MASTER THESIS

LISA LIEFTINK

# APPENDICES

waternet
waterschap amstel gooi en vecht
gemeente amsterdam

TU Delft

# CONTENT APPENDICES

These appendices are part of the MSc thesis report:
**Pathways for Climate-Adaptive Haven-Stad.**
Spatial Adaptive Policy Pathways approach for
Climate Adaptation Planning in Haven-Stad, Amsterdam.

# APPENDIX BASE

1 INTRODUCTION

2 RESEARCH CONCEPTS

3 RESEARCH SET-UP

# 1

# INTRODUCTION

1.1 Climate Change & Higher Densities

Froma, N. (2015)

## 1.1.1 CLIMATE CHANGE

Over the past years the effects of climate change have become increasingly apparent in the Netherlands. The future is uncertain, but there is a great certainty that climate change will intensify in the coming years. This enlarges the importance to get more insight in the expected trends and the effects on urban environments.

### Dutch Climate Scenarios

The KNMI (Royal Netherlands Meteorological Institute) translates the results from IPCC (Intergovernmental Panel on Climate Change) to climate scenarios for the Netherlands. In 2015 they presented four new climate scenarios, which differ from each other depending on the developments in global temperature rise and the change in air circulation pattern (KNMI, 2015). The changes are presented for the climate in year 2050 and 2085, relative to the climate in the period 1981-2010 (KNMI & PBL, 2015). Although the scenarios differ, certain changes are expected in each scenario:

*Temperature*

Between 1901 and 2013 average temperatures in the Bilt increased with 1.8 degrees Celsius (KNMI, 2015). And it is expected that the temperature will continue to rise, to an average of 1.0-2.3 degrees Celsius in 2050. In addition, there will be an increase in temperature extremes; there will be more mild winters and hot summers (KNMI & PBL, 2015). Figure 1.2 shows the KNMI projections for the temperature increase in winter and summer.

*Drought*

Drought is likely to occur more often in the future, following the trend since 1951 (KNMI & PBL, 2015). The KNMI uses the precipitation deficit as the indicator for drought (KNMI, 2015). Due to higher temperatures (Figure 1.2), there will be more evaporation, as the air can contain more water. Next to that, the total amount of precipitation in summer will probably decrease (Figure 1.3). Less precipitation and more evaporation will result in more precipitation deficits, so more droughts. In addition, the predominant circulation pattern may change, which can result in drier winds from the east.

*Sea level*

Since 1900 the sea level rose by 1.8 mm/year along the Dutch North Sea coast (KNMI, 2015). The sea level is expected to rise faster in the future. The sea level rise depends on the global temperature rise and the KNMI projects an increase between 25 and 80 centimeters in 2085 (KNMI & PBL, 2015). However, when considering more extreme scenarios, the sea level could rise even higher. Figure 1.1 shows the measured and projected sea level at the Dutch North Sea coast.

*Precipitation*

Annual precipitation increased by 26% between 1910 and 2013, in each season except summer (KNMI, 2015). In the future there will be even more precipitation in each season, except from the summer season. Over the full year, including summer, extreme precipitation will increase (KNMI & PBL, 2015). In summer, this is because the intensity of extreme rain showers will be higher. Also hail and thunderstorms will get more intense (KNMI, 2015). Figure 1.3 shows the total measured and projected precipitation amounts in winter and summer.

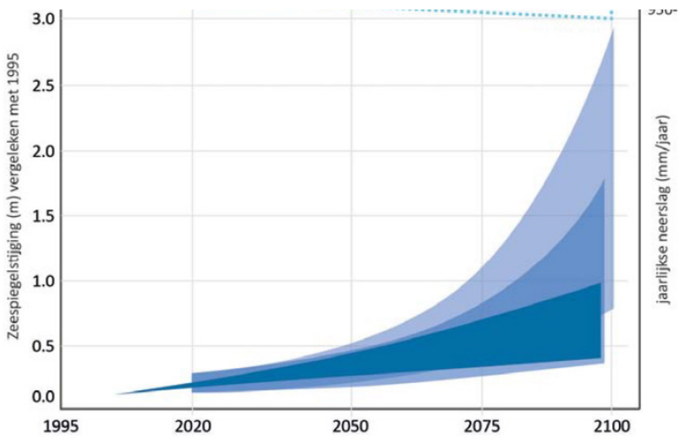



*Figure 1.1*. Projections of sea level rise. Adapted from *"Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid"* (p.30), by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

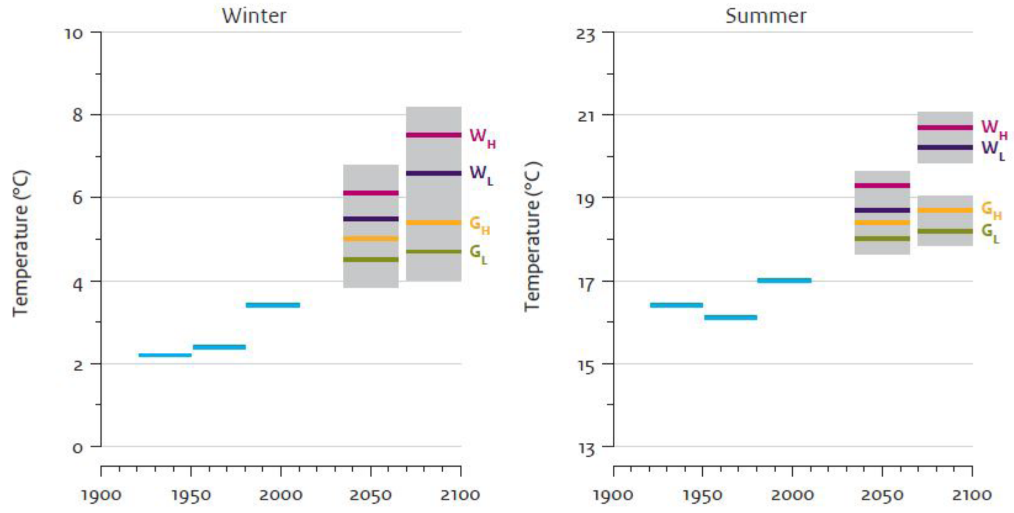



*Figure 1.2.* Winter and summer temperature in De Bilt: observations 30-year averages (in blue), KNMI'14 scenarios (in four colours) and natural variations (in grey). Reprinted from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation"* (p.11), by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

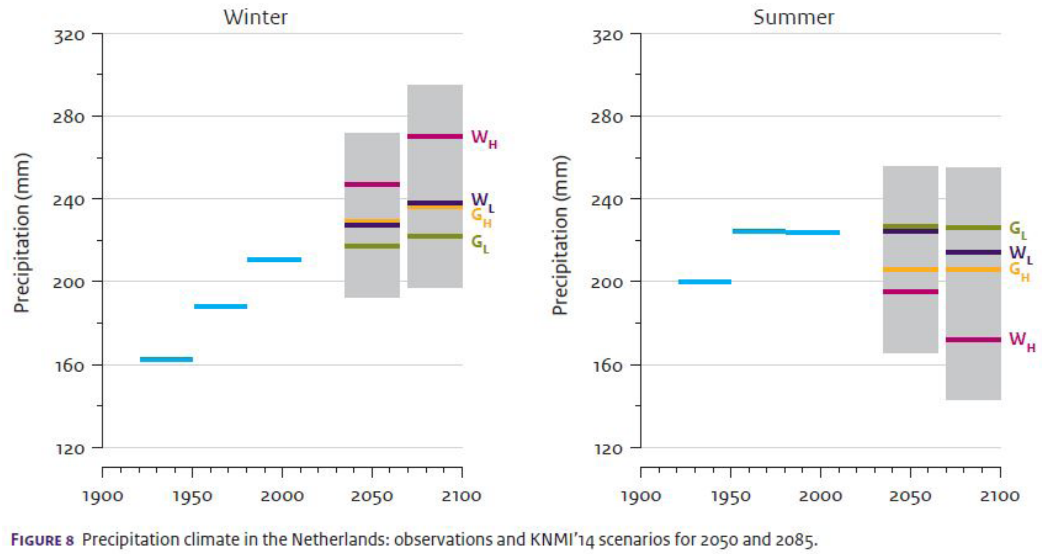



*Figure 1.3*. Precipitation climate in the Netherlands: observations 30-year averages (in blue), KNMI'14 scenarios (in four colours) and natural variations (in grey). Reprinted from *"KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation"* (p.13), by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

## 1.1.2 HIGHER BUILDING DENSITIES

Due to population growth, a growing housing shortage and a space shortage, it is expected that urban developments in the Netherlands will mainly and firstly take place inside existing city boundaries and in high densities.

*Population Growth*

The population of the Netherlands in 2020 is 17.4 million (CBS, 2020). It is expected to grow till 18.5 million in 2050, due to both natural growth and migration. The growth will concentrate in the Randstad, Noord-Brabant and parts of Gelderland and Overijssel, as can be seen in Figure 1.4 (PBL & CBS, 2019). Especially in the big cities, such as Amsterdam, the population will grow strongly. According to the forecasts, it is very likely that this growth in the big cities will not only continue till 2035, but also till 2050. At the same time, the average size of a household will shrink, which means that there is need for even more housing (PBL & CBS, 2019).

*Housing Shortage*

The Netherlands is facing a housing shortage and the demand keeps growing as the population will grow. Especially in the big cities the shortage is major. At the start of 2020 the percentual shortage is 4% in the Netherlands and 7.4% in the Metropolitan Region Amsterdam (Capital Value, 2020). It is expected that there is need for housing for 750.000 households till 2035 (PBL & CBS, 2019). The aim of the Dutch government is to build 845.000 new houses between 2020 and 2030 (Rijksoverheid, 2020).

*Space Shortage*

Space is becoming increasingly scarce in the Netherlands. As explained above, more housing is needed to supplement the housing deficit. But there are more space claims; for instance for the energy transition, for water basins, and for more sustainable agriculture (NOS Nieuws, 2020). Figure 1.5 shows the current and future space claims in the Netherlands. According to researchers of the University of Wageningen, the Netherlands needs 10 percent more space in order to execute all plans (NOS Nieuws, 2020). One of the consequences of this space shortage is that new housing developments will take place, in the first instance, inside the existing city borders (Rijksoverheid, 2020).

*Building in Higher Densities*

Due to the growing housing shortage, agreements have been made to build 75.000 new houses every year (Rijksoverheid, 2018). Due to the space shortage, the first focus is on inner-city housing developments. As space is often also scarce in the exising cities, this will result in the development of high-density neighbourhoods. This means that there will be more high-rise buildings and that more people will live on the same surface area.

*Location Choice*

Important to notice is that the population density is growing fast in the most vulnerable low-lying areas of the Netherlands in the west, while the population is shrinking in the higher lands in the east. This is mainly caused by the concentration of the Dutch economy in the Randstad in the west. However, as climate change increases, the importance of location choice grows.

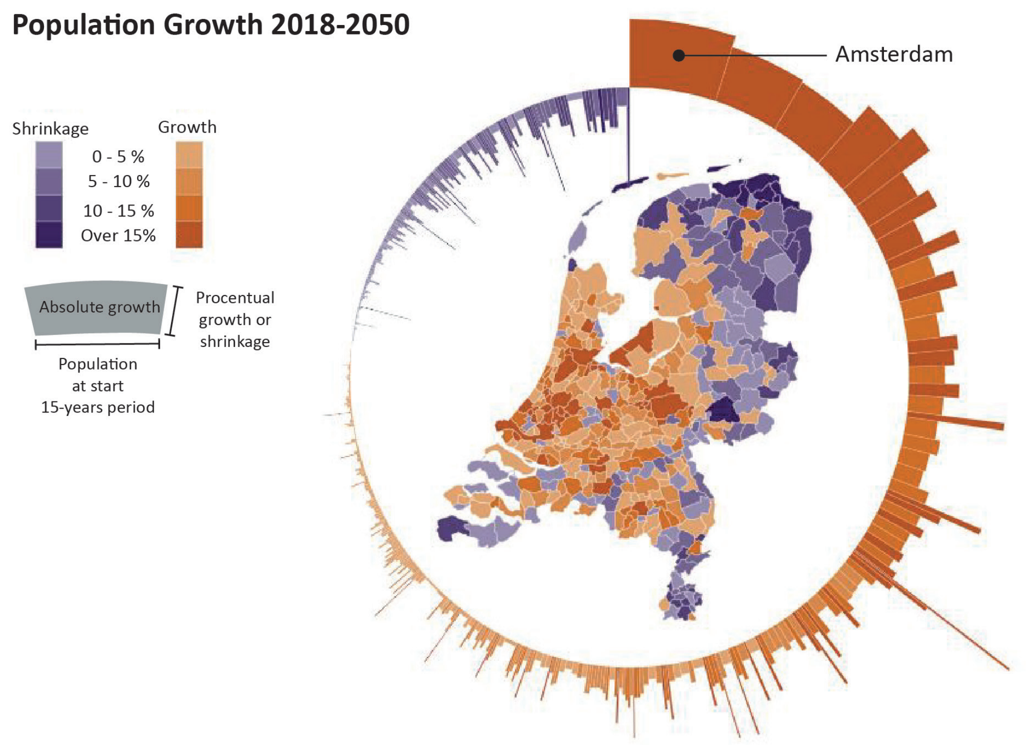



*Figure 1.4.* Dutch population growth 2018-2050. Adapted from “Themasites PBL”, by PBL & CBS, 2019 (https://themasites.pbl.nl/o/regionale-bevolkingsprognose/). Copyright 2019 by PBL.

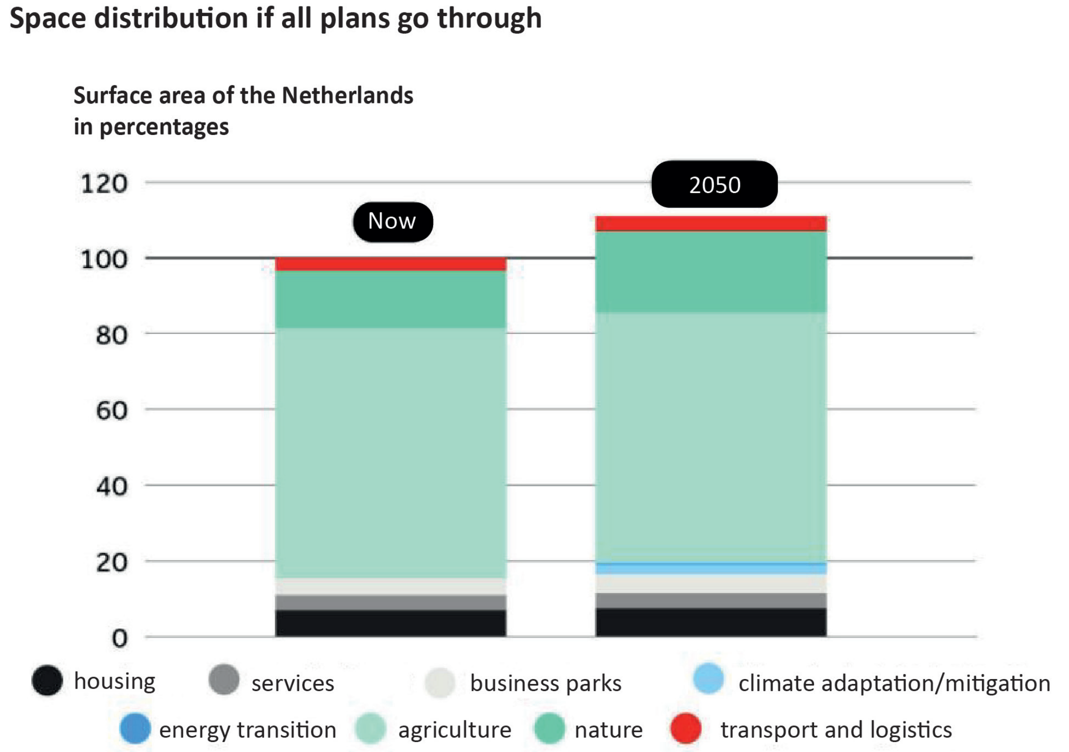
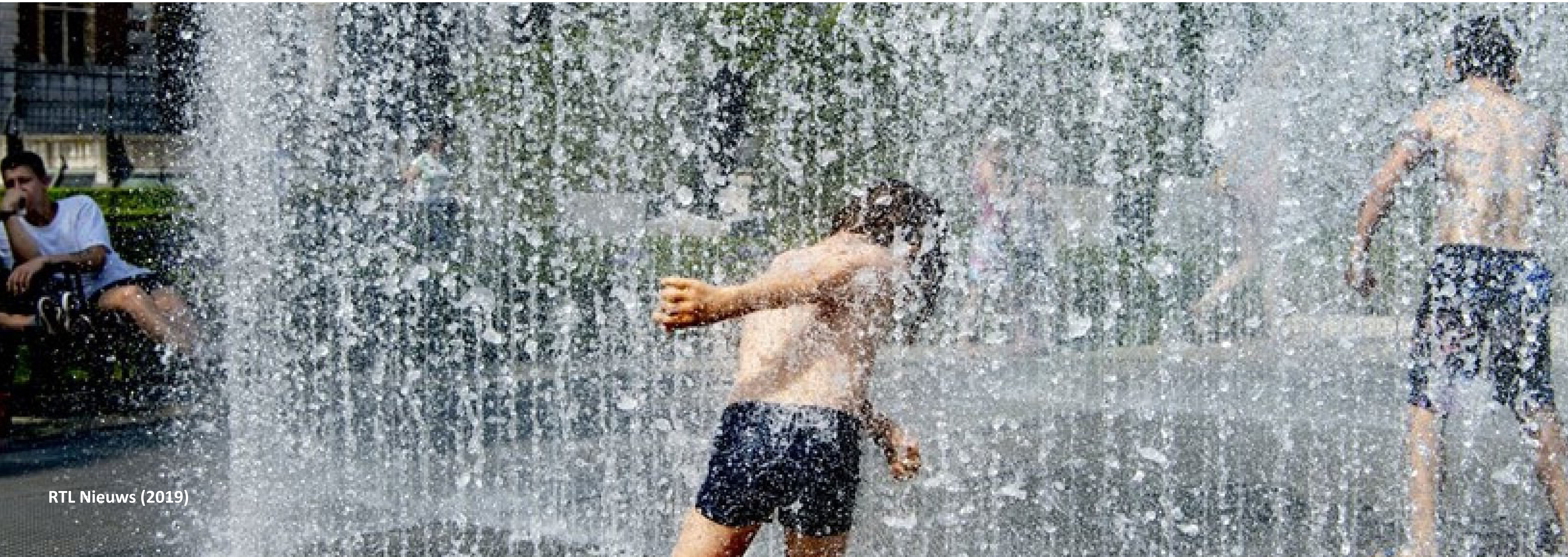



*Figure 1.5.* Space shortage in the Netherlands in 2050 if all plans go through. Adapted from “NOS Nieuws”, by NOS Nieuws, 2020 (https://nos.nl/artikel/2347876-ruimtetekort-in-nederland-minister-gaat-weer-meebeslissen.html). Copyright by Wageningen University.

