessment, so maybe this measure will be already autonomously taken.

II. Does the measure initiate further activities for adaptation to climate change? (N)
    a. If Yes, please name which

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (N)

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y)

V. Is the adaptation measure iterative? (N)

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N)

a. Please describe briefly how

Dike reinforcements can be seen as a sustainable measure, since 'the needs of the present and future generations are met'. With dike reinforcement the flood risk decreases until an economic more optimal level.
Dike reinforcements can be linked with other ambitions, such as spatial ambitions. If this linkages are made, it can bring benefits for other social, environmental or economic objectives.

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y)

Outcome

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health ?

The addressed threat is flooding. The measure reduces flood risk. Especially, economic values and socio-cultural values are at stake. Since the Netherlands is a densely populated country with a high GDP, a flood can cause enormous damages. Climate change increases flood risk by higher river discharges and sea level rise.

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)
26%

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits (Please refer to results of economic evaluation in chapter 5)

The benefits are higher than the costs of the measure.

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies(eg. CAP/Cohesion policy ?

We don't know.

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (N)

XIII. Does the measure have effects on employment? (N)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure? Direct effect after implementation

XV. What is the timeframe during which the measure will have an effect? Life time 50 years (but longer effect)

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (N)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

Depends on which location the measure will be implemented. However, it is not expected that it will cause additional environmental pressures, since on most locations dikes are already present.

Equity

XVIII. What are the impacts on different social or economic groups, are there expected impacts on particularly vulnerable groups? (distributional impact)

No

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (N)

5. Impacts, Costs and Benefits of Adaptation measures

(This section of the CSLD follows the Economic Assessment Steps put forward by UFZ and thoroughly described in D4.1, chapter 4. Please check D4.1 for any doubts or questions. In case of duplication of information with previous sections of the CSLD feel free to copy paste.) For more detailed guidance (incl. two examples) please see the above mentioned chapter 4 of D4.1. Please do not hesitate to contact volker.meyer@ufz.de, oliver.gebhardt@ufz or Filipe Alves if you have questions about how to fill out this section.

a) Preliminary Risk Assessment and identification of adaptation tipping points

What is the climate change related problem/risk you would like to reduce by adaptation?

Climate change will increase the risk of flooding due to sea level rise, increasing number of precipitation events and more severe rainfall. Additionally, a flood would have a greater impact today than it would have had 50 years ago, due to the growth of the population and urbanization of the most flood prone areas of the Netherlands. The Rotterdam area is a densely populated part of Holland (1,6 million inhabitants) with extensive economic activity. In this area, the consequences of a flood will be enormous.

The Netherlands is protected by 17.500 km of dikes, which is a grey adaptation measure. Additionally, in the Rotterdam area there are several storm surge barriers, such as the Maeslant barrier. These barriers close in cases of high water levels to protect the hinterland. As part of the Room for the River program that started as a reaction of the floods of 1993 and 1995, the Netherlands planned 32 room for the river measures. The goal of this program was to accommodate a discharge volume of 16,000 m3/s in the branches of the Rhine by 2015. The Rotterdam area implemented one of these room for the river measures, a flood plain excavation (Schasfoort et al, 2013).

Currently, not all the dikes are high enough to meet the current flood protection standards. In 2050 30% of the dikes and in 2100 50% of the dikes will not meet the current flood protection standards, due to climate change and land subsidence, which is substantially higher than in the current situation. The current flood protection standards are based on a 50 year old optimization of costs and benefits (damage), which are legislated in 1996. These standards are expressed as the average exceeding frequency per year, which is an expression of the hydraulic load that a water defense must be able to withstand. For example, for the western part of the Netherlands this exceeding frequency is 1 time in the 10.000 years (Van der Most et al, 2010)

The increase in population, higher economic value behind the dikes and the impact of climate change led to the decision to update the flood protection standards. Currently, the Dutch government established the new flood protection standards, which are based on a risk assessment. In 2050 all the dikes have to meet this new standards. At that time, the dikes have to be adjusted to the then prevailing climatic situation. See figure 7 for both the current standards and new standards (I&M 2014).

Sectors under risk

The following sectors have the highest potential damages due to floodings (DPRD 2012):

Areas inside the dike: The residential sector, mainly the areas South of Holland – New Waterway, Alblasserwaard and Vijfheerenland and Lopiker- and Krimpenerwaard have a potential high number of fatalities and high economic damages.

Areas outside the dike: Low lying nature areas and agricultural sector, current urban and residential sectors (historical city center of Dordrecht, Northern island of Rotterdam, Neighbourhood Feyenoord and the port). Expected damage will be on household content and interiors as well as failure of business processes and environmental damage.

The shipping sector will be affected by more frequently closing of the Measlantkering, due to higher water levels. Consequently, the hinterland will be less accessible.

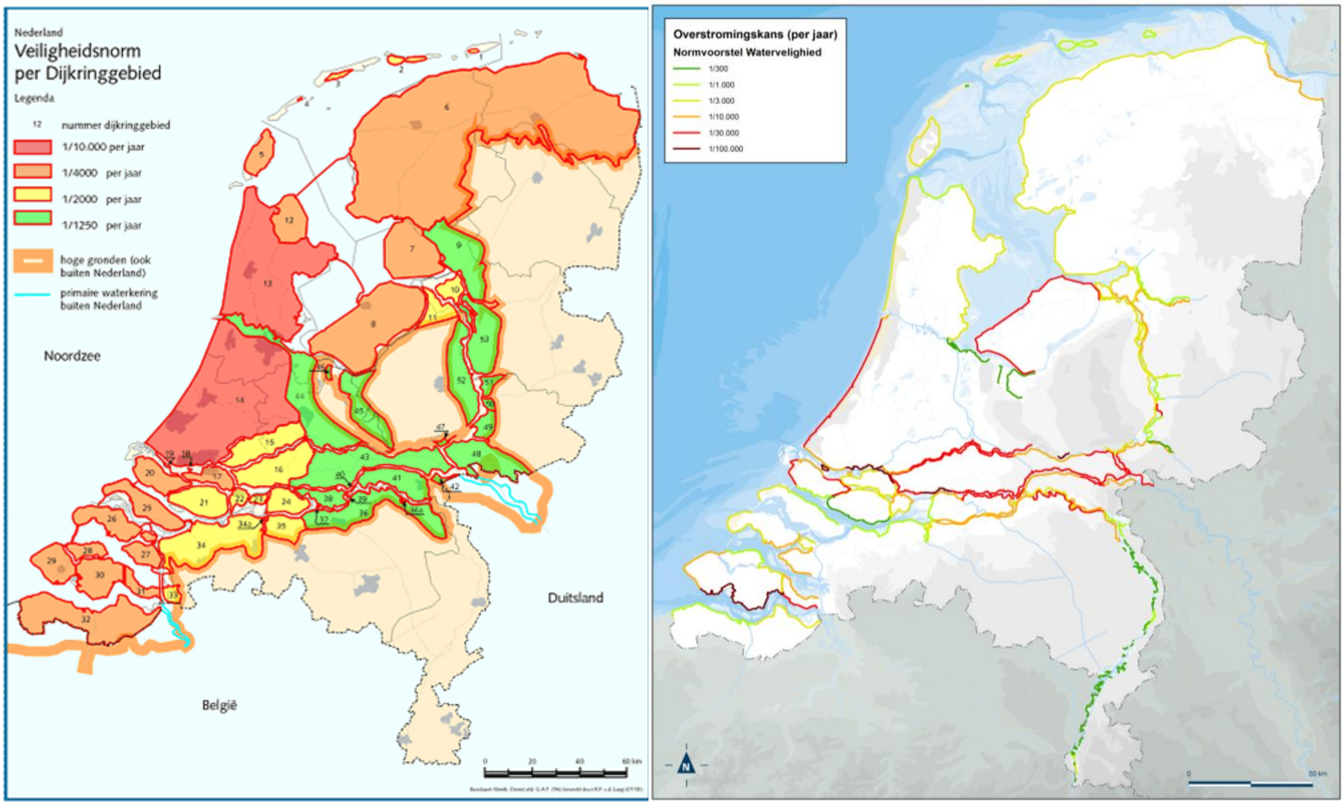


Figure 7: Current (left) and proposed (right) flood protections standards (DPV 2014)

Which adaptation tipping points can be identified?

The tipping point for flood safety depends mainly on the Dutch flood protection standards. Currently, the flood safety standards are not met on all locations in the Rotterdam area. Therefore, we can argue that there is already a tipping point. However, this task is already embedded within current policy, the high water protection program will take action to higher dikes on vulnerable locations. Since there are more reasons for not meeting the standards than climate change, we not consider this as a tipping point. In addition, sea level rise and higher peak river discharges cause increasing flood risks and call for further dike improvement in complex areas (current policy) or alternative flood risk reducing measures. For example, sea level rise of 85 cm may cause a 60 to 70 cm rise in river water levels at the height of Rotterdam. This additional risk is not embedded in current policy, therefore we can state that this is the tipping point. However, somebody have to decide when a tipping point is reached. For example, is there already a tipping point if 1% of the dikes do not meet the flood protection standards? The Dutch law subscribes that all the dikes have to meet the flood protection standards. This means that the first dike stretch that does not meet the flood protection standards due to climate change, will cause a tipping point. Unfortunately, there is no information about when this will happen in the different scenarios. However, there is some information about the shortage of dike height in 2050 and 2100 due to climate change for the 'steam' scenario (see figure 8). In 2100 in a 'rest' scenario a similar shortage of dike height will be reached as in a 2050 steam scenario (DPRD 2012). The new flood protection standards add some complexity. In 2050 all the dikes have to meet the new standards, which mean that tipping points will change after 2050.

In sum, there is not enough information to identify a tipping point. In addition, a dike is programmed for improvement in the national Flood Risk Management programme, whenever a dike does not meet the targets. In some cases other measures can be implemented instead of dike reinforcement, such as room for the river measures. Consequently, if the safety standards will not be met, the Flood Risk Management programme will intervene (DPRD 2014). Therefore, the actual tipping point will never be met, instead there will be a tipping point just before not meeting the safety standards.

The Maeslant storm surge barrier in the Nieuwe Waterweg envisions the most clear tipping point. The design took account of a sea level rise in between 20 and 50 centimetre per century. If the sea levels increase more than 50 centimetre per century the barrier exceeds its functional life span, which means that the barrier no longer satisfies the safety standards for the hinterland. Depending on the climate scenario the barrier has to be replaced between 2070 and 2120 (Jeuken et al, 2013).