# 2

# RESEARCH CONCEPTS

2.1 Theoretical Concepts - Academic Paper


RTL Nieuws (2019)

# The Embracement of Uncertainty

Post-structuralism and adaptation pathways
for climate adaptation planning

AR3U023 Theories of Urban Planning and Design
MSc Architecture, Urbanism and Building Sciences,
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**Abstract**
The negative effects of climate change in urban areas are becoming increasingly apparent and the awareness of the need for climate change adaptation is already present (Hallegatte, 2009; Wise, et al., 2014). However, the development of climate change is uncertain, which turns out to be one of the main barriers to the implementation of climate adaptation. To break down this barrier, uncertainty should be embraced by urbanists. One of the paradigms that could play an important role in this embracement is the post-structuralist paradigm. In addition, adaptive pathways could support urbanists in working with climate uncertainties. To develop an understanding of the potential of the post-structuralist paradigm and adaptive pathways for climate adaptation planning, a literature study has been carried out. It has been concluded that both the post-structuralist paradigm and the adaptive pathways have potential to support urbanists to give a place to uncertainty in climate adaptation planning. However, more research is needed to unlock this potential. Future research should focus on the usability of spatial adaptive pathways in climate adaptation planning, and even more important, on the embracement of uncertainty in urban design and planning practice.

**Keywords** - Climate change adaptation; uncertainty; post-structuralism; adaptive pathways; spatial planning



## 1 Introduction

The negative effects of climate change in urban areas are becoming increasingly apparent and the awareness of the need for climate change adaptation is already present (Hallegatte, 2009; Wise, et al., 2014). Climate adaptation can be defined as ‘the process of adjustment in natural or human systems to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities‘ (IPCC, 2018). It is essential to implement climate adaptation to ensure liveability and safety for city inhabitants now and in the future. This implementation is however still not fast and broad enough to keep pace with the climate changes; there exists an implementation gap (Runhaar, Wilk, Persson, Uittenbroek, & Wamsler, 2018; Whitney & Ban, 2019).

Previous research has been done on the barriers to climate adaptation to gain insight into the implementation gap. Multiple authors identified ‘uncertainty of climate change’ as one of the main barriers (Australian Government, 2011; Biesbroek, Klostermann, Termeer, & Kabat, 2011; Biesbroek, Klostermann, Temeer, & Kabat, 2013; Eisenack, et al., 2014; Runhaar et al., 2018; Van Buuren et al., 2013; Weyrich, 2016; Woodruff 2016). Climate change uncertainty can be explained as the lack of certain knowledge about current states and future events (Biesbroek, Termeer, Kabat, & Klostermann, n.d.). It also includes the lack of knowledge about direct and indirect effects of the (changing) climate on other systems, such as the urban and social systems.

The uncertainty barrier should be broken down to make climate adaptation happen and to protect (future) inhabitants. However, the uncertainty itself will not (fully) disappear (soon). Urbanists often work with uncertainties (Balducci, Boelens, Hillier, Nyseth, & Wilkinson, 2011), but as climate adaptation is a fairly new task, approaches are still being sought to address climate uncertainty (Woodruff, 2016). To give climate uncertainty a more emphatic place in spatial planning, urbanists should be able to accept and work with them.

One of the paradigms that could play an important role in the embracement of uncertainty is the post-structuralist paradigm (Dujardin, 2019). This paradigm accepts the continuous existence of uncertainties and interprets it as the task for urbanists to plan for change (Balducci et al., 2011). Adaptative pathways could be an approach to translate the paradigm into a new way of working, as it can be used to design adaptive policies to handle climate change uncertainty (Zandvoort, et al., 2017). The use of this approach is researched in different sectors, but the spatial translation is still understudied (Zandvoort, Kooijmans, Kirshen, & Van den Brink, 2019).

In this literature study, researches and viewpoints about uncertainty in climate adaptation planning are discussed. The aim is to develop an understanding of the potential of the post-structuralist paradigm and adaptive pathways for climate adaptation planning. The study offers some important insights into the uncertainties of climate change, the viewpoints of post-structuralists, and the use of adaptation pathways for spatial planning. Due to limitations in time and words, this essay cannot provide a complete overview of all knowledge, paradigms, approaches, and discussions on this subject.

The remainder of the paper is organized as follows: In the next chapter, climate change uncertainties and their effects on climate adaptation planning are discussed. In chapter 3 an introduction is given to the post-structuralist paradigm and the link to climate adaptation planning. In chapter 4 an exploration is made into the usability of adaptive pathways for spatial planning for climate adaptation. Finally, in chapter 5, the conclusions are drawn.

## 2 Planning for the Future Climate

### 2.1 An introduction to climate change uncertainty

Van Buuren et al. (2013) defined uncertainty as one of the characteristics of climate change. Both the development of climate change itself, as the consequences of climate change are not fully known (Van Buuren, et al., 2013). The magnitude, timing, and sometimes even the direction of the changes is uncertain (Woodruff, 2016).

Deser, Philips, Bourdette & Teng (2012) explain that climate change uncertainty arises from three main sources: Forcing, model response, and internal variability (Deser, Philips, Bourdette, & Teng, 2012). The uncertainty in forcing is caused by incomplete knowledge of external factors. These external factors, such as land use and greenhouse gas emissions, influence the climate system. Model uncertainty is caused by the different responses different models can give to the same external forcing. This is often caused by differences in physical and numerical formulations in the models. In addition, a model is always a simplification of a complex reality, which implies that it will never fully represent this reality. Internal variability is another term for the natural variability of the climate system. This is the variability that exists without the influence of external forcing. It is about the natural processes in the atmosphere, ocean, and the coupled ocean-atmosphere system (Deser et al., 2012).

Stults and Larsen (2018) divided the resulting climate change uncertainties into four different types. These are:

1. Uncertainty in future climate conditions;
2. Uncertainty in climate-related behaviours and political decisions external to the municipality;
3. Uncertainty in climate-related local coping capacity;
4. Uncertainty in effective local responses.

The first type contains uncertainties about the direction of change, the intensity and severity of change, the timing and location of change. The second type is about uncertainties in human behaviour in response to weather or climate. It is about uncertainty in human actions, behaviours, and policies. The third type is about the coping capacity of local communities. This connects to the vulnerability of the community to possible climate changes. The fourth type contains uncertainties about the effectiveness of local responses. It is not fully known what are the best strategies to prevent negative local impacts (Stults & Larsen, 2018).

Figure 1 shows the relations between the main sources of uncertainty (Deser et al., 2012) and the uncertainties resulting from it (Stults & Larsen, 2018). The main sources cause uncertainty in future climate conditions, which can be the source of uncertainty in climate-related behaviours and political decisions. These behaviours and political decisions can influence forcing by influencing external factors. For instance, if a decision is made to forbid all CO2 emissions immediately, the CO2 emissions will go down and will influence the climate system. This change in forcing will again feed uncertainty about future climate conditions.



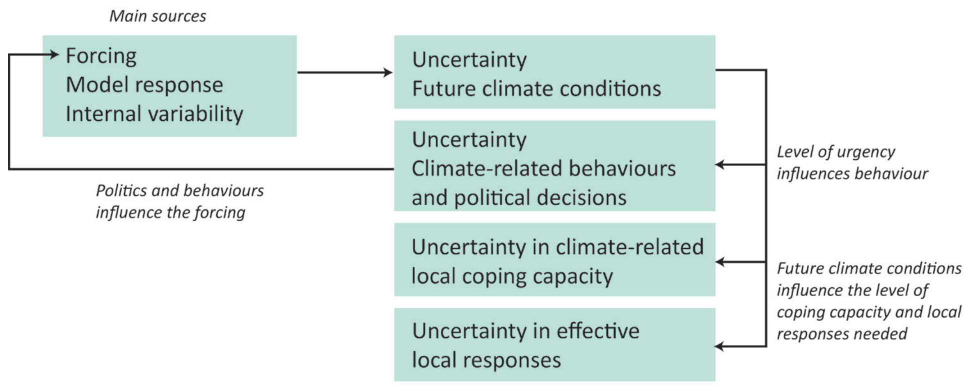


*Figure 1.* Relations between the main sources of uncertainty and the types of uncertainty resulting from it. By author, 2020.

The reports of the IPCC (Intergovernmental Panel on Climate Change) clearly reflect the climate change uncertainties, as climate change is projected in the form of different scenarios (IPCC, 2014). It is important to understand that these projections are not forecasts and that they are based on multiple assumptions about future developments. Figure 2 is used as an example to show how big the uncertainties could be. Figure 2 shows the projections for the global average surface temperature change (relative to 1986-2005) for the highest scenario (red line, RCP8.5) and the lowest scenario (blue line, RCP2.6). The graph shows two important aspects of climate change uncertainty. First, the difference between the highest and lowest scenario is quite significant, especially after 2050. In 2100 this difference is around 3 degrees Celsius. Second, the lines themselves are surrounded by an uncertainty margin (the light red and light blue shading). As the projections go further into the future, this margin grows. For the highest scenario, the difference in 2100 between the lowest projected temperature and the highest projected temperature is around 2 degrees Celsius. To keep these differences of 2 and 3 degrees Celsius in perspective: At this moment in 2020, the goal is to keep the temperature increase below 1.5 degrees Celsius, as it is indicated that an increase of 2.0 degrees Celsius would cause significantly more problems (Koninklijk Nederlands Meteorologisch Instituut (KNMI), 2018). This is only a difference of 0.5 degrees Celsius.

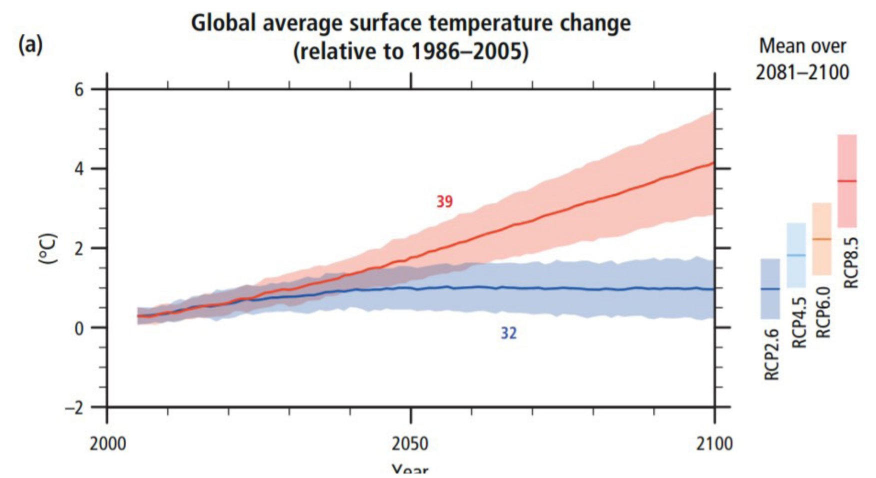


*Figure 2.* Graph of the Global average surface temperature change (relative to 1986-2005) till 2100. Reprinted from *"Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change"*, by IPCC [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], 2014, p59. Copyright 2014 by IPCC.

**2.2 Climate adaptation planning under uncertainty**
As the climate change effects are becoming clearer, the awareness of the need to take into account climate change in decision-making grows (Hallegatte, 2009). Especially decisions with a long-term commitment, such as urbanization plans, can be very sensitive to changes in climate (Hallegatte, 2009). Climate change adaptation is essential to prepare urban areas for current and future climatic threats, and spatial planning is the traditional and logical field to adapt the urban fabric to the climatological stresses.

However, the uncertainty of climate developments makes adaptation planning a lot more challenging (Van Buuren et al., 2013; Woodruff, 2016). It is not fully clear if adaptation measures are necessary, how much adaptation measures are needed, and if the adaptation measures will work as they are planned to (Van Buuren, et al., 2013). In this way, the uncertainties form a barrier to the implementation of climate adaptation (Australian Government, 2011; Biesbroek, Klostermann, Termeer, & Kabat, 2011; Biesbroek, Klostermann, Temeer, & Kabat, 2013; Eisenack et al., 2014; Runhaar et al., 2018; Van Buuren et al., 2013; Weyrich, 2016; Woodruff 2016).

In the Resilience by Design research, multiple problems of current climate adaptation planning in the Metropolitan Region Amsterdam are addressed (One Architecture; Arcadis; Smartland; Climate Adaptation Partners; Over Morgen; University of Pennsylvania; DRIFT of Erasmus University, 2020). And as climate adaptation is a fairly new task, these problems will certainly also apply to other regions and cities worldwide. Firstly, the researchers appoint that long-term planning for climate adaptation is not fully considered in urban developments. Climate impacts are often underestimated, which prevents action and financing of climate adaptation (One Architecture et al., 2020). The time horizon of 2050, which is currently often used, is too short and does not reflect the spatial requirements and financial investments needed to prevent problems in the full lifetime of an urban development (One Architecture et al., 2020). Long-term impacts are not enough considered, which will result in the need for extra investments in the future. These investments will most probably lie in the public domain. In addition, it is not yet fully clear what climate adaptation is and this is reflected in a lack of national and regional policies for climate adaptation. The authors emphasize that big challenges will arise in the future if climate adaptation for the long term is not considered now in area developments (One Architecture et al., 2020).

Woodruff (2016) showed that urban plans often recognize climate uncertainties, but that only a few apply approaches to tackle them (Woodruff, 2016). As the climate uncertainties will not (fully) disappear (soon), it is no option to ignore or avoid them in adaptation planning (Woodruff, 2016). There is a need for new planning approaches that discover, assess, and address uncertainties (Woodruff, 2016). It becomes inevitable for urbanists to embrace, and work with, these climate uncertainties.



## 3 The Post-structuralist Paradigm

**3.1 An introduction to post-structuralism in spatial planning**
Balducci et al. (2011) argue that in traditional spatial planning it is often tried to reduce uncertainties to manage them. For this, planners try to use better models and data, and/or more deliberation. Another strategy is the turndown of strategic directions which interfere with more unknowns. Traditional strategic plans try to ensure pre-specified goals or end-states within a given timeframe. Scientific propositions or evidence are the basis for robust principles and laws, which give body to the plans (Balducci et al., 2011).

Figure 3 shows the matrix of means, ends, and uncertainty by Christensen (1985). This matrix shows four different planning responses and expectations of the government to four conditions (technologies/means are known or unknown and goal/ends are predetermined or open) (Balducci et al., 2011). Balducci et al. explain how traditional spatial planning operates in the box of programming. The plans pre-define the end-goals and the means (technology) to reach these end-goals are also fixed. However, the authors argue that it is not possible to predict the technologies over 15 years or more, which is the timeframe of a strategic spatial plan. They argue that traditional spatial planning fails to deal with uncertainties and the unforeseen (Balducci et al., 2011).

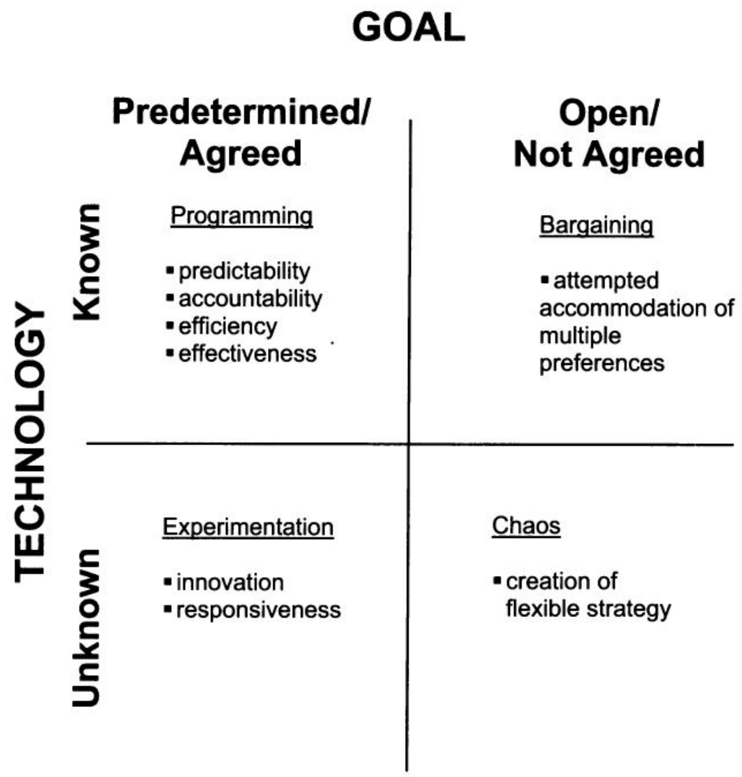


*Figure 3.* 'Expectations of government associated with prototype conditions of and responses to planning problems'. Reprinted from "Introduction. Strategic spatial planning in uncertainty: theory and exploratory practice", by A. Balducci, L. Boelens, J. Hillier, T. Nyseth, & C. Wilkinson, 2011, *The Town Planning Review, 82*(5), p484. Adapted from Christensen, 1985. Copyright 2011 by Balducci et al.

The fact that future means cannot be known, implies the need for spatial planning approaches that embrace uncertainty and incompleteness, and which are experimental and flexible (Balducci et al., 2011). In their paper, Balducci et al. (2011) suggest the post-structuralist paradigm for spatial planning in uncertainty. They argue that post-structuralist spatial planning is more suitable than traditional spatial planning to deal with 'wicked problems' such as sustainability. In the authors' opinion, a post-structuralist frame can support spatial planning; it can help to conceptualize complex urban dynamics and their relations, to accept their openness to chance, and to find their potential to change (Balducci et al., 2011).

One of the main notions of the post-structuralist paradigm is the embracement of uncertainty. Unlike the traditional planner, the post-structuralist planner does not try to predict, or project, a single future. The authors describe it as the task of spatial planners to explore possible futures and forward-looking possibilities (Balducci et al., 2011). To deal with complex conditions, planners should find advantages in working with multiple collaborating actors. In the end, the objective is a working association, which is considered more important than the plan itself. Spatial planners can support decision-making in the present, by the discussion of possible futures and insights into prospective change (Balducci et al., 2011). Post-structuralist planning is about 'encouraging the emergence of particular development trajectories' (Healey, 2008 as cited in Balducci et al., 2011). These trajectories, or pathways, could be followed in a flexible way; goals and means can be adapted to changing conditions. Post-structuralist strategic plans cannot ensure certainty but advise about possible pathways. The authors advocate a combination of short-term and long-term plans. The short-term plans are needed for adaptive capacity and flexibility; to be able to act on unexpected events. In addition, short-term plans can offer some insights for developer investments. The longer-term plans are needed to illustrate the agreed pathways, and should also be able to adapt (Balducci et al., 2011). The main challenge for spatial planning is ''to develop capacities and technologies for turning complexity and uncertainty into strengths for securing progressive social and environmental change' (Frame and Brown, 2008 as cited in Balducci et al., 2011).



**3.2 The post-structuralist paradigm for climate adaptation planning**

The post-structuralist paradigm could connect to the new challenge of planning for climate adaptation, as it embraces uncertainties and advocates flexible, or adaptive, spatial planning. In planning for climate change adaptation, both the goal and the technology are partly unknown (see Figure 3). The goal can be considered open, as it is unknown how the climate will change exactly, which implies that it is unknown to what a city is adapting exactly. The technology is partly unknown because it is not always fully clear which adaptation measures could be used best, and which adaptation measures will be created in the future. This together makes climate adaptation partly a chaotic planning task. According to the post-structuralist paradigm, there is a need for the creation of a flexible, or adaptive, strategy.

Multiple authors emphasize the demand for adaptive spatial planning to work with (climate) uncertainties (Haasnoot, Kwakkel, Walker, & Ter Maat, 2013; Van Buuren et al., 2013; Woodruff, 2016; Rauws, 2017).

Haasnoot et al. (2013) mention the emergence of a new paradigm for planning under deep uncertainties. Their description of this new paradigm matches with the post-structuralist paradigm, but they do not name the paradigm as such. According to the authors, a planner should 'create a strategic vision of the future, commit to short-term actions, and establish a framework to guide future actions' (Haasnoot et al., 2013, p. 485). The plan that results from this is adaptive as it can change over time to cope with changing circumstances, such as climate change. This 'new' paradigm is a reaction to traditional planning in which a static 'optimal' plan is made under the assumption that the future can be predicted. The problem with this traditional approach is that the chances are big that the plan will fail if the future develops differently from the predicted future (Haasnoot et al., 2013).

Van Buuren et al. (2013) agree that climate adaptation needs adaptive spatial planning. They explain that innovation in the spatial planning system is needed to fulfil two ambitions connected to an 'adaptive spatial planning' paradigm. The first ambition is that planning facilitates the socioeconomic ambitions of the society and the second ambition is that planning meets the uncertain climate constraints. The authors advocate an adaptive approach with a central role for learning, experimentation, dialogue, and flexibility. They explain that it is key to find the right balance between a robust and flexible approach. Flexibility is needed to be able to change the plans if the climate developments ask for it. And robustness is needed to secure long-term sustainability and profitability of spatial investments (Van Buuren et al., 2013).

Also Rauws (2017) pleas for an adaptive planning approach in which uncertainty is embraced. According to the author, such an approach 'strengthens the responsiveness of urban areas to both expected and unexpected changes' (Rauws, 2017, p. 32). Rauws (2017) argues that the first and most important focus of adaptive planning is on influencing and creating conditions for development. Attention to content and process comes second. The author emphasizes the fact that planning operates in an ever-changing world, full of processes of evolution and transformation (Tsoukas & Chia, 2002; Byrne, 2005, as cited in Rauws, 2017). As traditional planning instruments are mostly made for stable situations (Albrechts, 2010; Albrechts & Balducci, 2013, as cited in Rauws, 2017) he claims that adaptive planning instruments could complement planning for an uncertain future. In an adaptive planning approach, it is considered important for urban areas to be able to respond and adapt to change. This makes the strengthening of the adaptive capacity one of the main objectives.

In the eyes of Rauws (2017) adaptive planning is about 'influencing the possibility spaces for urban transformation with the aim to support an area in keeping its fit with the dynamic environment' (Rauws, 2017, p.33).

Woodruff (2016) warns that ignoring climate change uncertainty could result in ineffective or even maladaptive adaptation plans and strategies. Therefore, the author claims the importance of an approach in which there is space to discover, assess, and address uncertainty. Woodruff (2016) defines six opportunities to manage uncertainty. The first opportunity lies in acknowledging uncertainty and planning for change. The second opportunity is to focus on sensitivity and adaptive capacity. Sensitivity is defined as 'the predisposition to harm' and adaptive capacity as 'the ability to address impacts' (Frazier et al., 2014, as cited in Woodruff, 2016, p. 454). The third opportunity can be found in the development of no regret strategies. Using a risk framework is defined as the fourth opportunity, as showing the potential damage could motivate funding and political support. The fifth opportunity lies in the creation of flexible and robust strategies, which corresponds to the ideas of Van Buuren et al. (2013) (Van Buuren et al., 2013). The final opportunity is to take an iterative approach. This iterative approach includes monitoring the process and adjusting the planning according to it (Woodruff, 2016).

Adopting the post-structuralist paradigm has the potential to change urbanists' way of thinking, in which they recognize and embrace (climate) uncertainties. All authors discussed in this section therefore advocate an adaptive spatial planning approach. However, it is not yet clear how this approach takes shape in practice. One promising approach to support adaptive spatial planning is described in the following chapter.



## 4 The Adaptive Pathways Approach

**4.1 An introduction to adaptive pathways**

The adaptive pathways approach is a fairly new approach, which was first introduced in an academic paper in 2012 (Haasnoot, Middelkoop, Offermans, Van Beek, & Van Deursen, 2012). Haasnoot et al. (2012) developed and tested this new approach to explore different pathways for sustainable water management in river deltas under uncertainty. They explained the need for this new approach, as planning studies so far (2012) often worked with only a couple of plausible futures and one or two projection years (Haasnoot et al., 2012). This criticism is consistent with the criticism of the post-structuralist paradigm on traditional spatial planning. The adaptive pathways approach connects to the post-structuralist planning paradigm by the focus on the development of multiple pathways, which can be followed flexibly. The end-product of this approach, the Adaptation Pathways map (see Figure 4), is a tool to discuss uncertainty, multiple possible futures, and the deployment of actions over time. The map can also clarify the connection between long-term visions and short-term actions.

The development of adaptive pathways can be summarized in four steps (Van Veelen, Stone, & Jeuken, 2015; Zandvoort et al., 2017). In the first step the system, threshold values, and policy objectives are defined. The threshold values indicate what conditions the system can handle before it fails. For instance, a dike with a threshold value of 5 meters can cope with a maximum water level of 5 meters. In the second step, the adaptation tipping points are assessed. The adaptation tipping points indicate the moments in time at which the system will fail according to the policy objectives. These are the moments in time when adaptation is needed. The adaptation tipping points are based on the thresholds under different (climate) scenarios. In the example of the dike, it is known that the threshold value is 5 meters, but due to climate uncertainties, it is not known when a water level of 5 meters can be expected. That is why different climate scenarios are used. The third step is about the exploration and selection of adaptation measures and policy responses. For these measures and policies, the adaptation tipping points will be defined. In the fourth step, the adaptive pathways are developed and the Adaptation Pathways map is made (see Figure 4). Different combinations of measures define different pathways. These pathways are assessed, for instance with a multi-criteria analysis, and a preferred pathway is selected (Van Veelen, Stone, & Jeuken, 2015; Zandvoort et al., 2017).

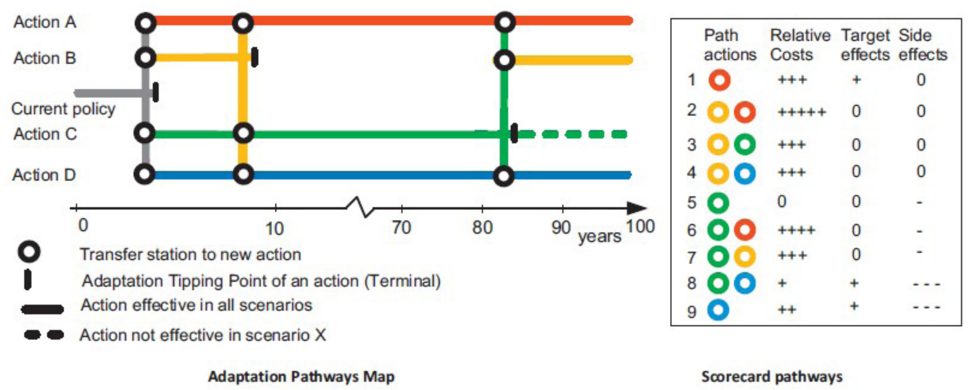


*Figure 4.* 'An example of an Adaptation Pathways map (left) and a scorecard presenting the costs and benefits of the 9 possible pathways presented in the map'. Reprinted from "Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world", by M. Haasnoot, J. Kwakkel, W. Walker, & J. Ter Maat, 2013, *Global Environmental Change, 23*, p. 488. Copyright 2012 by Elsevier Ltd.

Figure 4 shows an example of an Adaptation Pathways map (left) (Haasnoot et al., 2013). On the y-axis, possible actions, or adaptation measures, are listed. The x-axis shows in this case the time, but this can be replaced by a changing condition, for example, sea-level rise in meters. This can be done if it is not known how much a condition will change in time. The figure shows how the current policy (grey) will reach the adaptation tipping point (vertical black line) quite fast. Action A, B, C, and D are options for adaptation. Action A and D should be able to achieve the objectives for the next 100 years; the horizontal lines continue untill 100 years on the map. Action B reaches its adaptation tipping point already after 8 years. This means that it is needed to change policy and transfer to action A, C, or D to reach the objectives. Action C could be sufficient for the next 100 years in a certain scenario (for instance in the lowest climate scenario with the least sea-level rise), but is not sufficient anymore after 80 years in another scenario (for instance in the highest climate scenario) (Haasnoot et al., 2013).

There are five ways in which the adaptive pathways approach could support decision-making under uncertainty (Zandvoort et al., 2017). Firstly, by addressing multiple scenarios and by the selection of multiple pathways, which give a place to uncertainty. Secondly, by the use of objective-based thresholds, which reflect when adaptation is needed to reach the policy objectives. As third, the approach structures the abundance of adaptation measure options. As fourth, the approach can help to identify possible lock-ins. These are actions or policies which eventually do not reach the objectives and which are hard to transfer to other actions or policies. Finally, the approach incorporates the preferences of multiple actors (Zandvoort et al., 2017).



**4.2 Adaptive pathways for climate adaptation planning**

Adaptive pathways could also be applied in climate adaptation planning to give a place to uncertainty. The approach could be used to translate the post-structuralist paradigm into a new way of working. The adaptive pathways map can be a supporting tool to move the conversation from ‘when will the climate change exactly?’ to ‘what is the action perspective on the longer run?’. Although the adaptive pathways approach exists for almost 10 years now, it is not often found in urban design or urban planning research. It can be found in research about climate adaptation, but often without a spatial translation (Van Veelen et al., 2015; Zandvoort et al., 2017).

In this literature review, only one paper has been found in which adaptive pathways are used for spatial planning and in which the pathways are made spatial. In the research of Zandvoort et al. (2019) the adaptive pathways approach is used to make an adaptive landscape design for East Boston (Zandvoort et al., 2019). The researchers endorse that the spatial translation of adaptive pathways is far understudied. In the paper, it is shown how adaptive pathways can be used for spatial design, and how the pathways can be spatially translated. Landscape architecture was chosen as a discipline to test the spatial consequences of pathways (Zandvoort et al., 2019)

As in the standard pathways approach, they first created conceptual pathways to investigate the goals and possible measures. The researchers added a landscape analysis to define the possible effects of the different measures and to get a sense of how these measures could fit spatially in the landscape (Zandvoort et al., 2019). The most interesting is the second step, in which they conducted an iterative design process to explore the spatial implications of the pathways. Through this research-by-design process, the conceptual pathways were refined and tested till they were sufficient enough to add to the final pathways map (see Figure 5). Afterwards, the pathways were made visual, as can be seen in Figure 6. In conceptual drawings, the researchers showed how the landscape could develop over time by adding adaptation measures. In the end, they translated these conceptual drawings to the case study location of East Boston and made a faced implementation map (Zandvoort et al., 2019).

The researchers concluded that it is possible to spatially translate pathways and that these translations can support the decision-making process of policymakers. The addition of spatial design enriched the standard process, as it makes the consequences of pathways more transparent. Moreover, it gives more insight into the feasibility and timing of the implementation of the adaptation measures (Zandvoort et al., 2019).

Although the described research showed the usability of adaptive pathways for spatial landscape design, it is not fully clear what the usability could be for urbanism and climate adaptation planning on a smaller scale. As it is expected that a spatial version of the adaptive pathways approach has great potential to include uncertainties and create adaptive designs, this knowledge gap will be investigated in the associated graduation project. The spatial adaptive pathways approach will be used to develop an adaptive design for the urban water metabolism of the redevelopment project Haven-Stad, Amsterdam.

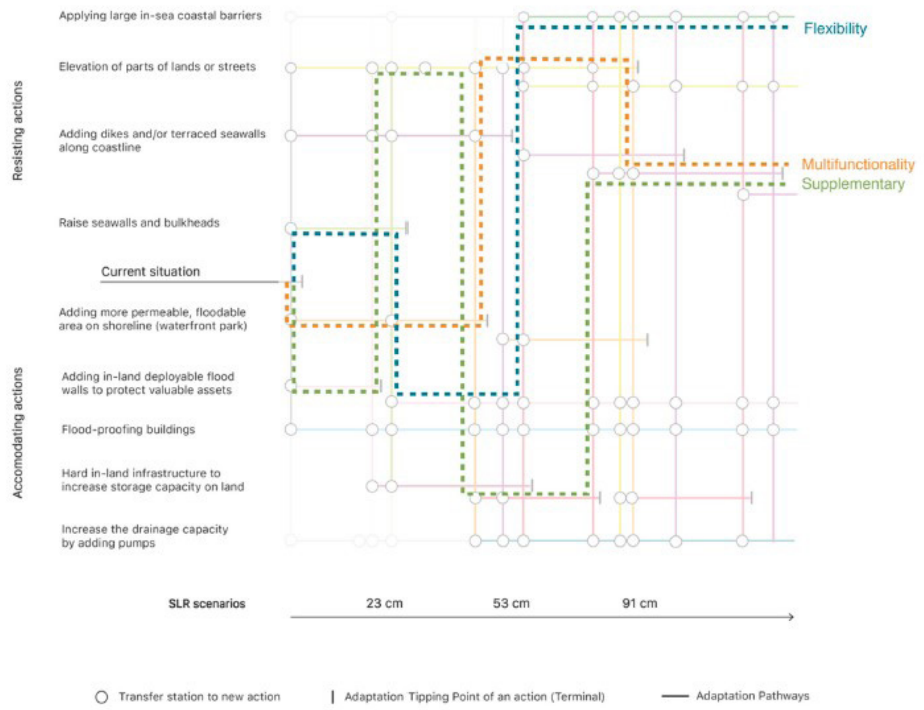


*Figure 5.* The final adaptation pathways map and three different trajectories of change, based on three strategies (flexibility, multifunctionality, and supplementary). Reprinted from "Designing with Pathways: A Spatial Design Approach for Adaptive and Sustainable Landscapes", by M. Zandvoort, N. Kooijmans, P. Kirshen, & A. Van den Brink, 2019, *Sustainability, 11*, p14. Copyright 2019 by Zandvoort et al.