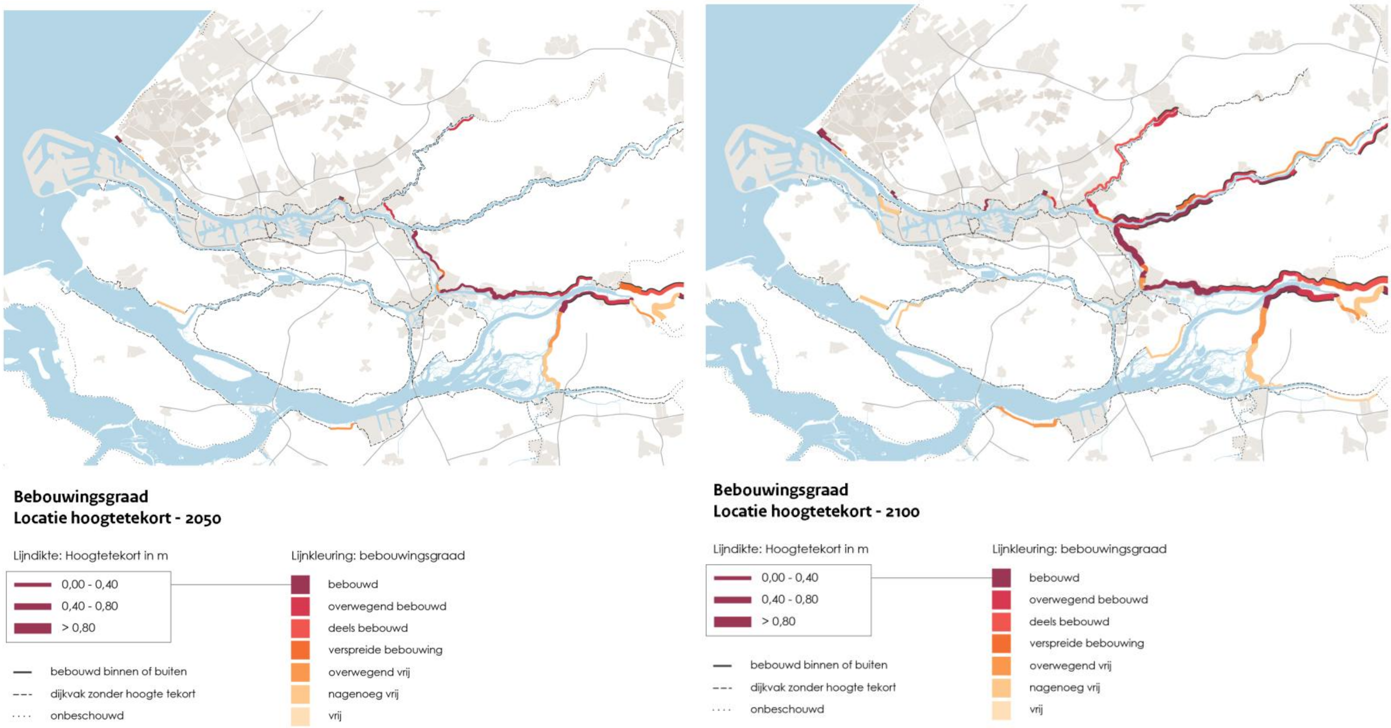


Figure 8: Dike heigth shortage in 2050 (left) and 2100 (right) (DPRD 2012).

b) Identification of Adaptation Measure and Adaptation Pathways

What are the alternative adaptation measures?

The main aim of the adaptation measures is to keep the Netherlands safe from flooding. This can be done by either reducing the probability of a flood or through reducing the consequences of a flood (Zandvoort & Van der Vlist 2014). The following type of measures reduces the probability (DPRD 2012):

- Dike reinforcement
- Construction of new quaysides or dikes
- Reducing the hydraulic load
- Building with nature solutions (such as lowering of groynes, deepening low flow channel etc).

This study considers mainly the before mentioned types of measures. However, there are other possible measures that mainly reduce the consequences of a flood, such as (DPRD 2012):

- Influence the pattern of a flood
- Adaptive building (building on stilts, wet proof building, dry proof building, floating buildings)
- Protect critical infrastructure
- Risk zoning, prohibit building in areas with a high risk.

- Improving crisis management
- Development of an adaptive evacuation strategy
- Development of shelters, wide evacuation roads etc.

Baseline option and complementary measures
The baseline strategy consists of maintaining the current flood protection levels with dike reinforcement. This means that it includes current backlog. We have no insight in autonomous adaptation; therefore autonomous adaptation is not included in the baseline strategy.

The flood protection standards cannot be met without dike reinforcements. Therefore, the strategy will always consist of dike reinforcement whether or not combined with another measure. All the measures are complementary to each other.

What are alternative adaptation pathways?

- What is the "sell-by"-date of the measures or bundles of measures? I.e. when will they – under conditions of climate change – not any longer be able to meet the defined objectives?

If the measures are combined with sufficient dike reinforcements, all the measures will meet the objectives. Additionally, you can look to the sell by date of the individual measures. Kind et al. (2014) showed the different potential measures with indicative time window according to the Delta scenarios 'steam' and 'rest' (figure 9). This gives an idea about the timespan of the different measures, but not about the ability to meet the defined objectives. Unfortunately, there is no information about the exact 'sell by date' of the individual measures, since in the Netherlands these measures will be always combined with dike reinforcements.

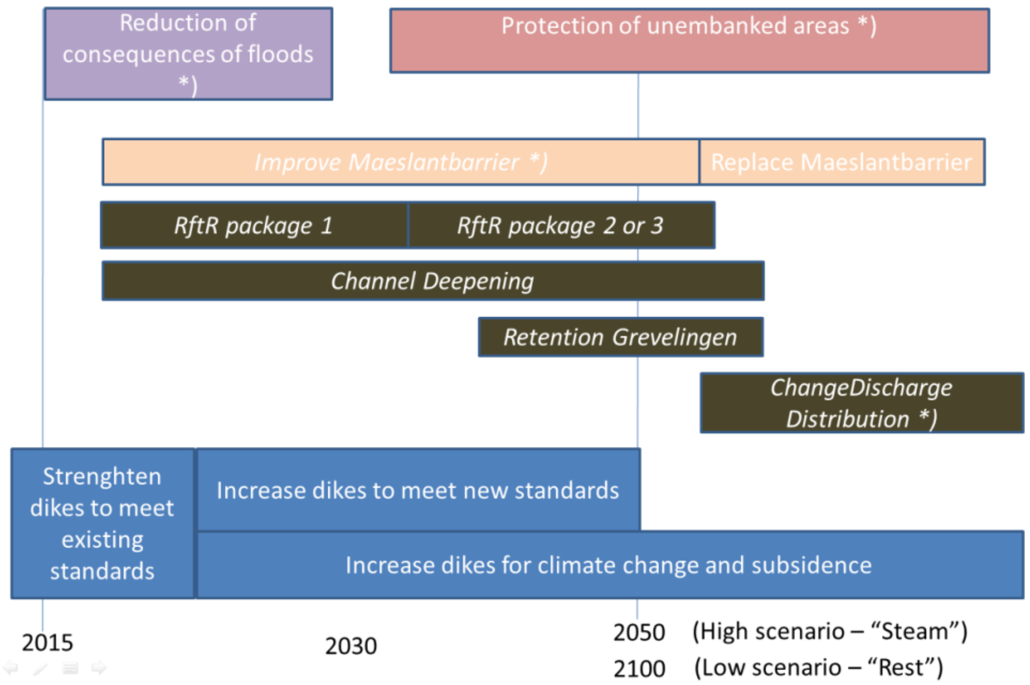


Figure 9: Adaptatation pathway developed by Kind et al. (2014)

The Dutch Delta Programme made a pathway aiming to meet the flood protection standards until 2100. Figure 9 shows that dike reinforcement in combination with room for the river measures will meet the objectives until 2100 under a steam scenario. Under a rest scenario the objectives will even be met until 2150. Already in 2018 a decision will be made about whether or not implementing the measure 'discharge distribution' instead of more dike reinforcements (I&M 2014). Since both alternatives will be effective, this decision will not be based on the 'sell by date'.

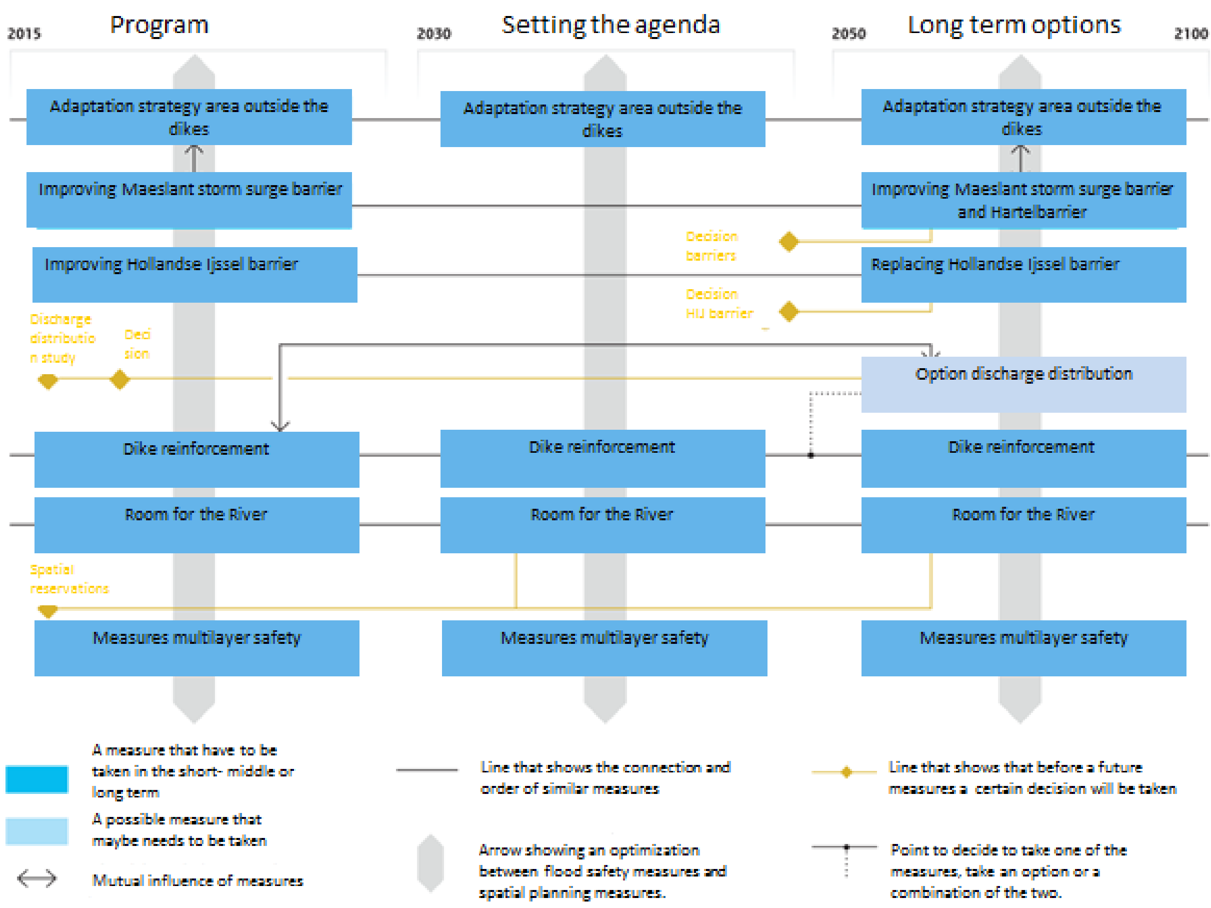


Figure 10: Adaptation pathways developed by the Dutch Delta Program (I&M 2014)

- What would be alternative measures or bundles of measures at these "tipping points"?

As mentioned before we cannot specify tipping points for each scenario due to a lack of information and regulations in the Dutch Water Act. The improvement or replacement of the Maeslant barrier is the only exception.

When comparing figure 9 and 10 we see that the number of potential measures is higher than the measures finally included in the adaptation pathway of the Dutch Delta Programme. Alternative measures could be for example, channel deepening, water storage in the Grevelingen lake and full closure of the 'Nieuwe Waterweg' with dams and sluices. When considering the Maeslant barrier tipping point, the possible alternatives are improvement or replacement of the Maeslant barrier. Improving the barrier entails the same probability of failure as the current design, while replacement involves an upgrade to a lower probability of failure during closing (probably 1/1000). Although around 2070 the Maeslant barrier reaches its technical lifetime, in 2070 the functional life is not reached in a G scenario. Therefore, improvement will be more promising than replacement in a G scenario. In a W scenario the Measlant barrier can be kept as a barrier, but it can also be replaced by a dam or a sluice.

c) Evaluation Criteria and Method

Which evaluation criteria should be used?

- What are the relevant positive and negative properties of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)?

First of all, we consider the investment and maintenance cost of the measure in the evaluation process. Secondly, we include the most important properties that can be affected by the measures. These have been limited to four categories:

- Flood risk
- Fresh water supply
- Disruption of shipping
- Nature

What is the appropriate evaluation method?

- Is it possible to express all relevant cost and benefit criteria in monetary terms?

It is not possible to express all cost and benefit criteria in monetary terms. However, it is possible to express the effects on flood risk and disruption of shipping in monetary terms. Since reducing the flood risk is the main objective of the measures; we will use a cost-benefit analysis complemented by a multi criteria analysis.

What are the preferences of stakeholders regarding the different evaluation criteria?

- Are there different stakeholder groups with varying preferences regarding the evaluation criteria?

Since fulfilling the flood protection standards is beneficial for all people in the region, flood risk is the most important evaluation criteria. A sufficient fresh water supply, which might seem beneficial for all stakeholders at first, is mainly beneficial for agriculture and in lesser extent industry, water companies and the shipping sector. The reason behind is the underlying Dutch policy. During periods of drought water is distributed based on the distribution priority sequence. Stability of the flood defences, the impact of drainage of peatlands, irreversible damage to nature, public water supply and energy supply are highly ranked at this sequence (Helpdesk water 2014). The Dutch drought problems will be not that widespread that there will be not enough water for this highly ranked functions. Therefore, mainly farmers will prefer the evaluation criteria fresh water supply. Concerning the evaluation criteria disruption of shipping, the stakeholders are skippers, skipper organisation and the industry dependent on shipping. The most important stakeholders for the evaluation criteria nature are nature organisations.

- Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion?
  (see BASE Deliverable 4.1, chapter 4.10.2 for guidance for the Swing-Weight method)

Since the multi-criteria analysis is a side analysis, we didn't consult stakeholders or experts to attach weights to the evaluation criteria. Therefore, we base the weights on the above mentioned analogy. We propose to use a weight of 2 for the criterion flood risk and 1 for the other criteria.

d) Data collection

What are the costs and what are the benefits of the alternative adaptation options?

- What potential data sources are available, including damage & impact assessment methods or existing CBA studies on adaptation measures?
- If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?
- How do the adaptation options perform with regard to each of the cost and benefit criteria selected in step 3a?

We will use the Planning Kit DPRD for the analysis of the cost and benefits of the different adaptation options. The Planning Kit DPRD was developed as a decision support tool to evaluate a wide variety of flood risk management strategies. The Planning Kit computes on an annual basis the design water level and dike height, taking into account the effects of climate change and soil

subsidence. For each year, the dike has to withstand the dike height test. When a dike fails this test, the dike is heightened[4]. To determine the amount of necessary dike heightening, a design horizon of 50 years is used, starting from the year of rejection. This means that after heightening, the dike has to withstand the dike height test for 50 years after the rejection, taken into account projections of climate change and soil subsidence (Kind et al. 2014). Since dike reinforcement is not the only possible measure to fulfill the objective, additional measures can be included. For example measures that will lower the design water levels, such as room for the river measures. Incorporating these measures will lower the design water level, causing the dike to pass the dike height test longer. However, measures lowering the design water levels will never make dike reinforcements redundent. The tool determines nominal and present values of all costs of measures and the present value of the benefits of the measures (Kind et al. 2014).

Costs

The planning kit includes the costs of dike reinforcements and the costs of other measures. Therefore, we will first consider the costs of dike reinforcement and then the costs of other measures.

The costs of the dike reinforcements are based on the model KOSWAT (Grave & Baarse 2011). This model estimates cost curves for every dike section. At first the model applies the latest insights in failure mechanisms, after which the costs are determined to heighten the dike. Step by step the dike is heightened with stages of 10 centimetre with a maximum of 2 meter. After every step the model estimates if the dike is high enough to fulfil the flood protection standards. Every step consists of fixed costs and variable costs (depending on which step). The fixed costs include e.g. replacement of infrastructure on the crest of the dike and aesthetic finishing (Kind et al. 2015).

The costs of additional maintenance due to the heightening of the dikes are presented through a percentage of the yearly investment costs. This percentage generally lies between 0 and 0,2 percent. In this analysis, we decided to include a percentage of 0 percent (Kind et al. 2015).

Additionally, we assume that costs increase by 33 percent if a dike is heightened that was already heightened[5] before (Fiselier & Prins 2007).

Costs of other measures are based on estimations of the 'Centre of Expertise on Costs and Benefits' of the Delta Programme (see table 4). We calculate the net present value of the costs with the formula:

NPV = NPV investment * (1+(management and maintenance costs as yearly percent of the investment/discount rate))

Table 4: Costs of measures (different as dike reinforcement) (Prins 2013).

Description	Costs (mln Euro)	Operation & Maintenance costs (% each jaar)
Replacement Maeslant barrier in 2070	956	0,82%
Partial performance Maeslant barrier	20	10%
Room for the River small 1	38	0,77%
Ruimte voor de rivier small 2	545	0,28%

[4] A dike is heightened after a lead time of 15 years. This has been included to accommodate for the time laps between rejection and reinforcement of a dike, due to policy decisions, design of the reinforcements, procurements, etc.
[5] By at least 1 meter

Ruimte voor de rivier small 3	455	0,40%
Water storage Grevelingen	263	0,38%
Local evacuation strategy	3	-
Channel Deepening	98	2,91%
Variant Spaargaren 1 Afgesloten zeezijde bij Maeslantkering	2430	0.03%

Benefits

The Planning Kit computes the expected flood damages in the area on an annual basis. We take the reduction of the expected flood damages as the main benefit. Our flood damage calculation includes:

- Casualities
- People affected
- Property damages (residential properties including vehicles, businesses)
- Infrastructure
- Agriculture
- Utility companies
- Loss of added value due to (temporary) closure of businesses
- Indirect damages

The information on damages and casualities is based on approximately 110 inundation scenarios (Kind 2011). The damage depends on the Delta scenario chosen for the calculation (e.g., Steam or Rest).

We used the value of a statistical life (6,7 million euro) to value the casualities. This amount includes a premium for people injured. We valued the intangible damage of people affected on 12.000 euro per person including a premium for evacuated people (Kind 2011).

Residual value: Measures taken just before 2100 with a remaining lifetime after 2100 lead to increased safety for a certain period before 2100, but also afterwards. Therefore, we calculate the residual risk for the period 2100-2150 for all strategies in the Planning Kit. An important assumption is that in the period after 2100 nothing will change (no further investment, no growth, no increase in the probability of flooding). The expected flood damage for the period 2100-2150 is then also discounted to the year 2015 and added to the estimated flood damage for the period 2015-2100.

What is the evaluation time frame?

The measures can be assumed for implementation at any year in the period 2017-2100. Although dike reinforcements have a design horizon of 50 years, the actual lifetime is longer due to the additional allowance for robustness of 30 cm. The lifetime of a new Maeslant barrier will be 100 years. Also room for the river measures have an expected lifetime of 100 year. However, the lifetime depends on the amount of management and maintenance.

Which discount rate should be applied?

For discounting costs and benefits, we use the 5.5% real discount rate per year, as prescribed by the Dutch government.

How to deal with data uncertainty?

We didn't include uncertainties related to the performance of the measure. However, we included scenarios to show the different performances of the measures. Additionally, we choose different years to implement the measure. Both are influencing the performance of the measure and showing some of the uncertainties decision makers have to take into account.

e) Evaluation and Priorization

What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?

One of the aims of this study was applying a cost benefit analysis to create efficient[6] adaptation pathways. Therefore, we derived the costs and damages of the alternative options from the planning kit DPRD (Kind et al. 2015). The planning kit assumes that the flood protection standards are always met. For example, the reference situation meets the flood protection standards just with dike reinforcements. If another measure is taken, for example room for the river 1, the remaining task is met with additional dike reinforcements. Recall that the estimates including costs of the measure and remaining damages due to flooding, other benefits of the measures such as benefits for nature, shipping or recreation are not considered. See chapter 5d for a more extensive explanation of the planning kit.

The results of the analysis are presented in table 5 and 6. The present value includes cost of the measure (including remaining dike reinforcement) and the remaining damage. We assume that a measure could be implemented at any time. However, we could not estimate the present value for all possible years of implementation. Therefore we estimated the present value for implementing the measure in the years 2030, 2040, 2050, 2060 and 2070. Improvement of the Maeslant barrier is always included in the Steam scenario, because in a steam scenario a tipping point is reached in 2070, while in a rest scenario this is attained much later (Kind et al. 2014).

When comparing table 5 and 6, we see that the difference between the scenarios is approximately 500 million euros. For the 'rest' scenario the costs ranges between 3.03 and 3.81 billion euro, while for the 'steam' scenario it ranges between 3.56 and 4.28 billion. Both the improvement of the Maeslant barrier and the higher difficulty to meet the flood protection standards in the 'steam' scenario may cause this difference. The relative small difference between the scenarios is because in each scenario the majority of the dike reinforcements are needed to meet existing and future flood protection standards (Kind et al. 2014). Room for the river small 1, the reference and channel deepening are in both scenarios the strategies with on average the lowest present value.