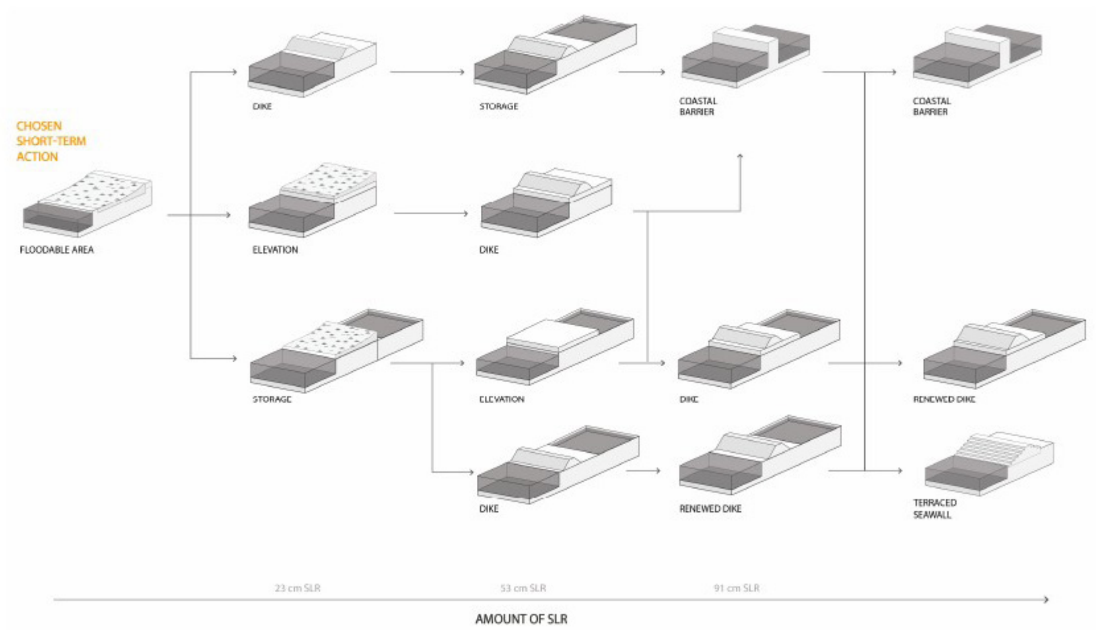


*Figure 6.* Conceptual drawings visualizing the trajectory of change for the multifunctional strategy. Reprinted from "Designing with Pathways: A Spatial Design Approach for Adaptive and Sustainable Landscapes", by M. Zandvoort, N. Kooijmans, P. Kirshen, & A. Van den Brink, 2019, *Sustainability, 11*, p16. Copyright 2019 by Zandvoort et al.



## 5 Conclusion

Climate change adaptation is essential to prepare urban areas for current and future climatic threats, and fortunately, the awareness of the need for this adaptation grows. However, there exists an implementation gap and one of the main barriers to implement climate change adaptation is uncertainty. The uncertainty barrier should be broken down, but the uncertainty itself will not (fully) disappear (soon). To overcome the uncertainty barrier, uncertainty should be embraced by urbanists. The post-structuralist paradigm can play an important role in accepting uncertainty, and the adaptation pathways approach can support urbanists to give it a place in spatial planning.

This paper first discussed climate change uncertainties and the implications for climate adaptation planning. It is explained how climate change uncertainties make adaptation planning a lot more challenging and that it is not an option to ignore the uncertainties. Afterwards, the paper discussed the post-structuralist paradigm, which advocates the embracement of uncertainty and adaptive spatial planning. It is explained how adaptive spatial planning could be used for climate adaptation planning. The adaptive pathways approach is explained and proposed as an approach to translate the post-structuralist paradigm into practice. It is shown how both the paradigm and the adaptive pathways have the potential to support urbanists in climate adaptive planning under uncertainty.

However, there is still a lot to investigate in the future. A first attempt has been made by Zandvoort et al. (2019) to make the adaptive pathways spatial for landscape planning (Zandvoort et al., 2019). However, it is not fully clear what the usability could be for urbanism and climate adaptation planning on a smaller scale. As it is expected that a spatial version of the adaptive pathways approach has great potential to include uncertainties and create adaptive designs, this knowledge gap will be investigated in the associated graduation project.

To unlock the potential, future research should focus on approaches to incorporate uncertainty in planning for climate change adaptation. But even more important is to embrace uncertainty in urban planning practice. To overcome the uncertainty barrier, urban planners and other actors in the urban planning and development process should be open to change their ways of working, to adopt a new way of thinking, and to explore how to plan for change.

**Acknowledgment**
I would like to thank Gregory Bracken for his lectures and feedback. And I would like to thank Kasper Spaan for his review and feedback.

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# 3

# RESEARCH SETUP

3.3 Methods

Driessen, M. (2016)

## OBSERVATION & PARTICIPATION - LIST OF MEETINGS

| Source | Meeting | (First) date |
|---|---|---|
| **TU Delft** | Delta Futures Lab (DFL) meetings | 02/10/2020 |
| | Water Management colloquium | 10/12/2020 |
| | Workshop Urbanism Studio UM&C | 26/11/2020 |
| | Presentation at DFL: Discussion adaptive pathways | 19/02/2021 |
| | Presentation at Water Management colloquium | 10/06/2021 |
| **Waternet** | MRA meetings (basisveiligheidsniveau), 5x | 19/10/2020 |
| | Team meetings 'gebiedsteams' Waternet, 9x | 05/11/2020 |
| | Koppelkansen meetings, 4x | 21/10/2020 |
| | Integrale aanpak openbare ruimte | 29/10/2020 |
| | SKG: NWA-ORC voorstel, 5x | 09/11/2020 |
| | Haven-Stad overleg (+gemeente), 4x | 10/11/2020 |
| | Bijpraten Haven-Stad, 5x | 18/12/2020 |
| | R&D Verdiept - Klimaatadaptatie | 08/12/2020 |
| | Inbo | 25/01/2021 |
| | Presentatie integraal raamwerk Haven-Stad | 28/01/2021 |
| | Risicodialoog waterveiligheid Haven-Stad | 28/01/2021 |
| | Boezemplan 2.0 | 28/01/2021 |
| | R&D Lunch Lecture - Overstromingsrisico's Amsterdam, wat kunnen we er aan doen? | 18/02/2021 |
| | Presentatie thesis bij Waternet gebiedsteam | 18/02/2021 |
| | Analyse waterveiligheid Haven-Stad | 30/04/2021 |
| | Focusgroep generatiefonds klimaatadaptatie | 21/04/2021 |
| ***Other*** | | |
| Wageningen University | Road to CAS (Climate Adaptation Summit; webinar) | 22/10/2020 |
| Metropool Regio Amsterdam (MRA) | Resilience by Design - Presentation results + session 3: De factor tijd bij gebiedsontwikkeling | 05/11/2020 |
| Deltaprogramma | Nationaal Deltacongres (online) | 12/11/2020 |
| KNMI | Op weg naar nieuwe klimaatscenarios | 16/11/2020 |
| Wageningen University | Vandaag beslissen voor morgen: Een toekomstbestendige delta in NL (webinar) | 30/11/2020 |
| Gemeente Amsterdam | Schetsen aan Haven-Stad - Thema Hoogstedelijkheid (webinar) | 26/01/2021 |
| COB, TU Delft, Vereniging Delta Metropool | Stad x Ruimte - Ruimte en transities (online masterclass) | 21/05/2021 |
| Planbureau voor de Leefomgeving (PBL) | Internationale klimaatafspraken - wanneer doet Nederland genoeg? (academy lecture) | 08/06/2021 |
| Royal Haskoning DHV & Hoogheemraadschap van Delfland | Strategie voor een transitie naar een duurzame, toekomstbestendige waterketen in 2050 (webinar) | 09/06/2021 |



## INTERVIEWS - LIST OF INTERVIEWEES

| Type | | Name | Works at... | Function | Date |
|---|---|---|---|---|---|
| **Interviews** | 1 | Lot Locher | Waternet, MRA | Strategisch Adviseur; Programma Manager Climate Adaptation MRA (Amsterdam Rainproof; Samen Klimaatbestendig) | 24/11/2020 |
| | 2 | Rob Koeze | Waternet | Strategisch Adviseur (Nationaal Deltaprogramma Ruimtelijke Adaptatie - Programmateam + Werkgroep gevolgbeperking overstromingen; Programmamanager Adaptatiestrategie Waterbestendig Westpoort) | 25/11/2020 |
| | 3 | Karlijn Kokhuis | Gemeente Amsterdam | Programmaleider Duurzaamheid Haven-Stad; adviseur/onderzoeker duurzame gebiedsontwikkeling | 16/12/2020 |
| | 4 | Wieke Pot | Wageningen University | Assistant Professor | 12/01/2021 |
| | 5 | Mark Koelman | Gemeente Amsterdam | Adviseur Duurzame Gebiedsontwikkeling | 04/03/2021 |
| | 6 | Valerie Deckers | Gemeente Amsterdam | Adviseur Duurzame Gebiedsontwikkeling | 05/03/2021 |
| | 7 | Annebet van Duinen | Provincie Zuid-Holland | Adviseur Klimaatadaptatie (Nationaal Deltaprogramma Ruimtelijke Adaptatie) | 08/03/2021 |
| | 8 | Paulien Hartog | Waternet | Strategisch Adviseur (Nationaal Deltaprogramma Ruimtelijke Adaptatie; Amsterdam Climate Adaptation Strategy; Amsterdam Rainproof) | 17/03/2021 |
| | 9 | Sander van der Wal | &Flux | Impact maker / Strategieen & Samenwerkingen opzetten | 14/04/2021 |
| | 10 | Steven Slabbers | Provincie Zuid-Holland | Provinciaal Adviseur Ruimtelijke Kwaliteit (PARK) | 17/05/2021 |
| **Expert sessions** | 1 | Dr.ir. Jos Timmermans | TU Delft, TBM Multi-Actor Systems | Researcher Delta Management | 08/12/2020 |
| | 2 | MSc. Supriya Krishnan | TU Delft, TBM Multi-Actor Systems | Ph.D. Candidate - Resilience Lab | 08/01/2021 |
| | 3 | Prof.dr.ir Matthijs Kok | TU Delft, Hydraulic Engineering | Professor of Flood Risk | 21/01/2021 |
| | 4 | Dr.ir. Frans van de Ven | TU Delft, Water Management | Associate Professor | 21/01/2021 |
| | 5 | Dr.ing. Mark Voorendt | TU Delft, Hydraulic Engineering | Researcher and Lecturer of Hydraulic Structures | 09/07/2021 |
| | 6 | Dr.ir. Nico Tillie | TU Delft, Landscape Architecture & Urbanism | Researcher and Lecturer of Urban Ecology & Ecocities Lab | 14/07/2021 |

***Appendix 5.3***
*For the summaries of the interviews*

## INTERVIEWS - INTERVIEW FORMAT

The interview format was set up to structure the interviews. However, as the interviews were semi-structured, sometimes different themes and questions came up during the interview. Questions were also adapted to match the interviewees expertise. In the interview summaries, the most important questions and answers are mentioned (Appendix 5.3).

*Note:*
Interview number
Name and function
Date and time

*0. Toelichting & Consent*
- Voorstellen
- Toelichting afstudeerproject, doel interview
- Vraag of het interview opgenomen mag worden
- Maak afspraken over de verwijzing naar de persoon en het opsturen van de samenvatting voor controle

*1. Organisatie & Persoon*
- Functie
- Afdeling
- Samenwerken met andere afdelingen

*2. Rol organisatie voor klimaatadaptatie*
- Definitie klimaatadaptatie
- Rol van de organisatie, moet/gaat rol veranderen?
- Invulling taken voor klimatadaptatie

- Ruimtelijke schaal
- Tijd schaal
- Betrokkenheid bij gebiedsontwikkeling
- Verandering ruimte/tijdschaal nodig?

*3. Samenwerking met andere organisaties*
- Samenwerkingspartners
- Rollen andere overheidsorganisaties voor klimaatadaptatie
- Verantwoordelijkheid voor hitte/droogte/wateroverlast/overstromingen
- Hoe en wanneer samenwerken
- Afhankelijkheid van elkaar

*4. Uitdagingen voor klimaatadaptatie*
- Grootste uitdagingen voor klimaatadaptatie
- Barrieres (intern/extern)
- Conflicten/spanningen/discussies
- Verschillende ruimteschaal/tijdschaal/verantwoordelijkheden, speelt dat mee?

*5. Suggesties voor aanpakken uitdagingen*
- Oplossing voor genoemde uitdagingen
- Conflicten/spanningen oplossen
- Aanbevelingen voor samenwerking
- Factoren die klimaatadaptatie bevorderen of voorbeelden van goede samenwerking

*6. Afsluiting*
- Tips voor andere interviews of bronnen
- Melden dat samenvatting voor check nog wordt opgestuurd



***Appendix 5.3***
*For the summaries of the interviews*

# APPENDIX ANALYSIS

4 HAVEN-STAD & CLIMATE CHANGE

5 CLIMATE ADAPTATION GOVERNANCE

# 4

# HAVEN-STAD & CLIMATE CHANGE



**By author (2021)**

## BUILDING DENSITY & TYPOLOGY

Haven-Stad will be a high-density urban area. The plan is to build 40.000-70.000 houses for 150.000 inhabitants and 45.000-58.000 workspaces on 650 ha (Gemeente Amsterdam, 2017). Figure 4.1 shows the rough calculation of the FSI values for different neighbourhoods in Haven-Stad. The FSI is the ratio between the floor area developed (including multiple floors) and the terrain area. A building with a floor space of 100 m2 (divided over 4 floors), on a terrain of 50 m2, gives a FSI-value of 100/50 = 2.

Figure 4.2 shows the building typology for Haven-Stad (Gemeente Amsterdam, 2017). The base plint is 8-10 meters and will contain workspaces and services. On top the main function will be living; this base block will have a maximum height of 30 meters. In each neighbourhood there will probably be towers till 60-80 meters and on special locations incidental towers till 150 meter (Gemeente Amsterdam, 2017).

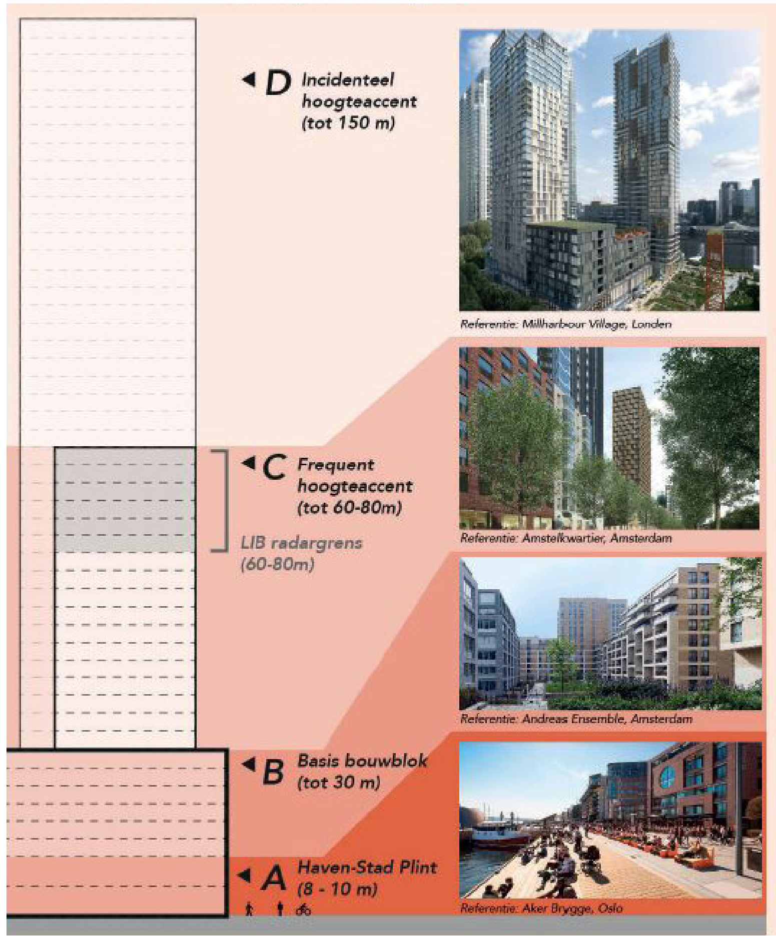



***Figure 4.1*** Building typology for Haven-Stad. Reprinted from *"Ontwikkelstrategie Haven-Stad. Transformatie van 12 deelgebieden"* (p.56), by Gemeente Amsterdam, 2017, Amsterdam: Gemeente Amsterdam. Copyright 2017 by Gemeente Amsterdam.

| Neighbourhood | Area [m2] | Floor area [m2] | FSI-value |
|---|---|---|---|
| Sloterdijk Centrum | 756000 | 1058264 | 1.4 |
| Sloterdijk I | 532000 | 1122000 | 2.1 |
| Zaanstraat | 86500 | 182000 | 2.1 |
| Minervahaven | 434000 | 1162000 | 2.7 |
| Sportpark Transf. | 70700 | 188000 | 2.7 |
| Alfadriehoek | 200000 | 520000 | 2.6 |
| Cornelis-D 2-3 | 255000 | 960000 | 3.8 |
| Cornelis D 0-1 | 316000 | 690000 | 2.2 |
| Melkweg Oostz. | 290000 | 146600 | 0.5 |
| Coen + Vlothaven | 620000 | 1540000 | 2.5 |

***Figure 4.2***. FSI values in Haven-Stad.

# 4.2 CLIMATE STRESSES

## HEAT

### Vulnerability

*Relative*
Figure 4.3 shows the Urban Heat Island (UHI) effect in and around Haven-Stad. The UHI is the average difference in air temperature between the urban areas and surrounding rural areas. These higher temperatures in the city are caused by high percentages of paved area, high densities, and a shortage of open water and green (Gemeente Rotterdam, 2013). The figure shows two important things. Firstly, the north side of Haven-Stad is cooler than the south side, probably due to the proximity of a cooler rural area further north and a cool air flow from the river (the dominant wind direction is south-west).