Table 5: Present value for scenario Rest in million Euros

Strategy	2030	2040	2050	2060	2070
Reference	3042	3042	3042	3042	3042
Room for the River small 1	3033	3036	3032	3030	3043
Room for the River small 2	3261	3165	3105	3070	3071
Room for the River 3	3257	3173	3110	3086	3070
Room for the River 4	3250	3162	3099	3063	3072
Water storage lake Grevelingen	3129	3102	3072	3055	3054
Full closure with dams & sluices	3811	3543	3322	3209	3150
Channel deepening	3060	3051	3036	3031	3048
Combination of 2+3	3457	3294	3177	3121	3098

Table 6: Present value for scenario Steam in million Euros

Strategy	2030	2040	2050	2060	2070
Reference	3574	3574	3574	3574	3574
Room for the River small 1	3562	3572	3568	3566	3574
Room for the River small 2	3787	3702	3642	3606	3603
Room for the River 3	3787	3702	3645	3611	3603

[6] We define efficient as achieving the goal with minimum effort or expenses. In this case minimum expenses comprise minimum remaining damage.

Room for the River 4	3762	3702	3639	3603	3603
Water storage lake Grevelingen	3619	3608	3580	3565	3570
Full closure with dams & sluices	4282	4074	3837	3716	3678
Channel deepening	3588	3589	3574	3565	3578
Combination of 2+3	3984	3913	3856	3823	3813

Since we want to compare the measures, we deduct the strategies from the reference strategy (see figure 11). The results show that only ‘room for the river 1’ and in some years ‘channel deepening’ are alternatives for the reference strategy. Additionally, ‘water storage Grevelingen’ can be a reasonable alternative in a steam scenario. Notable is that the present value becomes smaller if the measure is implemented later in time. This is due to the high discount rate and the fact that dike reinforcements in the reference situation are always implemented in the year 2032. Figure 11 shows that full closure of the ‘Nieuwe Waterweg’ and a combination of room for the river 2+3 are the least favourable options based on the costs and damage due to flooding.

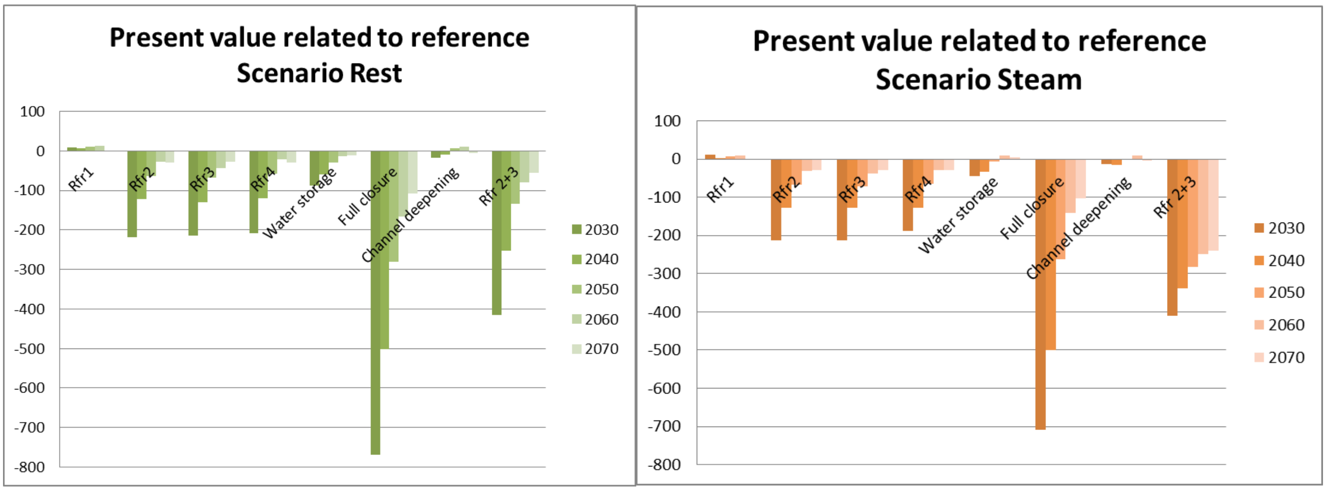


Figure 11: Present value of the measures minus the present value of the reference scenario in million euros for scenario Rest and Steam

Based on the costs and remaining damages of the strategies we are able to analyze the costs and benefits of individual strategies. We distinguish two types of benefits of the measures. First is the reduction in the present value of the cost of dike reinforcements. This benefit arises since investments in dikes are postponed as a consequence of water level reducing measures. The second benefit is the reduction in the present value of the expected damages. This benefit arises only when measures are implemented relatively early, before a dike which has a positive water level reducing effect from the measure has failed the height test. This will lead to temporarily excesses (above the legal standard) in flood protection for certain dikes, and hence to a further reduction of the expected damages (Kind et al. 2014). We calculated benefit-cost ratios by dividing the total of the two types of benefits by the cost of the measures, see figure 12. The results show that room for the river 1 and channel deepening are the strategies with a positive b/c ratio in a rest scenario, while in a steam scenario the b/c ratio of channel deepening decreases and water storage Grevelingen becomes positive. The other strategies have on average really low b/c ratios. Recall that a benefit-cost ratio is a ratio. For example, a benefit of 6 euro and an additional cost of 2 euro result in a ratio of 3, while a benefit of 60 million and additional costs of 20 million euro also result in a ratio of 3. Therefore, the ratios have to be compared with absolute numbers.

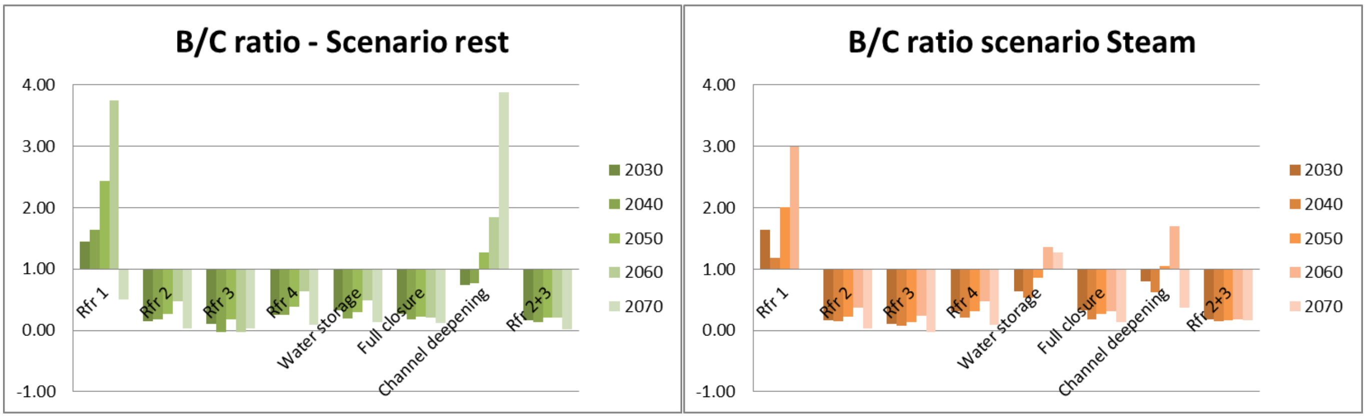


Figure 12: Benefit cost ratio in Scenario Rest and Steam

With these results we made adaptation pathways based on costs and benefits, which may support policy makers in making decisions under uncertainty. These adaptation pathways are not based on the effectiveness of the strategies, since we assume that all strategies will meet the same flood protection standards, but on the costs and benefits to reach the flood protection standards. We consider that the most efficient pathways are the pathways with the lowest present value. Subsequently, the tipping points can be defined as the point where the current management strategy is no longer the most efficient one. Since we did not include all the benefits in the estimation, we do not assume that there is one most optimal pathway. Therefore, we included all strategies differing less than one per cent from the reference strategy. Each year a strategy has the lowest present value, we consider these strategies together as the most efficient pathway. A similar approach was taken for the second and third most efficient pathways.

Table 7: Present value rest scenario in m EUR

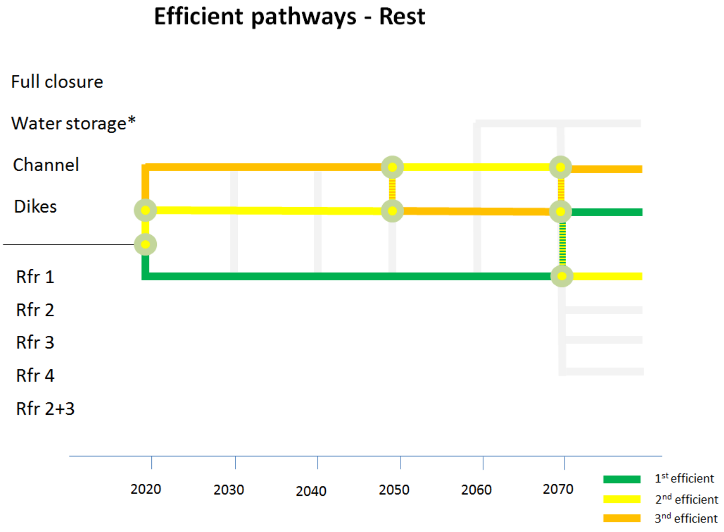
Strategy (rest)	**2030**	**2040**	**2050**	**2060**	**2070**
Reference	3042	3042	3042	3042	3042
Room for the River small 1	3033	3036	3032	3030	3043
Room for the River small 2	3261	3165	3105	3070	3071
Room for the River 3	3257	3173	3110	3086	3070
Room for the River 4	3250	3162	3099	3063	3072
Water storage lake Grevelingen	3129	3102	3072	3055	3054
Full closure with dams & sluices	3811	3543	3322	3209	3150
Channel deepening	3060	3051	3036	3031	3048
Combination of 2+3	3457	3294	3177	3121	3098

Note: The green PVs differ less than 1% different from the reference.

Table 8: Present value steam scenario in m EUR

Strategy (rest)	2030	2040	2050	2060	2070
Reference	3574	3574	3574	3574	3574
Room for the River small 1	3562	3572	3568	3566	3574
Room for the River small 2	3787	3702	3642	3606	3603
Room for the River 3	3787	3702	3645	3611	3603
Room for the River 4	3762	3702	3639	3603	3603
Water storage lake Grevelingen	3619	3608	3580	3565	3570
Full closure with dams & sluices	4282	4074	3837	3716	3678
Channel deepening	3588	3589	3574	3565	3578
Combination of 2+3	3984	3913	3856	3823	3813

Note: The green PVs differ less than 1% different from the reference.