The south side is probably warmer because of the greater area of pavement and the proximity of the dense and hot inner city and hot harbor area. Secondly, the figure shows the cooling effect of local green and water. The UHI effect is less (around 0.6 oC) in the Westerpark in the south due to the amount of green (more evaporation and shading). The Noorder-IJ Lake and the surrounding park in the north have the same cooling effect. Also the areas adjacent to the river are cooler than the surroundings.

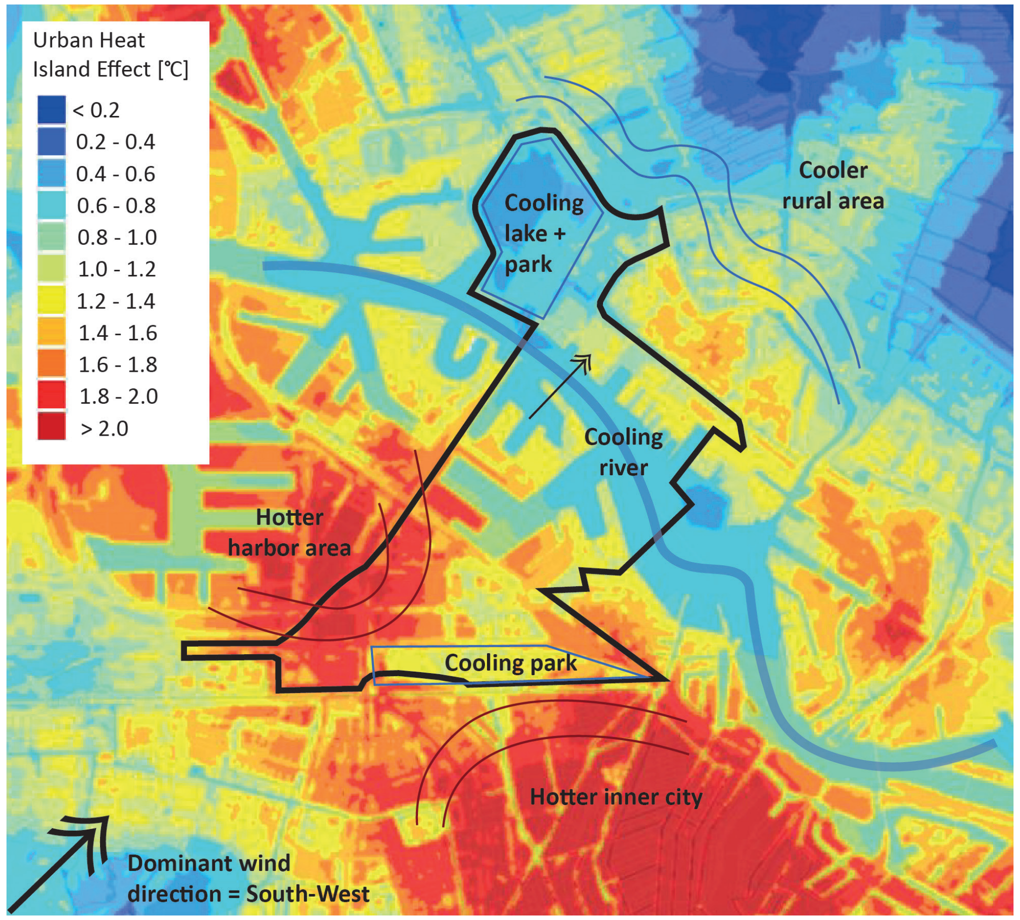



*Figure 4.3*. Urban Heat Island Effect. Adapted from "Atlas van de Regio", by PBL, n.d. (https://themasites.pbl.nl/atlas-regio/kaarten/index.php). Copyright by Geodan.

*Absolute*
Figure 4.4 shows the average wind chill temperature (PET) on 1 july 2015 between 12:00 and 18:00. The RIVM selected this day, as it is a representative for a 1:1000 heatday for the summer period April till September. In the current climate the chance of such a day is once in 5.5 years. The wind chill temperature is used as indicator for the influence of heat to human health and is a better indicator than the air temperature (Gemeente Amsterdam, n.d.), as shown in Figure 4.3 . A PET between 29-35 oC gives moderate heat stress, a PET between 35-41 oC gives big heat stess, and a PET above 41 oC gives extreme heatstress (RIVM, 2019). Figure 4.4 shows that the wind chill temperature can rise till 46 oC Haven-Stad. The local parks are again way cooler, with sensible temperatures between 34-37 oC.

This is a difference of almost 10 oC. However, the cooling effect of the river water is less for the wind chill temperature than for the UHI. The UHI map shows an average air temperature difference over the year, while the wind chill temperature map shows the wind chill temperature on one single summer day. It could be that there was also no wind on the hot summer day, reducing the cooling effect of the water. The figure also shows that wind chill temperatures are higher around higher building densities. This can be explained by the fact that there is more material to absorb and radiate the heat, there could be a blockage of (cooling) wind flow, and there is less space for water and green.

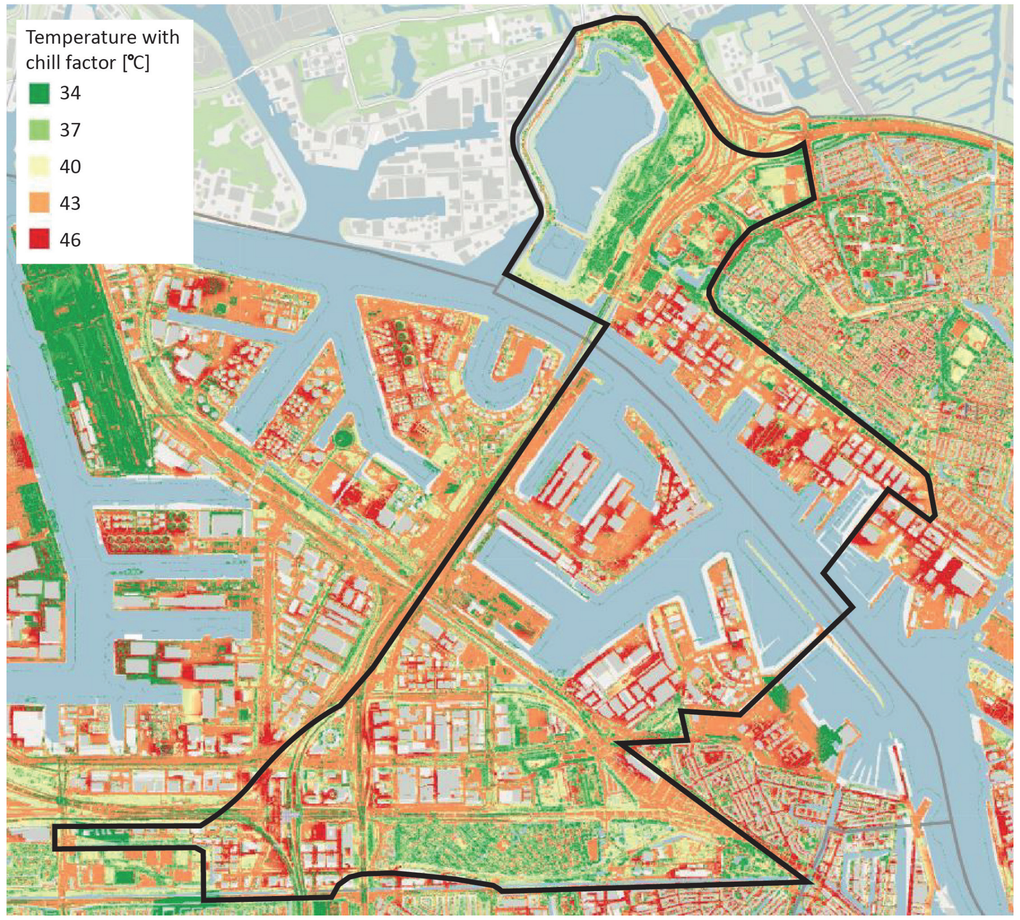



*Figure 4.4.* Average wind chill temperature (PET) on 1 july 2015, 12:00-18:00. Adapted from "Maps Amsterdam Klimaatadaptatie", by Gemeente Amsterdam, n.d. (https://maps.amsterdam.nl/klimaatadaptatie/). Copyright by Gemeente Amsterdam.

# 4.2 CLIMATE STRESSES

*Warm nights*

During the day, urban areas absorb the heat and this heat is slowly dissipated during the night. The city cools down slower than the rural areas, as the building materials and pavement retain the heat much stronger than for instance green fields. The temperature differences are therefore often higher during the night (Gemeente Rotterdam, 2013). Figure 4.5 shows the amount of warm nights (> 20 oC) per year in the urban areas of the Metropolitan Region of Amsterdam.

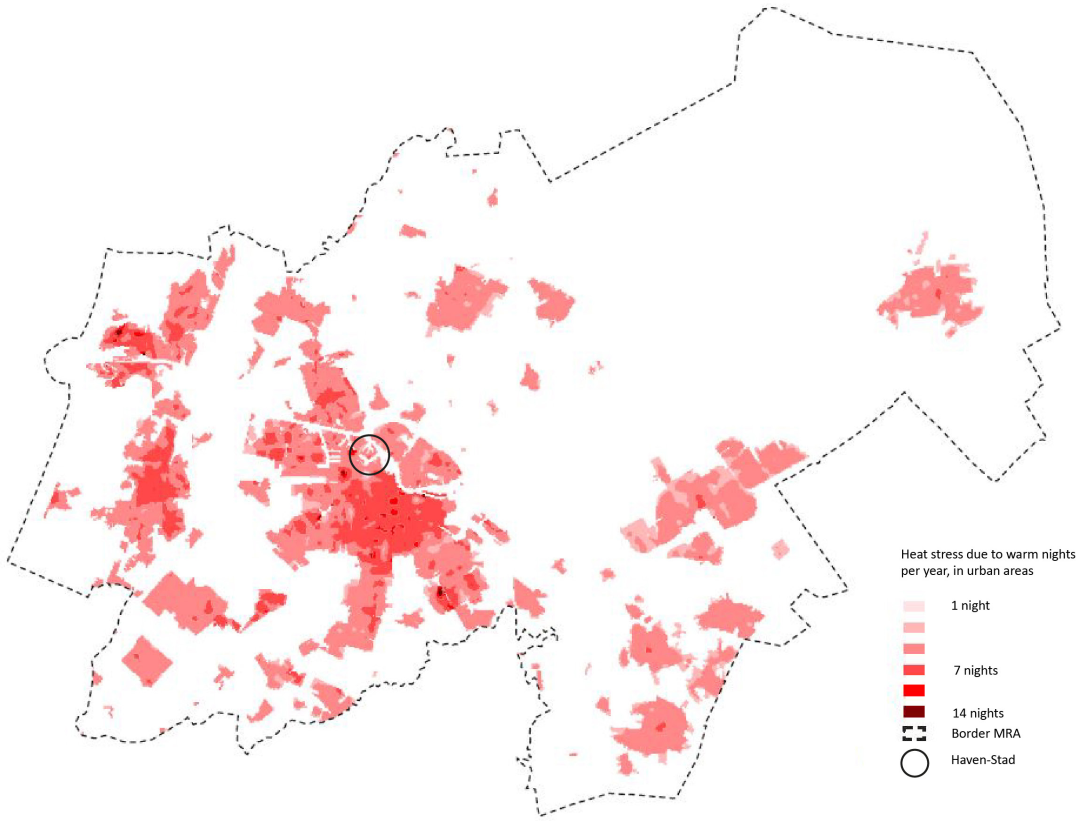



***Figure 4.5**. Heat stress due to warm nights per year in urban areas. Reprinted from "Quickscan Kaartenatlas. Klimaatbestendige, vitale en kwetsbare functies Metropoolregio Amsterdam"* (p.40/41), by Must Stedenbouw, 2018, Amsterdam: Must Stedenbouw. Copyright 2018 by Must Stedenbouw.



## Consequences

Heat can have negative effects on people, nature, and technique. Public health and liveability are for instance affected by heat due to more heat stress, a decrease of night rest, and increases in air pollution (Gemeente Amsterdam, 2020a; Gemeente Rotterdam, 2013). Warm weather can also lead to higher surface water temperatures, which influence the water quality and which can lead to the growth of algae and botulism (Gemeente Amsterdam, 2020a; Gemeente Rotterdam, 2013).

Nature and biodiversity are affected by the changing growing seasons and surface water temperatures. In addition, technical infrastructure and installations are affected. Extreme heat can cause energy blackouts and ICT failures, and warm summers can cause melting asphalt and failing bridges. Due to the higher air and water temperatures, the energy demand for cooling will increase. Figure 4.6 shows the consequences of heat for the sector 'the built environment and spatial planning' as defined in the NAS-adaptatietool (Ministerie van I&W, 2016).

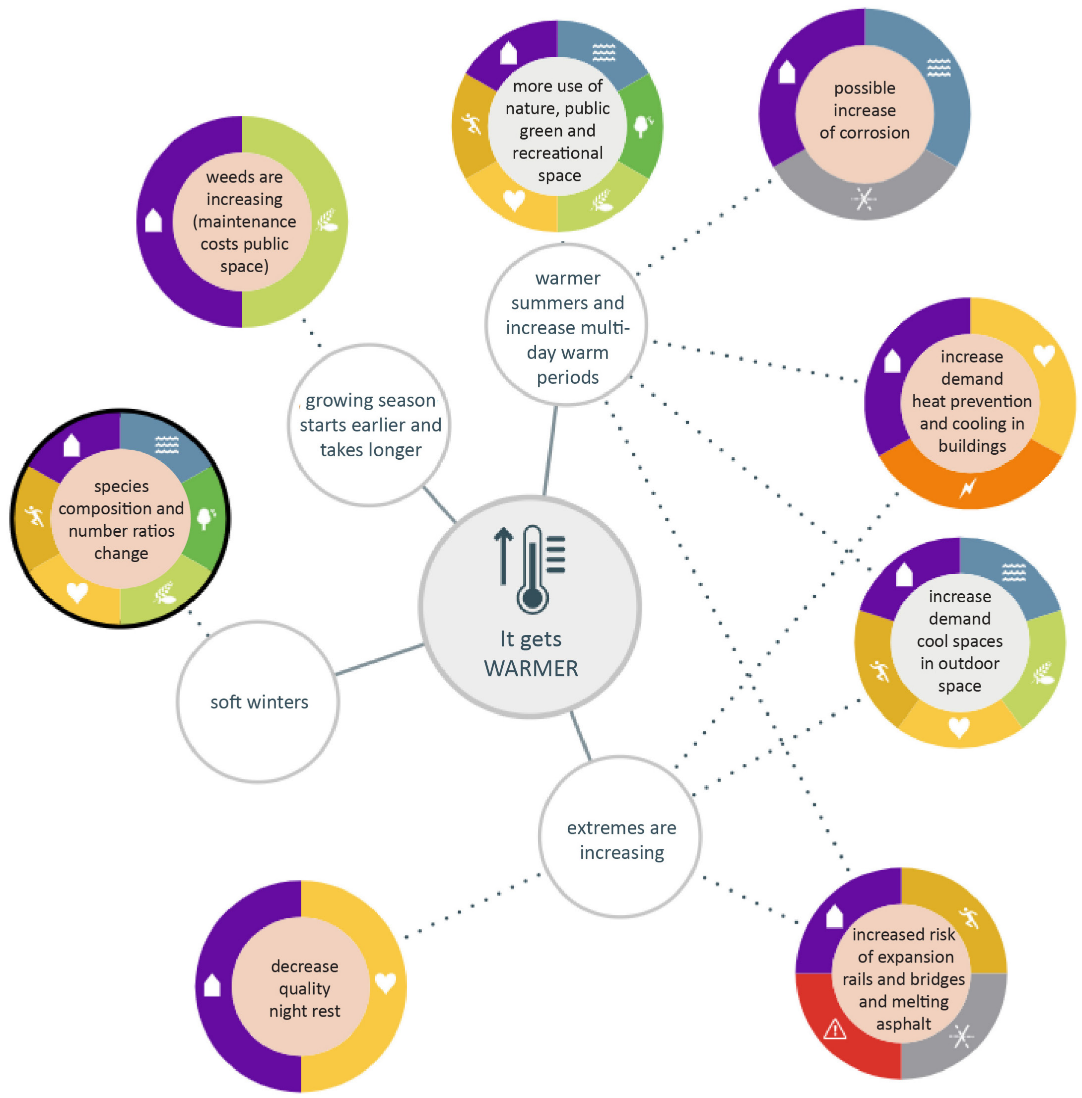


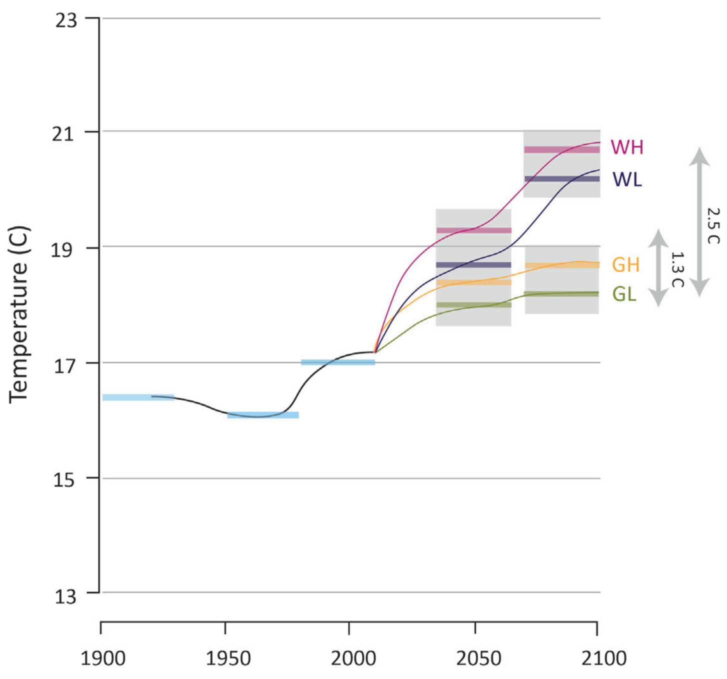

***Figure 4.6**.* Selection of consequences of a warmer climate. Adapted from "NAS-Adaptatietool", by Ministerie van I&W, 2016. (https://nas-adaptatietool.nl/). Copyright by Ministerie van I&W.