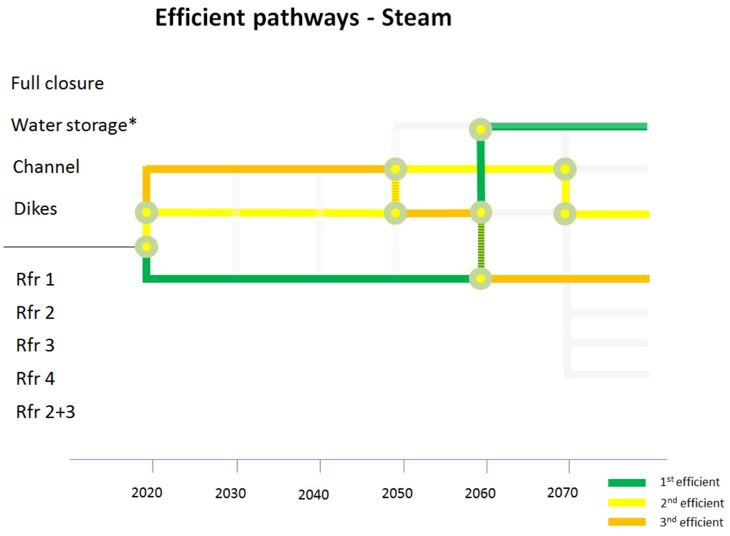


Figure 13: Economic efficient pathways in a rest scenario

Figure 14: Economic efficient pathways in a steam scenario

Figure and Figure show that until 2050 the pathways are the same in both scenarios, after this year the path-ways start to differ. For example, in 2060 in a steam scenario water storage is the most efficient pathway, while in a rest scenar-io water storage is not even one of the three most efficient pathways.

Table 9: The present value in both scenarios (PV in steam plus PV in rest)

Strategy (rest)	2030	2040	2050	2060	2070
Reference	6616	6616	6616	6616	6616
Room for the River small 1	6595	6608	6600	6596	6617

Room for the River small 2	7048	6867	6747	6676	6674
Room for the River 3	7044	6875	6755	6697	6673
Room for the River 4	7012	6864	6738	6666	6675
Water storage lake Grevelingen	6748	6710	6652	6620	6624
Full closure with dams & sluices	8093	7617	7159	6925	6828
Channel deepening	6648	6640	6610	6596	6626
Combination of 2+3	7441	7207	7033	6944	6911

Note: The green PVs differ less than 1% from the reference, the red numbers differ more than 5% from the reference.

The pathways give policy makers an indication of the best options from a perspective of cost and benefits. However, policy makers want to make a decision that they will not regret. Therefore, we combined the two pathways into one pathway. We did this in two ways by just superimposing the pathways on one another (Figure 15) and by summing the present value of both scenarios for each strategy (see Figure 16 and Table 9). Besides showing all the strategies differing less than one percent, we made pathways that show all strategies differing less than five percent from the reference strategy (Figure 17). This illustrates that the differences between strategies become much smaller during time. Finally, we made a pathway summing all the most efficient of the before mentioned pathways. Although the advantage is that the image becomes clearer, the disadvantage is that the good scores of both channel deepening and dikes (reference) are not presented in the image (see Figure 18). Showing just this pathway will provide policy makers with incomplete information, which may result in suboptimal choices. Therefore we state that this type of pathway always have to be shown in combination with preferably pathway combined 2 or combined 5%.

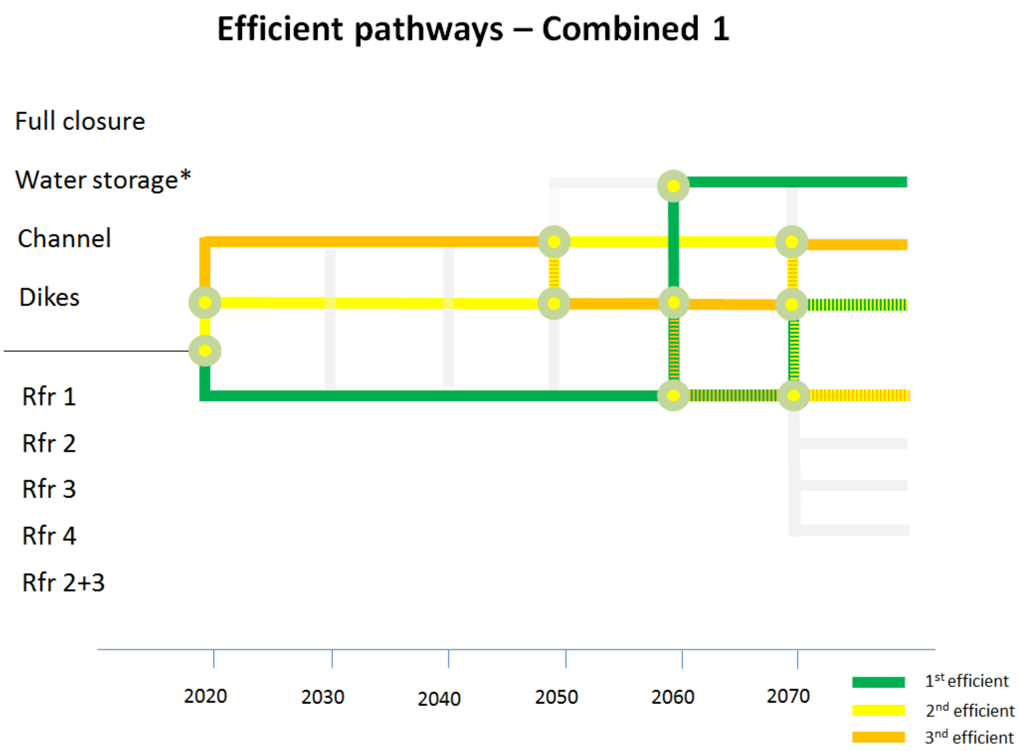


Figure 15: A combination of the most efficient pathways for rest and steam by superimposing the two pathways.

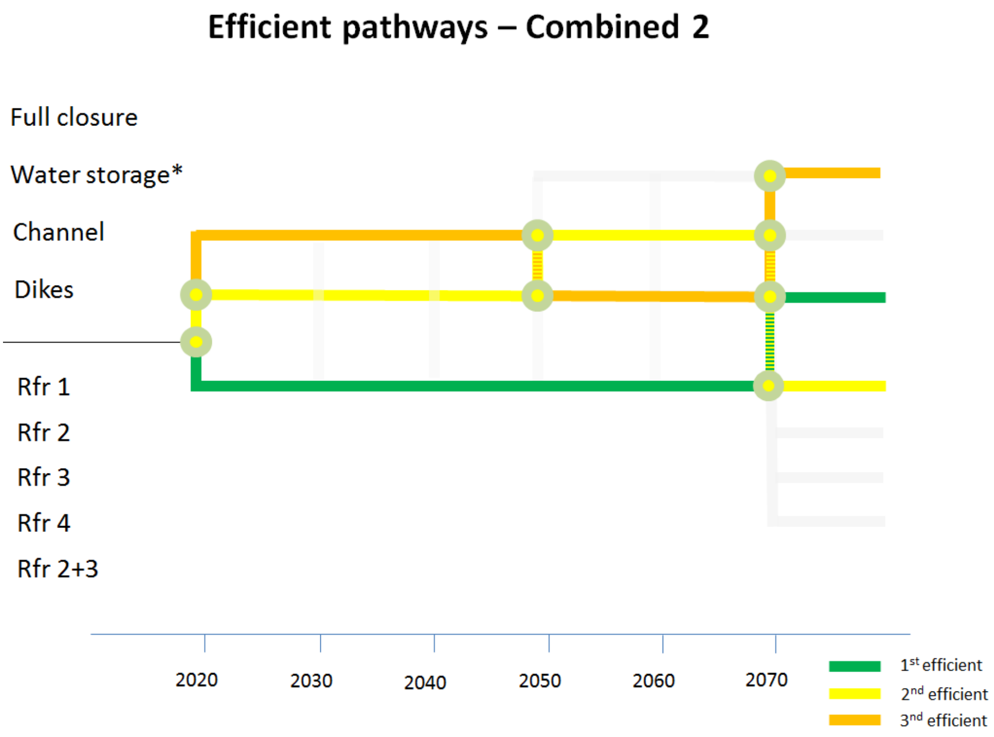


Figure 16: A combination of the most efficient pathways for steam and rest by constructing new patyways from the sum of present values.