## Projections & Uncertainties

Figure 4.7 and 4.8 below show the KNMI'14 projections for the mean summer temperature and the number of summer days (KNMI, 2015). The lines are indicative, as the KNMI defined the 30 year averages (the colored rectangles). The uncertainty in the temperature projections can be seen in the difference between the four scenarios. The absolute difference in temperature between the lowest and highest scenario is indicated with the vertical arrows.

The figures show that in each scenario the mean summer temperature and number of summer days will increase. However, the uncertainties are quite significant and grow over time. The natural variation of the 30 year averages (grey boxes) add on to the uncertainty. In the scenarios for 2085 the difference between the lowest and highest number of summer days is 21, three weeks. The difference in the mean summer temperature is 2.5 C, which can make the difference between moderate or big, and big or extreme heat stress.

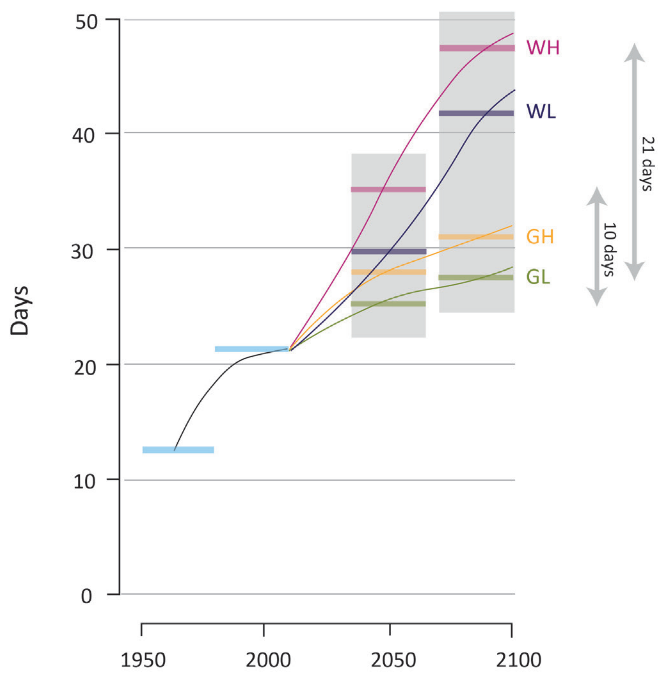
Mean Summer Temperature




Observations (30-year averages)
Natural variations of 30 year averages = +/- 0.25 C
Difference between lowest and highest projection in 2050 and 2085

***Figure 4.7.*** Projections of the mean summer temperature. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

Number of Summer Days (>= 25 C)




Observations (30-year averages)
Natural variations of 30 year averages = +/- 13%
Difference between lowest and highest projection in 2050 and 2100

***Figure 4.8.*** Projections of the number of summer days. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.



## Heat in Future Haven-Stad

In the future, temperatures are expected to rise. There is uncertainty about the exact temperature rises, but the overall trend is clear: It will get warmer in the Netherlands. Due to the higher temperatures, the number of summer days (temperature above 25 oC) and tropical days (temperature above 30 oC) will increase in the Netherlands (KNMI, 2015; Gemeente Amsterdam, 2020a). The KNMI projected an increase between 1-2.3 oC for the mean summer temperature, an increase of the number of summer days with 22-70% in 2050, and an increase of summer nights with 0.5-2.2%, for 2050 (compared to the reference period 1981-2010) (KNMI, 2015).

Due to the development of Haven-Stad, stoney masses are added to the area. These masses absorb heat, which causes the area to warm up more and to cool down slower. If the hot days collide with drought periods, less evaporative cooling can also cause an increase in temperature. Without climate adaptation measures, temperatures in Haven-Stad can rise above the current 46 oC during heat days, which causes extreme heat stress for the inhabitants, nature, and techniques.

## PLUVIAL FLOODING

### Vulnerability

*Height & Soiltype*
Figure 4.9 shows the heights and top soiltypes in Haven-Stad. The former harbor areas are the highest and are 0 m till 2.5 m above NAP. These areas are part of the boezem system. The lower areas can be found inside the dikes, so in the polder areas. There the heights go as low as -2.5 meters NAP. The low polder areas are more vulnerable than the higher areas in the boezem. The rain water collects at the lowest points and can not drain directly to the canal.

But also in the higher areas water can collect in local lows. Three main top soil types can be found in Haven-Stad: Sand, clay and peat. The clay and peat soils are more vulnerable than the sand soils, due to the lower infiltration capacities. The most vulnerable areas are thus the low peat polders, followed by the higher clay areas. The harbor areas are the least vulnerable due to the height, sand soil and possibility to drain into the canal.

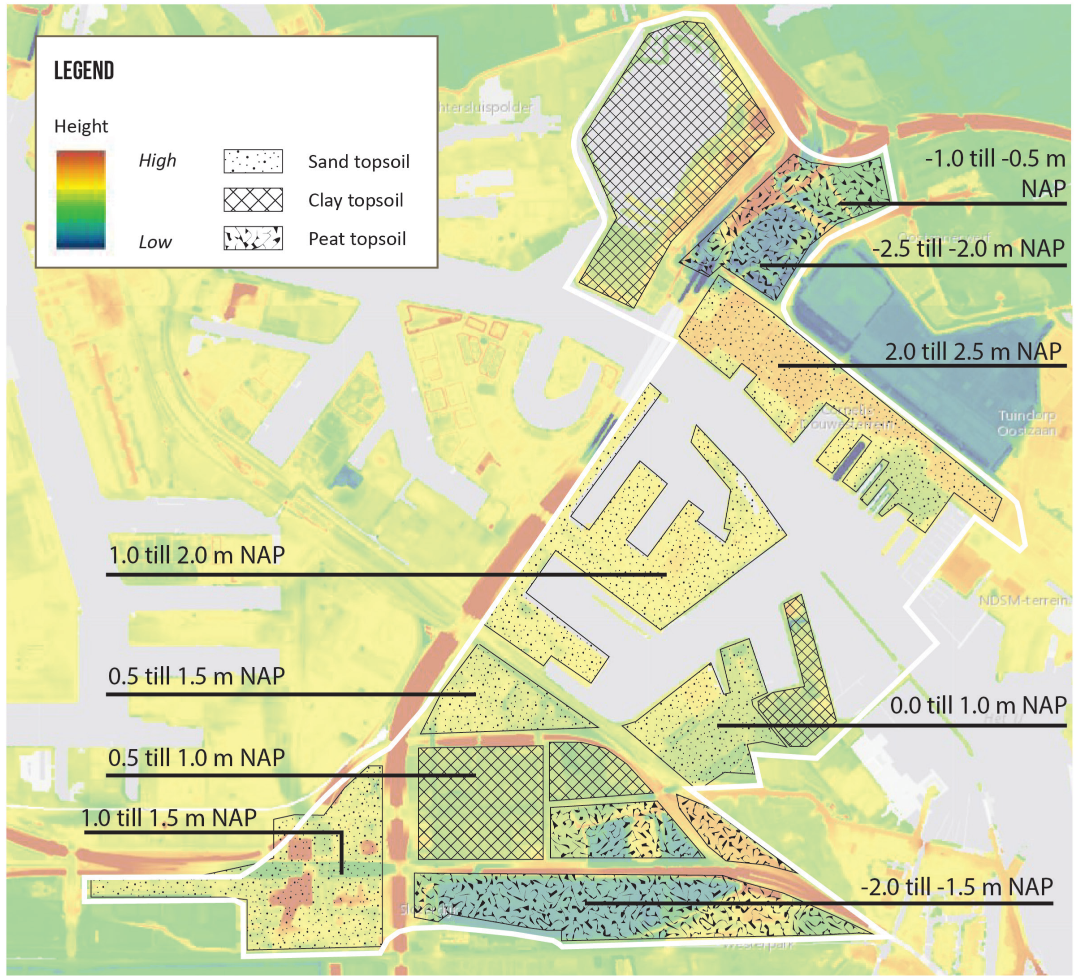



*Figure 4.9.* Heights and top soil types in Haven-Stad. Information from:
- "AHN-viewer", by Actueel Hoogtebestand Nederland, 2018. (https://ahn.arcgisonline.nl/ahnviewer/).
Copyright 2018 by Actueel Hoogtebestand Nederland.
- "DINOloket BRO GeoTOP", by TNO Geologische Dienst Nederland, n.d. (https://www.dinoloket.nl/ondergrondmodellen).



*60 mm in 1 hour*
Figure 4.10 shows the model result of a rainfall event of 60 mm in 1 hour above Haven-Stad. This correponds to a 1/100 year event in the current climate (Beersma, Hakvoort, Jilderda, Overeem & Versteeg, 2019). In all areas small local depths can be found till 0.10 m. The low-lying peat polders show the most pluvial flooding and the highest depths, from 0.30 m.

In the Coenhaven and around station Sloterdijk high depths (from 0.30 m) can be found on the main roads. Flooded streets can become inaccessible, but can also prevent damage of surrounding buildings.


*Figure 4.10.* Waterdepth after precipitation of 60 mm in 1 hour. Adapted from "AGV Klimaatatlas", by Waterschap AGV & BOWA, n.d. (https://agv.klimaatatlas.net/). Copyright by Lizard.

*120 mm in 1 hour*

Figure 4.11 shows the model result of a rainfall event of 120 mm in 1 hour above Haven-Stad. This correponds to a 1/500-1/1000 year event in 2050 (Beersma, Hakvoort, Jilderda, Overeem & Versteeg, 2019). The figure shows how the pluvial flooding is more wide-spread and how the water depths increase, in comparison to the event of 60 mm/h. Especially in the neighbourhood Sloterdijk I a lot of extra streets are flooded, and with high waterdepths (>0.30 m).

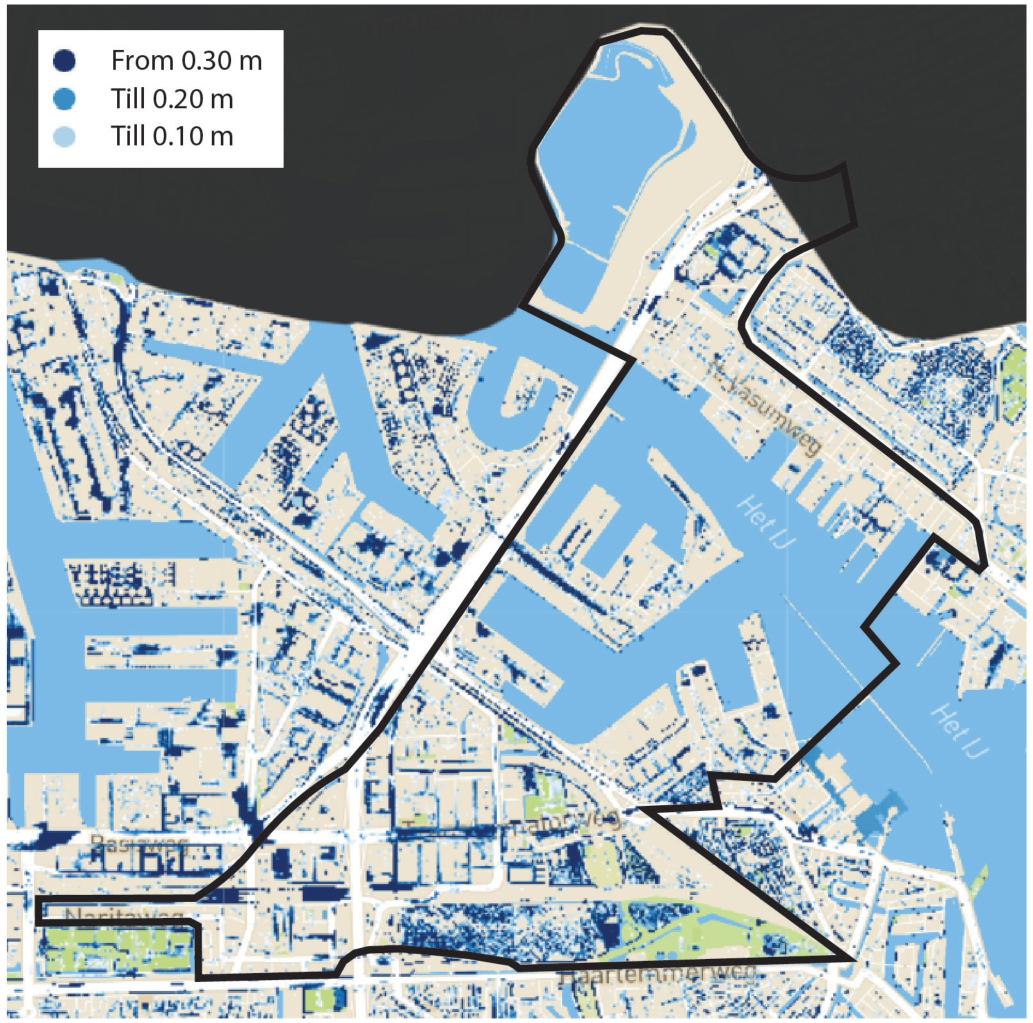



*Figure 4.11.* Waterdepth after precipitation of 120 mm in 1 hour. Adapted from "AGV Klimaatatlas", by Waterschap AGV & BOWA, n.d. (https://agv.klimaatatlas.net/). Copyright by Lizard.



## Consequences

Figure 4.12 shows the consequences of a wetter climate. Extreme peak precipitation increases and can cause pluvial flooding. Pluvial flooding can negatively effect nature, assets, and people. The water can drown plants and trees, as the roots suffocate. In addition, the surface water quality can decrease due to more sewage overflow events, which is bad for the health of ecosystems and of people (a.o. waterborne pathogens).

Health can also be affected by mold in flooded or damp basements. The condition of (frequently) flooded streets can decline faster and also buildings can be damaged. The streets can also become inaccessible (also for emergency services). The chance of power failure increases. (Gemeente Amsterdam, 2020a; Gemeente Rotterdam, 2013).