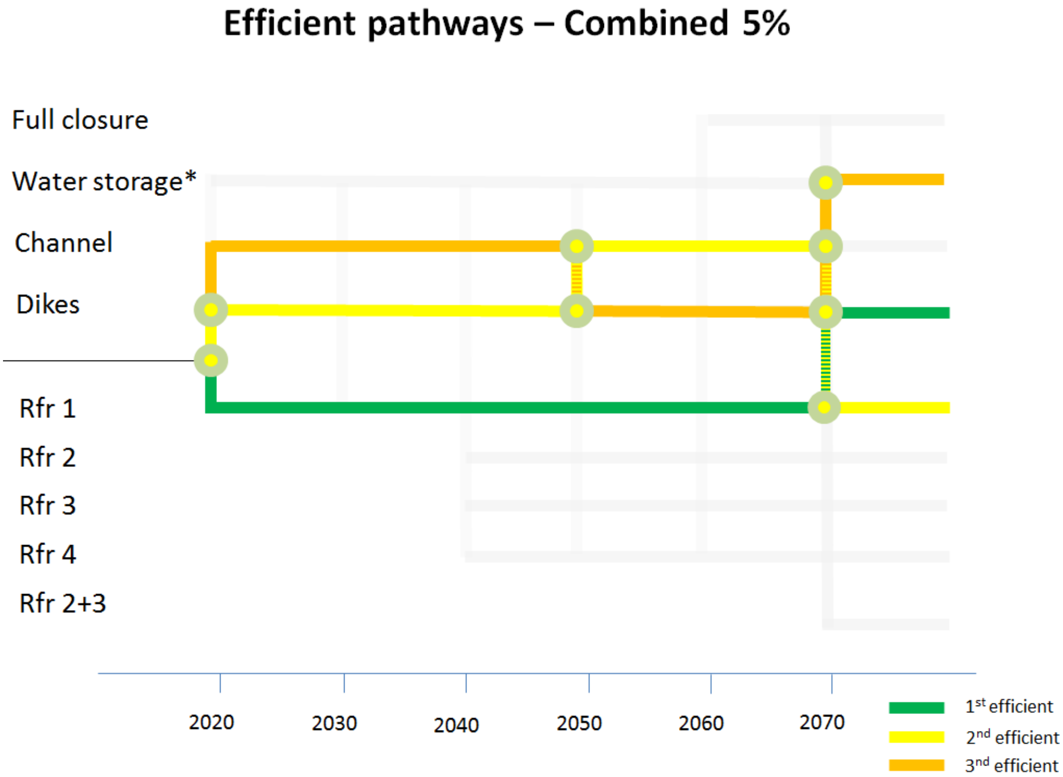


Figure 17: Pathways that differ less than 5% of the reference strategy

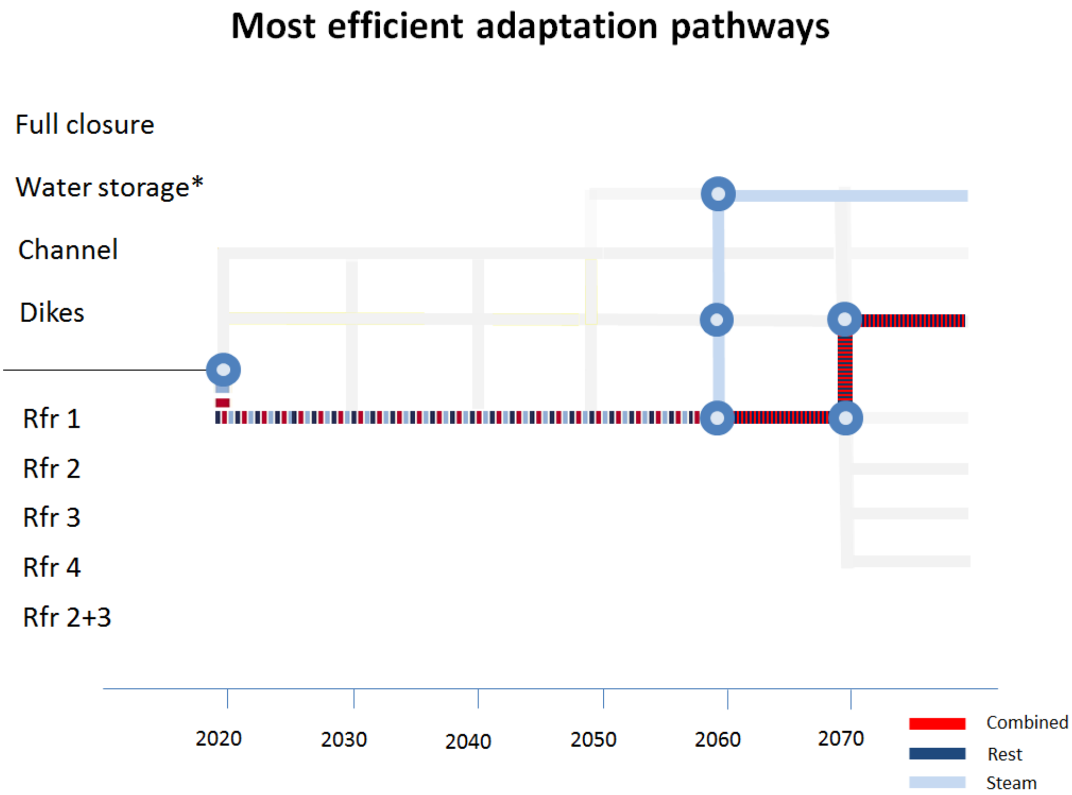


Figure 18: The most efficient pathways according to the analysis.

Decision makers want to make the best possible choice. However, all the possible uncertainty has to be eliminated to make this best possible choice. Since, it is not possible to eliminate all uncertainty, handling uncertainty the best possible way is a good alternative. The efficient pathways help policy makers to better deal with this uncertainty. The strategies having a similar result in both scenarios comprise less uncertainty than others. From the perspective of efficiency, these strategies are more favourable than others. Figure 19 shows that room for the river 1, 2 and 3 and channel deepening have the smallest spread between the scenarios, while water storage Grevelingen, full closure and a combination of room for the river 2 and 3 have a large spread. Although water storage is in the pathways approach one of the more efficient options, considering the wide spread between the scenarios, this strategy is less favourable for decision makers. Since this has to be taken into account, we choose to indicate this with an asterix in the pathway figures.

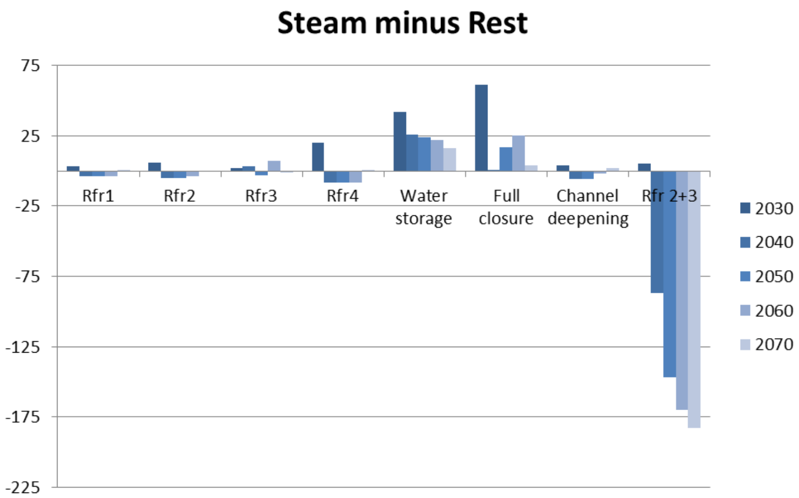


Figure 19: Difference between steam and rest scenario in m EUR.

The pathways are based on costs and avoided damages of different strategies. We did not include benefits different than avoided damages. However, in theory a cost-benefit analysis includes all benefits. Therefore, we conducted a multi-criteria analysis using the program Primate (Figure 20). In this MCA we included effects on ecology and shipping. These effects are based on expert judgments. Since not all the benefits seem to be even as important, different weighing factors are applied. Avoided damage and costs get a weighing factor of 4, while ecology and shipping got both a weighing factor of 1. These factors are also based on expert judgment. The results show that room for the river is still the most preferred option, followed by channel deepening, dike reinforcement and water storage. However, the analysis shows as well that there is a large variety in the rank of the different options. For example, water storage has both rank number 1 and rank number 4. This is probably due to the large spread between the scenarios. The small difference between the results of the cost-benefit analysis and the MCA may be caused by the small difference between the scores on ecology and shipping for the different strategies and by the low weighing factor of the ecology and shipping indicators.

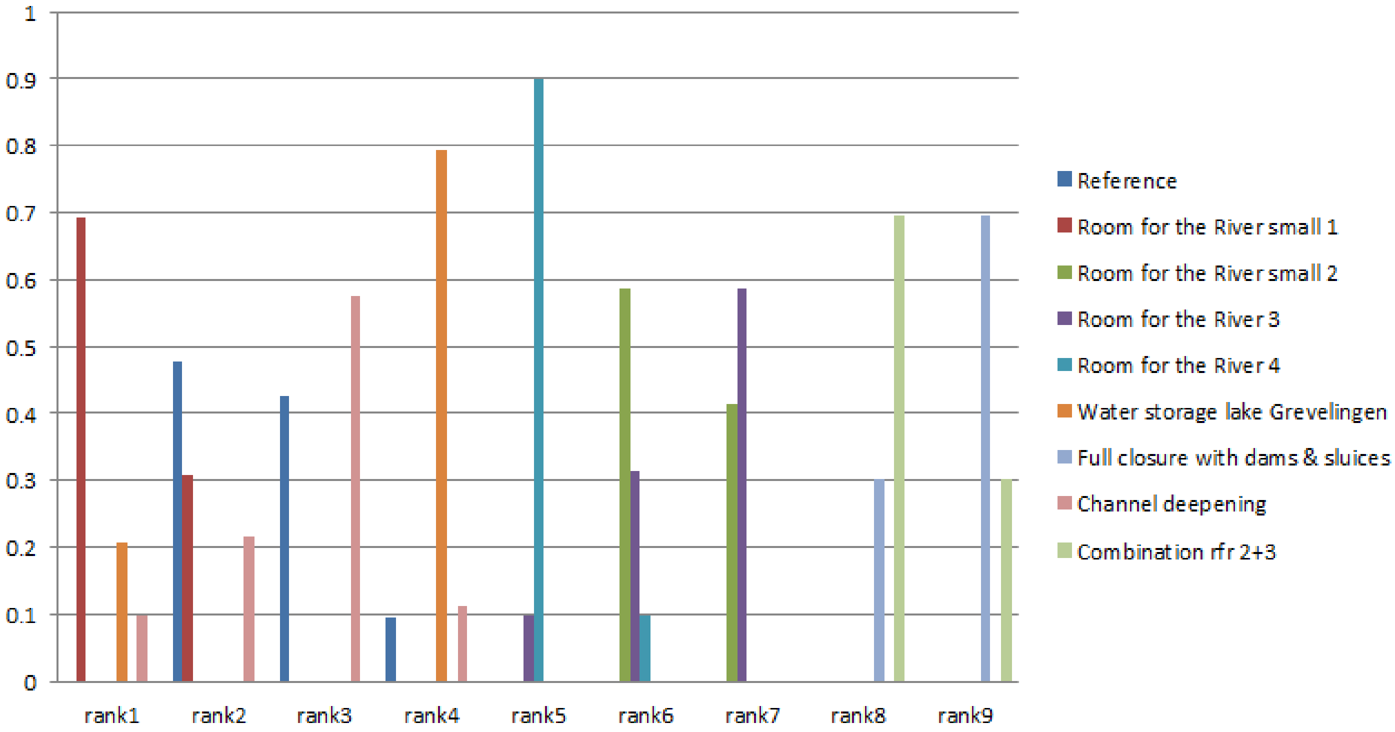


Figure 20: The results from the Multi Criteria Analysis

What are the main lessons learnt from the case study?

Transferable results?

Although, the method that we used is transferable to other case studies, the results are not easy transferable to other areas. The main reason is that the Dutch situation is very different to situations in other countries. The Netherlands has strict flood protection standards and an extensive dike network. Therefore, the proposed adaptation measures and their effect may deviate from flood adaptation measures in other countries. For example, in the Netherlands the costs of dike reinforcement is most of the time smaller than the costs of other measures, while in countries without an extensive dike infrastructure, these measures may be more expensive than other flood protection measures. Although the transferability is limited, some general statements can be made about flood protection measures. For example, the results show that the costs and benefits of other measures than dike reinforcement are nearly always higher than dike reinforcement in the Netherlands. This result can be probably transferred to areas with an extensive dike infrastructure. In addition, even though the results are not easy transferable, the efficient pathways method can easily be transferred.

Feasibility of methods?

The evaluation of costs and benefits with the 'Planning kit DPRD' is a rather new way of estimating costs and benefits of flood protection measures. However, it is based on the basic assumptions of cost-benefit analysis. The construction of efficient adaptation pathways seems to be a simple exercise in a situation with an already existing service level (e.g. flood protection standards). However, the method has still to be optimized and the usefulness has to be demonstrated. The approach of this case study is best applicable in cases with an agreed upon service level.

Important data sources?

The most important data sources in this case study are:

- Costs estimates of dike reinforcements for different years and costs of other measures
- Necessary dike reinforcements to meet the flood protection standards
- Flood damage data including casualties, people affected, property damages, damages to infrastructure, agriculture and utility companies, loss of added value due to closure of businesses and indirect damage.

Recommendation to improve the efficient pathway approach.