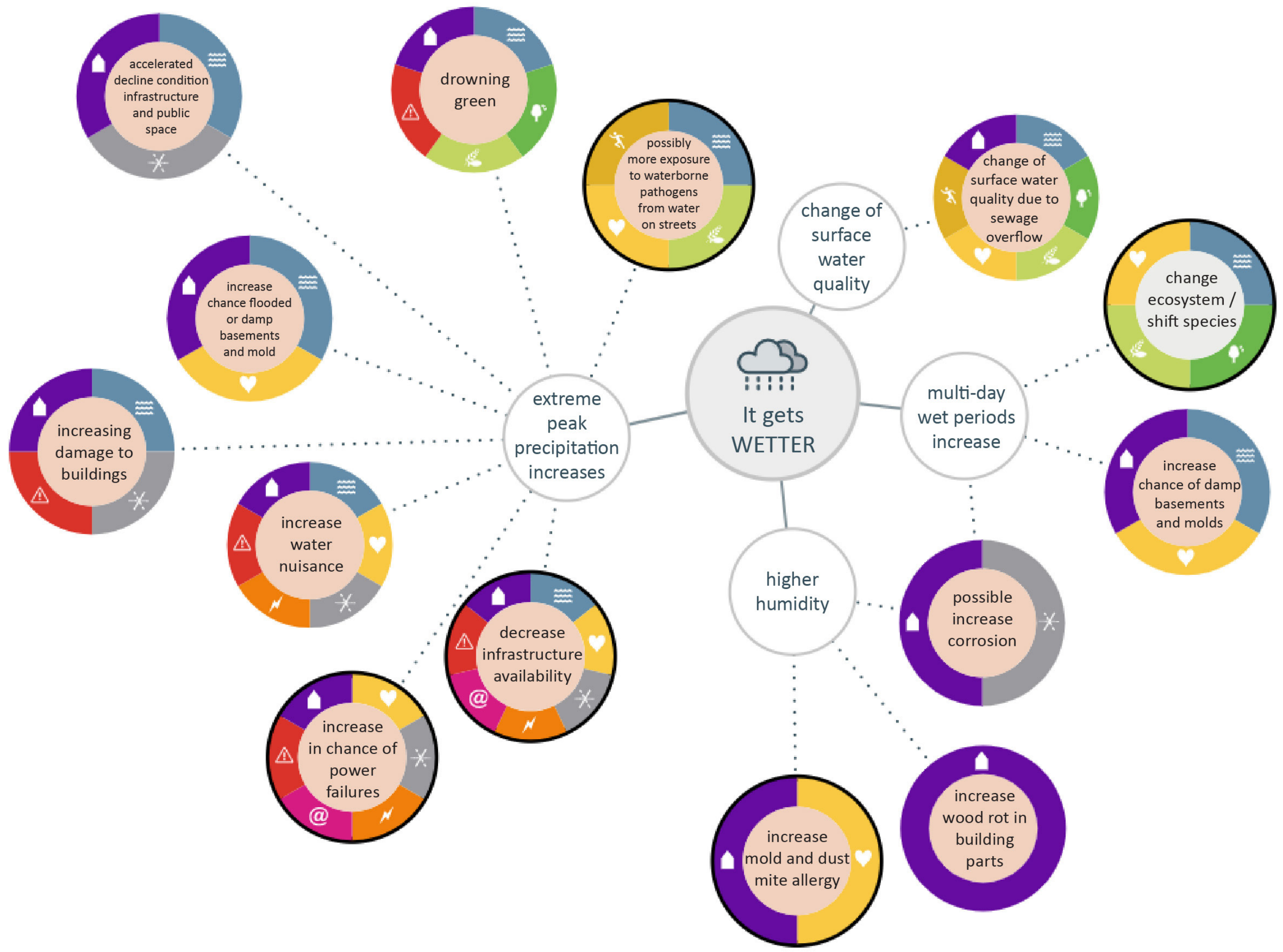



*Figure 4.12.* Selection of consequences of a wetter climate. Adapted from "NAS-Adaptatietool", by Ministerie van I&W, 2016. (https://nas-adaptatietool.nl/). Copyright by Ministerie van I&W.

## Projections & Uncertainties

Figure 4.13 shows the projections for the maximum hourly precipitation intensity per year in summer (KNMI, 2015). Again, the lines are indicative, as the KNMI only defined the 30 year averages (the colored rectangles). It is projected that the total precipitation in summer will decrease, but that the intensity of rainshowes will increase (more heavy summer storms). The projections for the intensity increases are given as a range of percentages (for instance: an increase between 5-15%). This reflects that it is hard to project, because it is about short and extreme events. Adding the natural variations, which are quite significant with -/+ 14%, the intensities are highly uncertain. Figure 4.14 shows the projections for the 10-day precipitation sum (1/10 years) in the winter (KNMI, 2015). In each scenario it is projected that this precipitation sum increases.

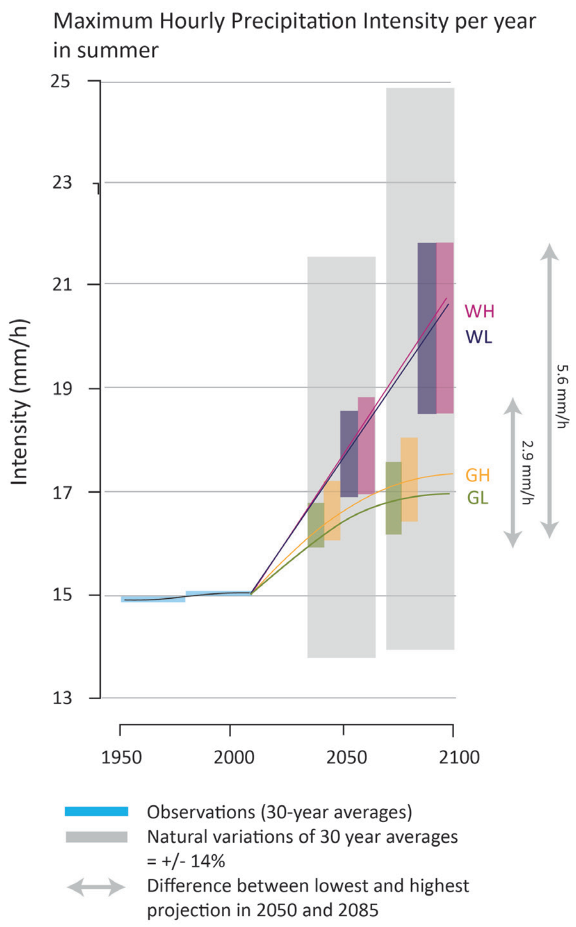



*Figure 4.13.* Projections of the maximum hourly precipitation intensity per year in summer. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

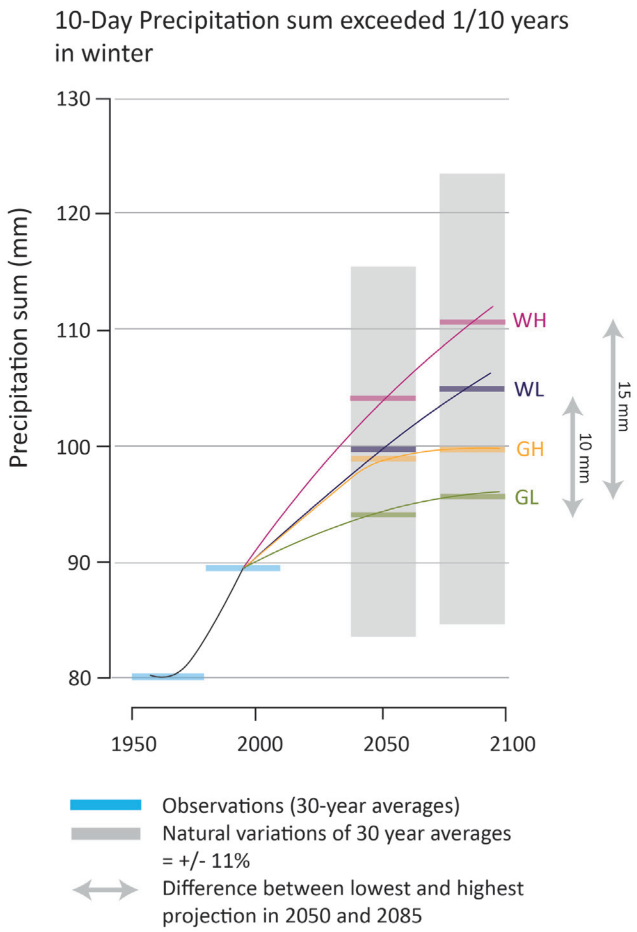



*Figure 4.14.* Projections of the maximum hourly precipitation intensity per year in summer. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

## Pluvial flooding in Future Haven-Stad

In the future, both the frequency as the intensities of rain showers is projected to increase (Gemeente Rotterdam, 2013). Pluvial flooding can thus also be expected to occur more often. Both the heavier rainstorms in summer as the higher precipitation sums in winter can cause an increase in pluvial flooding events. Figure 4.15 shows the average amount of precipitation in the MRA. On the left side it can be seen that Amsterdam is situated in a wet area of the Netherlands. The right figure shows how the annual precipitation increases under a high (W) climate scenario for 2085.

Currently, the area of Haven-Stad is highly paved, which can increase pluvial flooding as the water cannot drain into the ground. The development of Haven-Stad gives opportunities to reduce pluvial flooding by reducing the paved area and by adding infiltration and storage facilities. An expansion of the watersystem and soil raises can also contribute to the reduction of pluvial flooding.

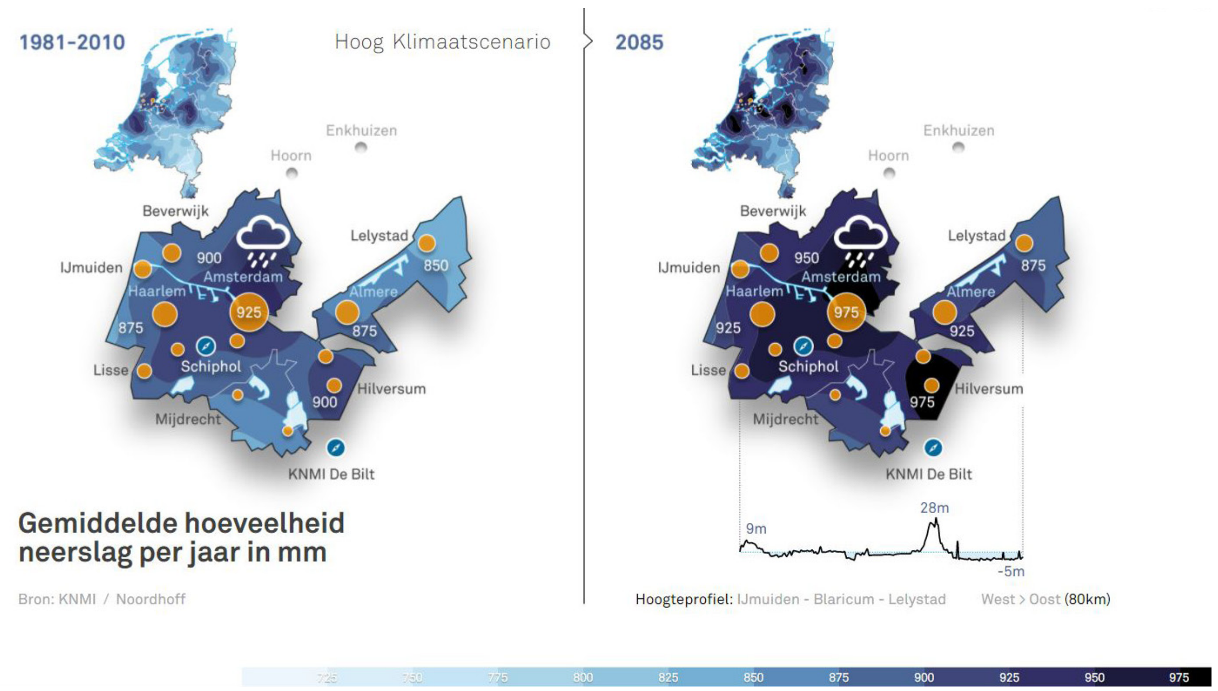



*Figure 4.15.* Average amount of annual precipitation in mm in Metropolitan Region Amsterdam. Reprinted from "Ons klimaat verandert", by KNMI, n.d. (http://klimaatverandering-mra.vormgeving.com/). Copyright by KNMI.

## DROUGHT

### Vulnerability

*Netherlands*
The precipitation deficit is the indicator for drought in the Netherlands. It is the calculation of the difference between the amount of precipitation and the calculated reference evaporation (KNMI, n.d.). Figure 4.16 shows graphs of precipitation deficits in the Netherlands, summed from 1 April till 30 September. A positive value for the precipitation deficit, means that there is more evaporation than precipitation. It can be seen that 2018 and 2020 were relatively dry years, but with very different courses over time. Figure 4.17 and Figure 4.18 show the regional differences and the severity of the drought of 2020 compared to the long-time average. Compared to the rest of the Netherlands, the precipitation deficits in and around Amsterdam are low.

*Metropolitan Region of Amsterdam*
Figure 4.19. zooms in to the Metropolitan Region of Amsterdam. In the climate of 1981-2010, the long-time average precipitation deficit was not very high, between 0-100 mm. However, this figure is about a long-time average of 1981-2010, and as can be seen from Figure 4.18 the drought was already way more severe in 2020. Haven-Stad lies in the black circle with deficits between 0-75 mm. It is hard to tell the exact effect of the drought on the scale of Haven-Stad. Groundwaterlevels could give an indication, but there are not enough groundwater measurements found.

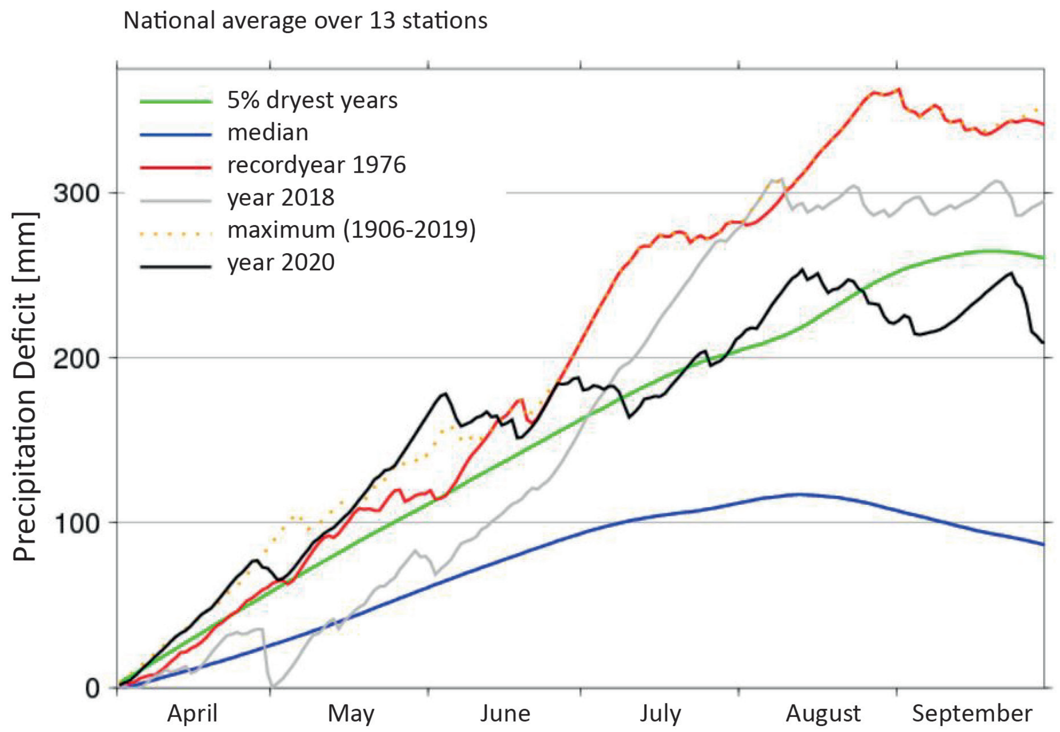



*Figure 4.16*. Precipitation Deficit in the Netherlands. Adjusted from "Neerslagtekort/Droogte", by KNMI, n.d. (https://www.knmi.nl/nederland-nu/klimatologie/geografische-overzichten/neerslagtekort_droogte). Copyright by KNMI.

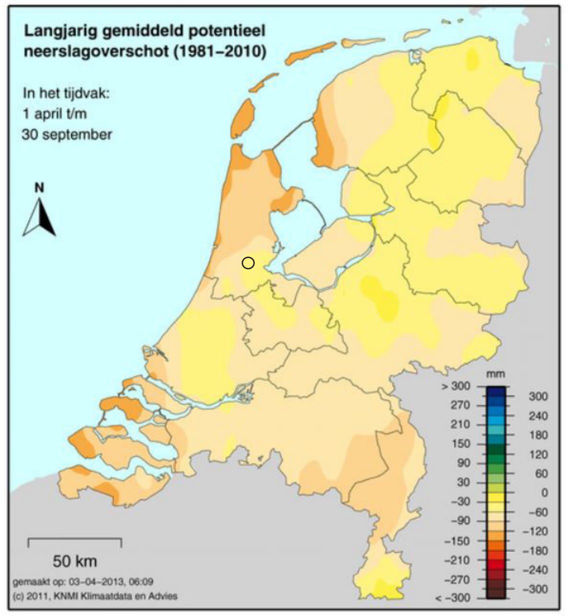



*Figure 4.17*. Precipitation Surplus in the Netherlands (negative = less precipitation than evaporation) Long-time average 1981-2010. Reprinted from "Doorlopend potentieel neerslagoverschot", by KNMI, n.d. (https://www.knmi.nl/nederland-nu/klimatologie/geografische-overzichten/neerslagoverschot). Copyright by KNMI.

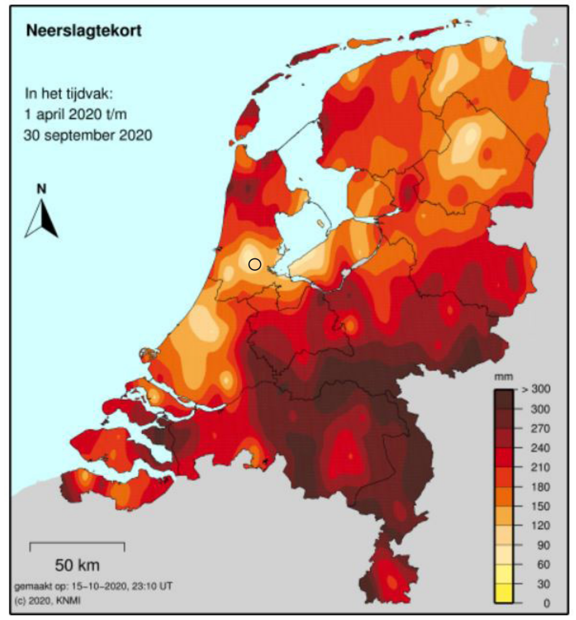



*Figure 4.18*. Precipitation Deficit in the Netherlands in 2020 (positive = less precipitation than evaporation) Reprinted from "Neerslagtekort/Droogte", by KNMI, n.d. (https://www.knmi.nl/nederland-nu/klimatologie/geografische-overzichten/neerslagtekort_droogte). Copyright by KNMI.