The efficient pathways consist of strategies that can be implemented in a certain year, it shows which strategy can be best chosen from a perspective of cost and benefits at a certain year. In addition, it shows which options are relevant for the long term from a cost benefit perspective. The approach does not yet include path-dependency or flexibility of strategies in the pathways. This has to be further investigated. In this analysis we choose to not combine all strategies to make the analysis not too comprehensive. However, we analysed one combination of strategies to test the applicability of the efficient pathway approach. The results showed that combining strategies may higher or lower the costs or benefits more than just the sum of two strategies (see the combination of strategy room for the river 2 and 3). Combination of strategies may add efficient options for policy makers, potentially with lower costs and benefits than the individual strategies. However, a combination of strategies requires a new estimation of the costs and benefits of combined strategies, which also requires creation of new pathways that show the most efficient combination of strategies. Also recall that not all strategies in this analysis can be combined with other measures, for example the strategy 'just dikes' has this limitation. After implementing another strategy than 'just dikes' returning to the former strategy is not possible until at least the year 2100, due to the expected lifetime of 100 year of most strategies.

The efficient pathways consist of all the strategies differing up to 5 per cent from the reference strategy, implying that the performance of these strategies is not significantly different. However, in this early stage of the decision making process the uncertainty margin of the cost and benefit estimation is approximately 30 per cent (Fiselier & Prins 2007). This calls for pathways including strategies differing up to 30 per cent from the reference strategy. However, the costs of strategies include the costs of dike reinforcement needed to meet the current flood protection standards, while this are not costs of adaptation to climate change. In a further analysis these costs have to be deducted from the total costs, which will affect the percentages (and the significance levels).

6. Implementation Analysis – Understanding, Leadership and Governance of the implementation of adaptation measures

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so.

Please answer the following six questions giving specific evidence and examples where possible. In principle all implementation activities should be analysed, i.e. activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW.

To ensure the answers provided are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider. Please read through this checklist and ensure you have discussed in your answers, all those factors that were in some way relevant to the implementation of your case study.

Summary: Checklist

When answering the main questions below ensure you consider each factor listed in the checklist below that might have had a role in the implementation of your case study work. Write in the table how important each factor has been to the implementation of your BASE work and adaptation in general at your case study; where 1 = unimportant, 2 = slightly important, 3 = Important, 4 = Very important, and 5 = Critical). The checklist might not be all-inclusive, so feel free to discuss other factors that are not listed.

Key factors:	Rank from 1 – 5
i. **Knowledge and information about climate adaptation**	5
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	3
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	1
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	3
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	5
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	5
vii. **Resources** (e.g. financial, human)	3
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	3
ix. **Other** (specify ____)	NA

Summary: Information (based on your answers to the questions below)

a) Specify sectors covered (e.g. coast, city, agriculture):
   Flood prone areas in both urban and rural environments along the main tributaries of the Rhine river and along the North Sea coast.

b) Specify adaptation measures covered (e.g. altering cultivation practices, building defences; explain why they were chosen):
Flood defences, room for the river measures, multi-layer safety. Chosen based both on existing practices, economic efficiency, geographic possibilities and constraints and cultural fit in the institutional- and social context.

c) Specify climate change impacts covered (e.g. flooding, heat stress, sea level rise):
Emphasis on flooding due to impacts of climate change on sea level rise and change in riverine discharges.

d) Specify main results of activities (e.g. changes, outputs):
New policy for Dutch water management based on a set of new safety standards and further detailed application of measures such as room for the river and flood defences. IN the case water management at large also changed, as is also reported elsewhere (Van Alphen 2015; Schutlz- Van Haegen & Wieriks 2015).

a) Recent history of adaptation measures and strategies in the Rotterdam case

1.How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! Note: Retrospective case studies will not answer this question, but have to update their answer to question 1 E of this document on the history of adaptation at their case study. (Approximately 500 words)

Climate change adaptation measures and strategies were in 2008 subject of the so-called second Delta committee. The report of the Delta Committee to parliament (Delta Committee 2008) lead to the instalment of the Deltaprogramme. In a broad, joint fact finding process this programme, as explained above, developed strategies on five broad themes and specifically for 6 regions. The region of Rotterdam (Rijnmond-Drechtsteden) was one of the five. In the process there was an iteration from a broad scale problem assessment (with cost benefit of main strategies and more specific measures therein, see Jeuken et al. 2013), to a fine-tuned set of strategies adopted by the regional board, consisting out of both municipalities, provinces, the waterboards and national governmental stakeholders (I&M 2014). This process for developing strategies, and advance adaptation measures was laid out in Van Rhee (2012) and is named 'adaptive delta management' (ADM) (see also: Van der Brugge et al. 2012; Vlieg & Zandvoort 2013). This ADM became the cornerstone of advancing the existing strategies already used in the Dutch flood risk context. Measures include dike reinforcement, Room for the River measures and multi-layer safety (Zandvoort & Van der Vlist 2014). Here the main efforts surrounding the current on-going implementation and barriers for this process are discussed.

For the Rotterdam area, Room for the River measures need to be taken upstream in the Rhine-Meuse delta, to effectively reduce flood risk and projected climate change effects on peak discharges. This is debated in the linked regional Deltaprogramme 'Rivers', which revolves around strategies and measures upstream. Within the process, a constant iteration between both programmes took place by means of joint problem solving and the step-wise approach within ADM. The main activities to coordinate higher level measures influencing the area of Rotterdam came

from the coordinating body of the national programme (the 'staff') and the regional staff responsible for the subprogrammes Rivers and Rijnmond-Drechsteden.

Within the process, a heavy emphasis was put on three main aspects: research, design solutions, and embeddedness in existing governance institutions. The programme heavily focussed on research into the feasibility and cost-effectiveness of both the overall strategy for climate change adaptation within flood risk, and specific measures like closing the Rijnmond estuary in the port of Rotterdam. This research followed the ADM approach and consisted out of modelling studies, renewed calculations of the strength of flood barriers and the cost-effectiveness on a range of societal relevant domains including economic damage and casualties of flooding, fresh water deficit, obstacles for shipping, nature and direct costs of measures (Jeuken et al. 2013; Slootjes & Jeuken 2013). Overall conclusions of the iterative research approach are that the current measures are sufficient to deal with climate change, although tailor-made applications are necessary for local specificities, and that the main strategies depend on both the upstream catchment area (including room for the river projects and altered discharge regimes at the German-Dutch border) and shipping ability when closing the Rijnmond estuary (Jeuken et al. 2013; I&M 2014).

Next to research, early on in the process a design oriented perspective was elaborated as relevant for embedding measures in the local environment. Therefore different design experiments were set-up, and an attempt was made to include design in to cost-benefit analysis (CBA) in the initial problem assessment (Jeuken et al. 2013; Nillesen 2014). While the second, the inclusion of design in CBA came to a halt because significant inclusion of spatial designs in CBA is very time intensive, the first experiments were further elaborated for the Rijnmond-Drechtsteden area. This was done by setting up design ateliers, wherein spatial experts and water management collaboratively with local stakeholders and governmental actors tried out different landscape architecture designs. These initiatives were supported by both the national staff and the Delta commissioner, the regional director and the societal steering group which led to further involvement of landscape architects under supervision of a national atelier team. Amongst others 7 designs for the Architecture Biënnale were created and used to both research how measures could be fitted into the populous and heavily used landscape and to envision the local effects of measures for communication and debate purposes.

The last element the process and implementation was focussed on was the institutional embeddedness and societal acceptability of the proposed adaptation measures and overarching strategy. This was done by two main instruments. The first were so-called 'bestuurlijke tafels' a discussion platform on a regular basis with all different governmental layers and institutions invited to deliver input into the strategy-making process. This enabled a direct link with existing spatial plans (also further elaborated in: Kerkt & Eshuis 2011) and exploration of the (im)possibilities within the institutional context. The second was a societal reflection board with key representatives of different societal groups. This 'maatschappelijke adviesgroep' (MAG) regularly reflected on the strategies, measures, and impossibilities of measures for their stake. This MAG included stakeholders from a range of sectors, including inland shipping, nature NGO's, logistics, industry, residents and was headed by the mayor of Rotterdam (MAG 2013)

By putting emphasis on these three aspects, research, spatial fit, and institutional embeddedness, the strategies and measures were heavily scrutinized and tested for their validity and implementability. Currently, the strategies and future steps within a pathways approach are further implemented.

b) Drivers of implementation

What drives the implementation process and who enables implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (500 – 1000 words)

See for framing of climate adaptation (**factor iii.**) and local and regional context (**factor iv.**) chapter 1, for involved actors (**factor ii.**) chapter 3, the nature of adaptation measures (**factor viii.**) is extensively discussed in chapter 4. This part will mainly deal with the regulatory framework on all levels and the related institutional context (**factor v. and vi.**) and where appropriate knowledge questions (**factor i.**) and resources (**factor vii.**) are included throughout the remainder of this chapter.

The overall strategies are subject of the new national memorandum for water which is obliged under the EU WFD and will be renewed in 2015. The first projects coming out of the adaptation strategy are included in the existing long term programme for spatial projects and the new High Water Protection Programme (hoogwaterbeschermingsprogramma), this programme is part of the overarching MIRT, the 'Meerjarenprogramma Infrastructuur Ruimte en Transport', wherein all large governmental projects for infrastructure, spatial development and transport are described and financial arrangements are provided on a yearly basis.

For the more specific measures (see chapter 4 for specification of the assessed measures: in summary room for the river measures where dike allocation or measures in the river bed are taken, and flood defences with specific configurations for different areas) there are several layers of **institutional governance** relevant. Each of these layers influences the implementation process, either accelerating or decelerating the implementation of adaptation measures. On the national level, the already mentioned national memorandum of 2015 has an important role to put into effect the created strategies and measures that are taken. The Deltaprogramme, which was legally substantiated in 2010, will remain to exist, including the above mentioned institutional and societal steering mechanisms. As such, the regional actors have taken up responsibility to embed the results of the Rijnmond-Drechtsteden strategies and subsequent measures into their policy-making activities and enforcement possibilities. Since the Law for the Delta (deltawet) will remain in effect, all layers of government are bound to implement the national memorandum, and as such implementation is legally enforced. This will have its effect on both regional and local scale.

On a regional scale the **governmental actors** that need to enable implementation of the adaptation measures are provinces and water boards. The first are obliged to include the provisions under the **water law** (Waterwet) into the **provincial 'structuurplannen'**, the main spatial plans. As such, the adaptation measures will take effect in a more integrated spatial vision, since structuurplannen deal with all types of land uses in a descriptive fashion. The structuurplannen have a future oriented perspective and are often development for 2 to 3 decades. They structure the local plans and the investment strategy of provinces, thus enabling or constraining the spatial implementation of the adaptation measures. Next to the provinces, also the waterboards have policy for the regional scale. The main instruments wherein adaptation measures need to be included are the enforcement mechanism for local and regional water systems functioning in both qualitative and quantitative respect. This is structured by means of the 5 year management and operation plan of water boards. However, most of the provisions and **legal boundaries** are also defined by the Water Law. Hence, mainly the national government is responsible for enacting upon the strategy by parliamentary adjustment of the water law or via the national memorandum on water in 2016 (the former national memorandum was amended based on the first results of the Delta Programme in 2014, under EU law the new national water plan will be discussed in parliament in 2015-2016 and become into force for the years 2016-2021).

On a local scale, the municipalities are also confronted with the effects of the proposed measures and strategy for Rijnmond-Drechsteden. The municipalities are primarily responsible for local land use, but this will only come into play if projects are executed out of the aforementioned MIRT. Currently, there is still a **law for spatial planning** (Wet ruimtelijke ordening) which structures the legal provisions for municipalities regarding all aspects surround altered land use. Under this law, the municipality are the sole enforcers of land use change by use of **local land use plans** (bestemmingsplannen). It is via these land use plans most of the spatial effects of measures will have to be sorted out. Furthermore, municipalities have sustainability goals and **local adaptation plans** which need to be streamlined with the other institutional levels. The involvement of mayors and municipalities in the 'bestuurlijke tafels' within the Deltaprogramme RIjnmond-Drechtsteden already led to streamlining sustainability and adaptation plans of municipalities with the strategies and measures proposed in the Deltaprogramme. This is at least visible in the Rotterdam municipal adaptation strategy, which was tailored to the state of the art knowledge and strategies in 2014 (personal communication; Rotterdam 2013). Within the Netherlands, Rotterdam is at the forefront of climate change adaptation via the Rotterdam Climate Initiative. This initiative constitutes all climate related threats and envisages solutions like water plazas, green roofs, sustainable and clean transport and greening the city. For these climate change adaptation measures the municipality of Rotterdam and the water boards are both responsible and the main **driving actors** for implementation. The link between flood defences and room for the river measures on a higher geographical scale is mainly sought via **local pilot projects** in the area outside the primary flood defence (see above), steering instruments for land and water use in the city (subsidies and prohibitions), and active involvement of companies and citizens in creating a sustainable and climate proof city (Rotterdam 2013). As such, there is an active role for municipalities to act themselves, and to use mechanisms to direct companies and citizens in the 'right' way. For the implementation of the larger scale Rijnmond-Drechtsteden strategy, mostly the land use change along the dikes, and the flood bank developments are of direct importance for enabling the implementation of measures by municipalities.

c) Encountered obstacles to implementation

What obstacles were encountered during the adoption or implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

Currently implementation is still on-going, amongst others via a downscaling of the strategies into more local effect studies and programme management in the already described High Water Protection Programme. Based on the concerns of the different regional governments (mainly municipalities in the Rotterdam area), expressed both in a meeting (DPRD 2014a) and via a set of letters (DPRD 2014b) wherein main worries about the strategies for local governance were described, we can identify four main obstacles for implementation of the strategy:

- Responsibility for finance and lead for implementation of measures (**factor ii. and vii.**)
- Unclear effects of measures on local areas (**factor i.**)
- Alteration of existing responsibilities (financial, legal) and instruments (legger, keur) (**factor ii., vi., vii.**)
- (Im)possibilities of legal assurance (**factor vi.**)

As of yet the responsibility for finance as well as the responsibility to lead the implementation of measures is unclear. The current institutional setting is designed based on responsibility of primarily the national government and the water boards regarding the lead and financial arrangements for management and operation of water defence systems. For projects, the secondary benefits lead to (sometimes a substantial) contribution of municipalities or provinces but as the Rijnmond-Drechtsteden programme bureau indicates, this depends on the site-specific characteristics and as such shall be subject of the project studies that have to be executed before any project will take place. The same accounts for the lead on most of the elements of the strategy and implementation of the measures. Lead of main projects on primary flood defence in Rotterdam will resort to the national government, although the municipalities and water boards have far reaching political freedom to take a lead on other topics. For measures within the urban or regional water system the lead, and primary financial responsibility will probably lay at the municipalities and the water boards respectively. This obstacle for implementation depends partly on the current institutional cultural vision that the responsibility for flood risk management is in the hands of the national government and water boards. As Allman et al. (2004) indicate for adaptation options, taking up responsibility and taking the lead in such cases demands at leads sufficient recognition of secondary benefits, active political action, and cooperation among different utilities and groups. In the Rotterdam area this will also demand a cultural change, wherein municipalities and provinces have to assume more responsibility for flood risk management.

The second probable obstacle are the unclear effects of measures on local areas. While the Rijnmond Drechtsteden studies already had some degree of detail in the effects on stretches of dikes and the localities where action has to be taken to cope with future flood risk, the full effects are unclear. In the later implementation of measures the effects might become clearer, however, this enhanced knowledge could both lead to renewed obstacles of financial responsibility or further problems for the actual implementation. Especially in the case of dike reinforcement for water storage, and for room for the river projects the effects could create large obstacles. While for water storage the necessity is less clear (compared to 'normal' dike reinforcement), room for the river measures demand much space and have a larger effect on the municipals jurisdiction. The demand for space, and integration in the existing landscape proofed to be problematic in, for example, the Kampen region along the IJssel (Neuvel & van der Knaap 2010), but was overcome in most of the riverine area by establishing a quality team focussing on both the content and the process of plans (Klijn et al. 2013). These experiences could provide lessons for overcoming obstacles for the implementation of this type of measure.

A common concern of different governments is the alteration of existing responsibilities and instruments. As already indicated, the institutional context in the Netherlands has developed over ages, and both the division in responsibility and the use of instruments know a long history. The experience with instruments such as 'leggers' (consisting of GIS data, hydrological data and detailed data of dike profiles) to enforce the use of dikes, and the maintenance and operation of both dikes and artefacts within the flood protection zone, and the 'keur' (a legal instrument to enforce maintenance of the regional water system), is long standing, and local governments attach great value on these current practices. Also the aforementioned financial responsibility is a concern from a cultural perspective with a dichotomy between spatial planning and water management (Woltjer & Al 2007). With the proposed strategy for the RIjnmond-Drechtsteden, a clear transition is set in for an integration, and thus a shifting division in responsibilities for both spatial planning and water related issues. This could become a vital obstacle for implementation of the measures.

The last identified obstacle is the (im)possibility of legal assurance. This accounts both for governments as well as for shipping. There is a danger of losing property rights for measures including dike reinforcement and room for the

river, of diminished access to water ways (when closing off the delta at the Rijnmond estuary), and of affected business in the Grevelingen if water is actually stored. While these dangers are not prevalent as long as the measure is not taken, the risk without any legal assurance for either civilians, companies or local governments can lead resistance to measures. This is subject of research for the specific projects, but also led to lobbying of the current strategies into specific directions. This mainly accounts for shipping industry for closing of the delta, leading to locks which put heavy costs on the industry in waiting time and inaccessibility. The economic rationale behind the cost-benefit studies also indicate a negative ratio for this strategy, but the port of Rotterdam lobbies for an open Rijnmond estuary (Port of Rotterdam 2011). This indicates that a lack of legal assurance that the same cost benefit ratio for users remain can be an important obstacle for implementing measures. Possibilities to overcome this are fair and generous assurances for citizens, business and governments alike (Susskind & Cruikshank 2006).

d) Overcome obstacles

If any obstacles were overcome, how was this achieved? (Minimum 500 words)

Although measures are not taken yet, the Deltaprogramme Rijnmond-Drechtsteden Bureau already anticipated some obstacles within the strategy formation process. This has to do with two main obstacles: the possible resistance by different stakeholders, and the effects of measures. For the first a participatory approach was taken, both for the strategy formulation, as well as for the integration of measures within the regional and local landscape by using a participatory design atelier. For the effects of measures pilot projects were started, amongst other for the multi-layered safety approach for the unembanked areas in Rotterdam, and for the high densely build up island of Dordrecht. These pilots also took place in a participatory approach with collaboration of different governments, researchers and local stakeholders. As such, both participation and pilots contribute to avoid obstacles or overcome already existing resistance among stakeholders. As of yet, it is not clear if actual implementation will take place, although historical implementation of several measures (dike enforcement, room for the river) proof that implementation can take place.

e) Future prospects for Climate Change adaptation

What are the future prospects of the climate change adaptation activities in the case study? (200 – 500 words)

By using Adaptive Deltamanagement as the underlying approach for creating strategies and determining measures in the Rijnmond-Drechtsteden case, the future is already integrated into the current strategy. The pathways approach (Haasnoot et al. 2013) underlies ADM, and is an attempt to deal in an anticipative way (Vlieg & Zandvoort 2013) with possible future climatic and other changes. In the current standards for dikes, already a robustness factor is taken into account by over dimensioning the height of the dikes and taking conservative assumptions about possible river discharge and storm set-up into the equation. Furthermore the strategy has some capacity to be adapted over time by the pathways, possible leading to upscaling measures, or altering between different measures. For climate change adaptation activities it is also important that via the Delta Programme legislative precedent is created regarding both including climate change prognosis into standards and into budgets for governmental action. As such governments wanting to take future climate change adaptation measures have two hurdles less to take.

f) Key Message

What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (200 – 500 words)

We can identify at least two main messages for other cases regarding the implementation of climate change adaptation measures, and the process design to come to strategies and measures. First is the importance of including simultaneously different layers of government and stakeholders in society. This increased the validity of the current strategy and possibly also the implementation of the measures (See also: Susskind & Cruikshank 2006). The Rijnmond-Drechtsteden case shows that it is possible to bring together, and work together on strategizing for climate change adaptation, at least in the domain of water management. However, as Susskind et al. (1999) indicate, consensus about measures and their implementation demands collaboration of all stakeholders and groups in society. There is still some resistance to the lack of innovation in the Rijnmond-Drechtsteden strategy, especially a highly visible group of engineers scrutinizes the necessity to close of the Rijnmond estuary although they are discarded by the Deltacommissioner based on cost benefit analysis of their proposed solutions. This could become pivotal in the further implementation of the strategy.

The second main message is that underestimated role of landscape, which was put on the agenda in the Rijnmond-Drechtsteden case. Landscape is an essential part of creating policy for climate change adaptation. The attempts to include the quality of the living environment and search for creative solutions by means of design charrettes provide tools that could be used in other cases as well (Nillesen 2014). As demonstrated in the Rijnmond Drechtsteden area, a landscape approach can strengthen the integration of different solutions and provide insight in the larger social costs and benefits of (in)action and is an explicit contribution of the Delta programmes activities in Rotterdam adaptation for both policy studies and practice.

The key message of the economic analysis is that the efficient pathway approach can help to choose an adaptation strategy based on costs and benefits, which also considers climate change and time. The approach is best applicable in cases with an agreed upon service level. The results of the study showed that 'grey' dike reinforcements perform very well from a perspective of costs and benefits, mainly due to extensive dike infrastructure in the Netherlands. Only small room for the river measures in combination with dike reinforcements perform better than dike reinforcements. This shows that performance of a measure is highly dependent on the context of a country.

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