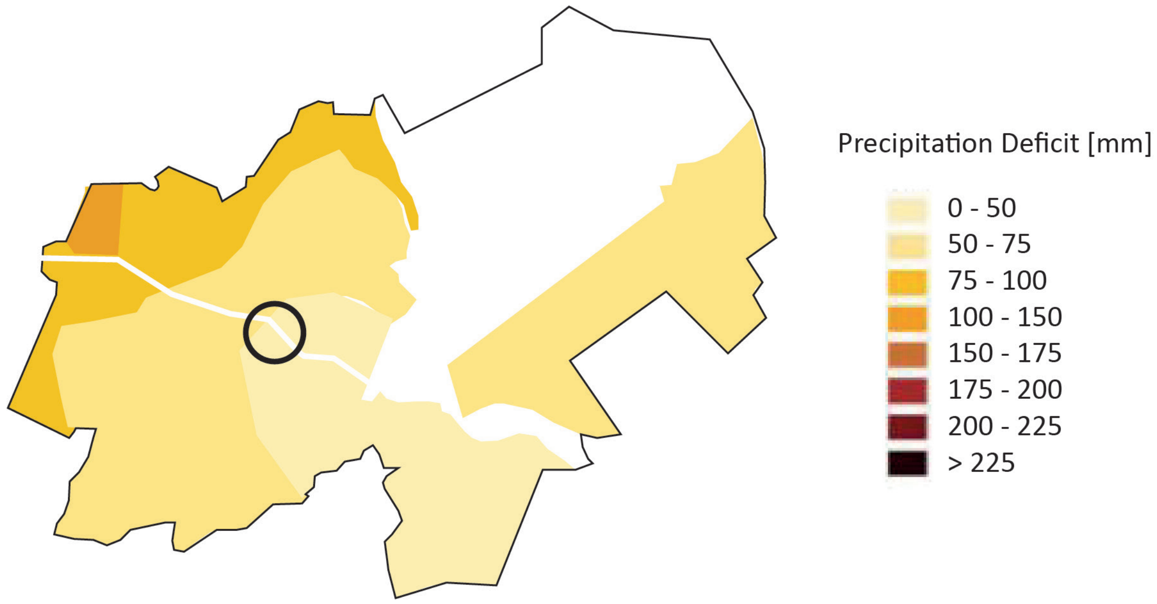



*Figure 4.19*. Precipitation Deficit in the Metropolitan Region Amsterdam. Long-time average 1981-2010. Adapted from "*Resilience by Design Metropoolregio Amsterdam - Landelijk gebied*" (p.134), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.

# 4.2 CLIMATE STRESSES

*Salinization*

Droughts, in combination with sea level rise, can cause increased salinization of the surface water and groundwater in Haven-Stad. The North Sea canal already has brackish water and this can potentially become saltier. Figure 4.20 shows that areas around Haven-Stad already have brackish surface waters (>500 mg Cl/L).

As can be seen in Figure 4.21 the depth boundary between fresh and brackish water is smaller close to the canal and behind the dunes.

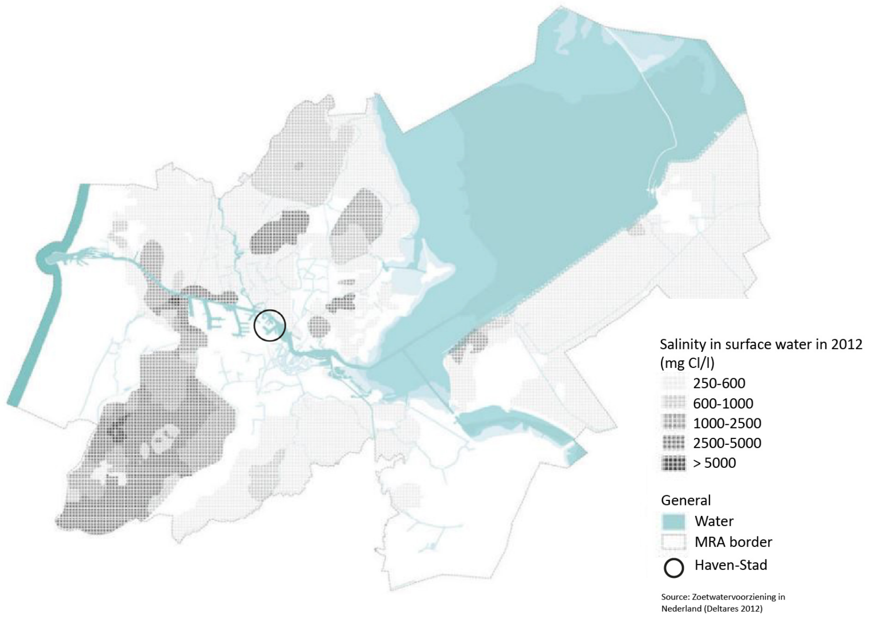



*Figure 4.20.* Salinity in surface water in the Metropolitan Region of Amsterdam in 2012. Adapted from "*Resilience by Design Metropoolregio Amsterdam - Landelijk gebied*" (p.137), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.

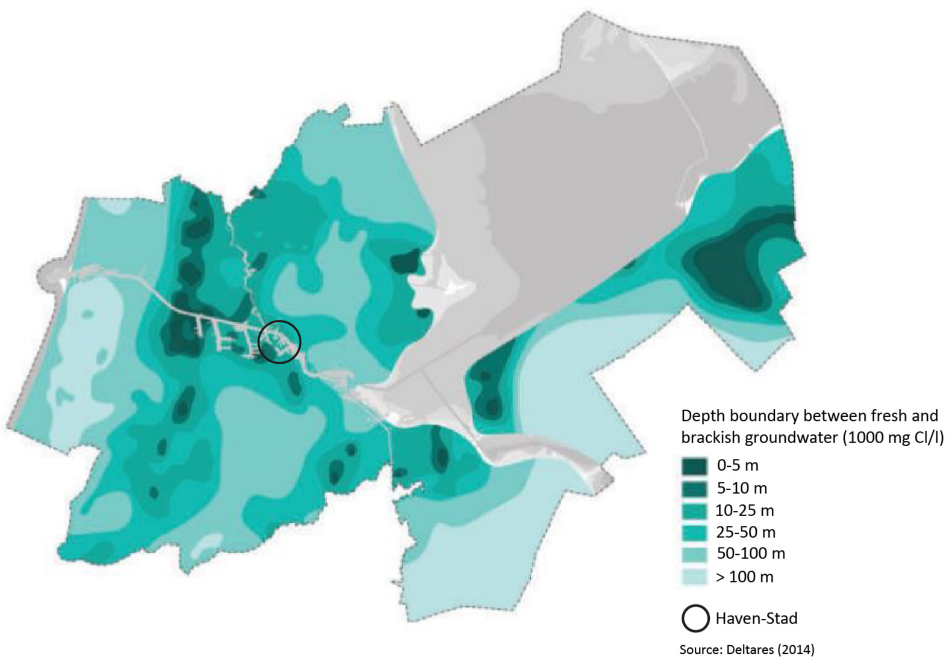



*Figure 4.21.* Depth boundary between fresh and brackish groundwater in the Metropolitan Region of Amsterdam. Adapted from "*Resilience by Design Metropoolregio Amsterdam - Landelijk gebied*" (p.141), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.



## Consequences

Figure 4.22 shows the consequences of a dryer climate. Droughts lead to lower groundwater tables and groundwater deficits, and to lower river levels (Gemeente Rotterdam, 2013). Lower groundwater levels can cause water shortages for the vegetation, which reduces the chances of survival and the cooling evaporation rates. The low levels can also be a problem for existing buildings with wooden piles, as the water does not protect the piles against pile rot anymore.

For the peat areas in Haven-Stad, drought can cause an increase in subsidence due to peat oxidation.Lower levels in the IJ river are disadvantageous for the ecology and for the shipping. The water quality can decrease if the continimants are less diluted. Increases in salinity reduce the freshwater availability, increase the chance of concrete rot in foundations, and potentially increase corosion.


*Figure 4.22*. Selection of consequences of a dryer climate. Adapted from "NAS-Adaptatietool", by Ministerie van I&W, 2016. (https://nas-adaptatietool.nl/). Copyright by Ministerie van I&W.

## Projections & Uncertainties

Figure 4.23 and 4.24 show the KNMI'14 projections for the highest precipitation deficit (KNMI, 2015). Again, the lines are indicative, as the KNMI only defined the 30 year averages (the colored rectangles). Drought is hard to project, which can be seen from the figures. Uncertainties get big, as the precipitation deficit increases fast and strongly in the H-scenarios (high difference in air circulation pattern), and less (fast) in the L-scenarios (low difference). In addition, the W-scenarios show a continuous increase, while the G-scenarios show a stabilization after 2050, or even a lowering (GL).

The drought projections are thus highly uncertain, but the figures show the possibility of a very steep increasing trend, which is essential to keep in mind. Due to the high uncertainties, the differences between the lowest and highest scenario are quite significant. The differences for the mean precipitation deficit are 42 mm in 2050 and 71 mm in 2085. The differences are a bit bigger in the projections for the highest precipitation deficit that is exceeded 1:10 years (a more extreme situation).

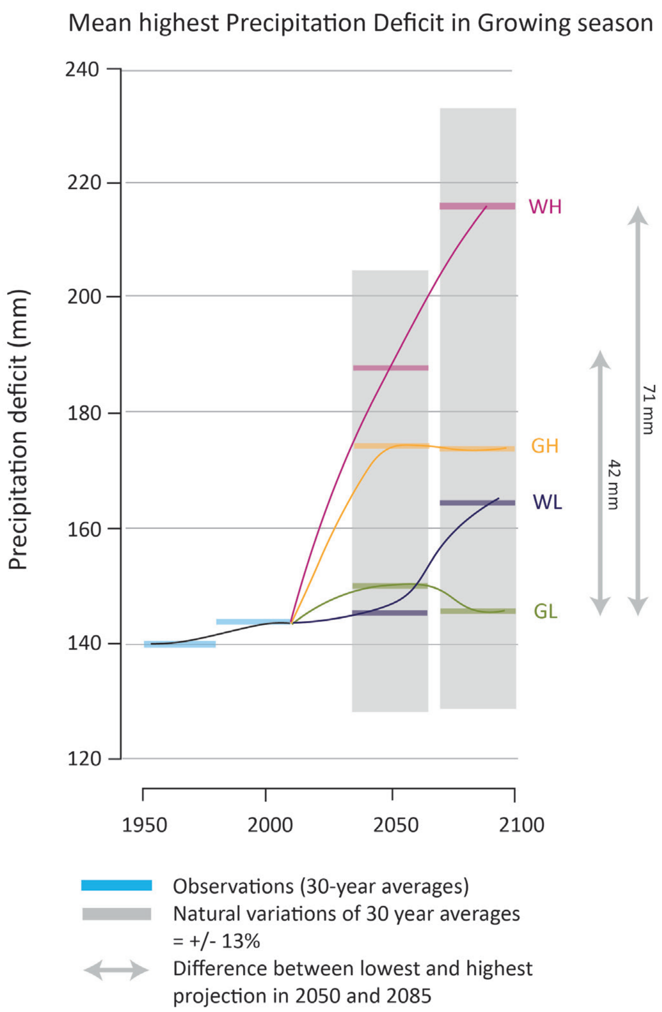



*Figure 4.23.* Projections of the mean highest precipitation deficit in growing season. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

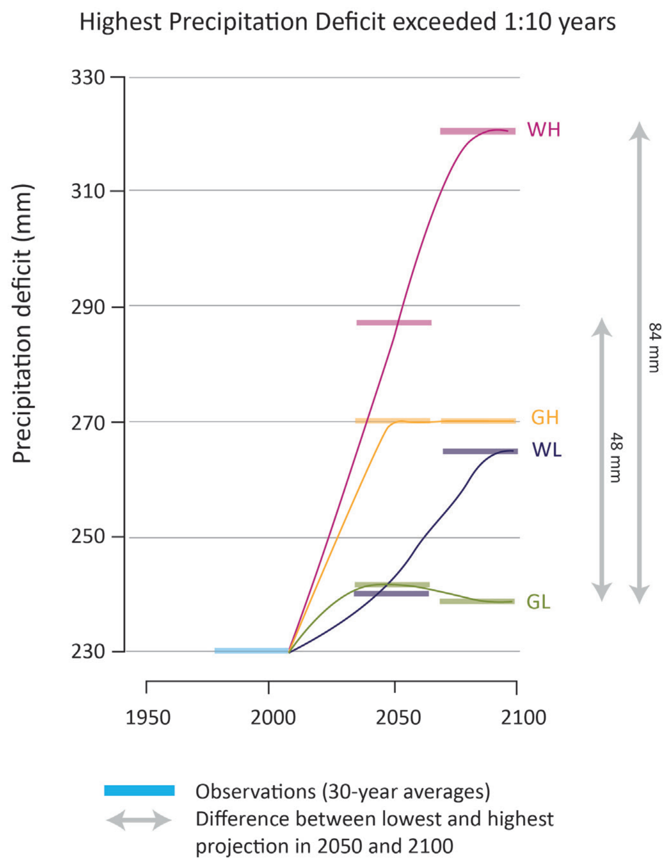



*Figure 4.24.* Projections of highest precipitation deficit exceeded 1:10 years. Information from "*KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation*", by KNMI, 2015, De Bilt: KNMI. Copyright 2015 by KNMI.

## Drought in Future Haven-Stad

As explained before, droughts are hard to project. Due to higher temperatures in summer, the potential evaporation increases. However, it is not sure if the rainfall in the summer will increase or decrease. An increase in rainfall could decrease the precipitation deficit. However, three of the four scenarios show a steep increase in precipitation deficit in the future. Figure 4.25 shows how a drought would look like in the G-scenarios (not too different from the current situation) and the WH-scenario (big difference with the current situation) in 2050.

The development of Haven-Stad will probably not change much about the droughts, as the scale of the droughts is much bigger than the scale of Haven-Stad. However, the surface of Haven-Stad is currently very sealed (paved). By adding green and by disconnecting areas from the sewer system, more water can infiltrate and supplement the groundwater over time.

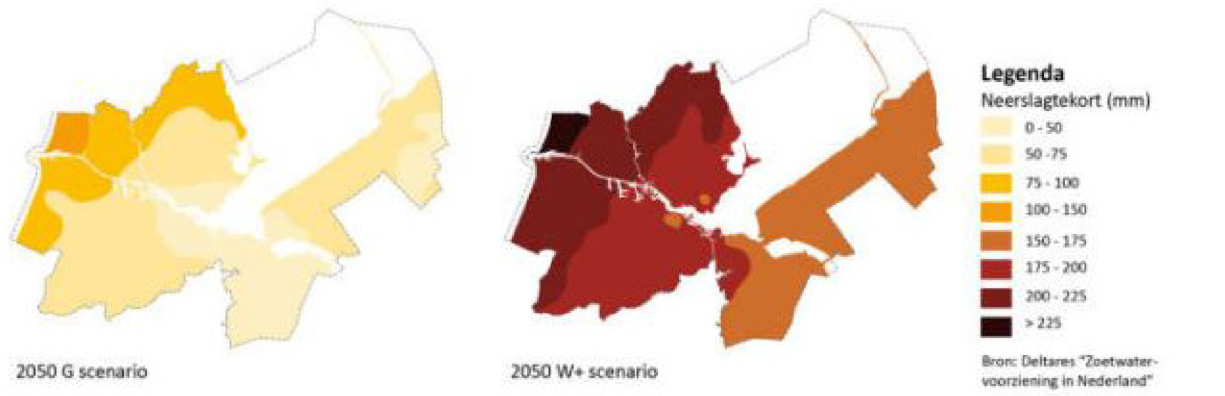



*Figure 4.25.* Projections of the precipitation deficit in the Metropolitan Region of Amsterdam in 2050. Reprinted from "*Resilience by Design Metropoolregio Amsterdam - Landelijk gebied*" (p.134), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.

# 4.2 CLIMATE STRESSES

## FLUVIAL FLOODING

### Vulnerability

Figure 4.26 shows the maximum flood depth in Haven-Stad at different flood probabilities. The maps combine different flood scenarios, which will probably not occur at the same time (Defacto Stedenbouw & RHDHV, 2021). Examples of such scenarios are failures of the Lekdijk and the IJmuiden complex. A flood from the Lek river has a long arrival time and a long flood duration of multiple days.

A flood from the North Sea (IJmuiden) causes higher flood depths, has a short arrival time, and a flood duration of only one day (breach scenario). A flood with a probability of 1/100 years causes floods along the quays of the North Sea Canal and in the Westerpark. A flood with a probability of 1/10.000 or 1/100.000 year causes flood depths of more than 1 m at multiple locations. The Westerpark and the

neighbourhoods in the north of Haven-Stad (both polders) face the highest flood probabilities (1/100 and 1/1000 years can already cause a flood) (Defacto Stedenbouw & RHDHV, 2021). Figure 4.27 shows the probabilities of different flood depths per neighbourhood. This shows again that the areas in the north and south face the highest risks (highest probabilities and flood depths). The flood depths can become more than 2 m.

The harbor areas along the North Sea Canal (boezem) come second, with smaller probabilities and depths. However, also these depths are still dangerous. The areas Alfa driehoek, Sloterdijk Centrum, and Sloterdijk I face the lowest risks.

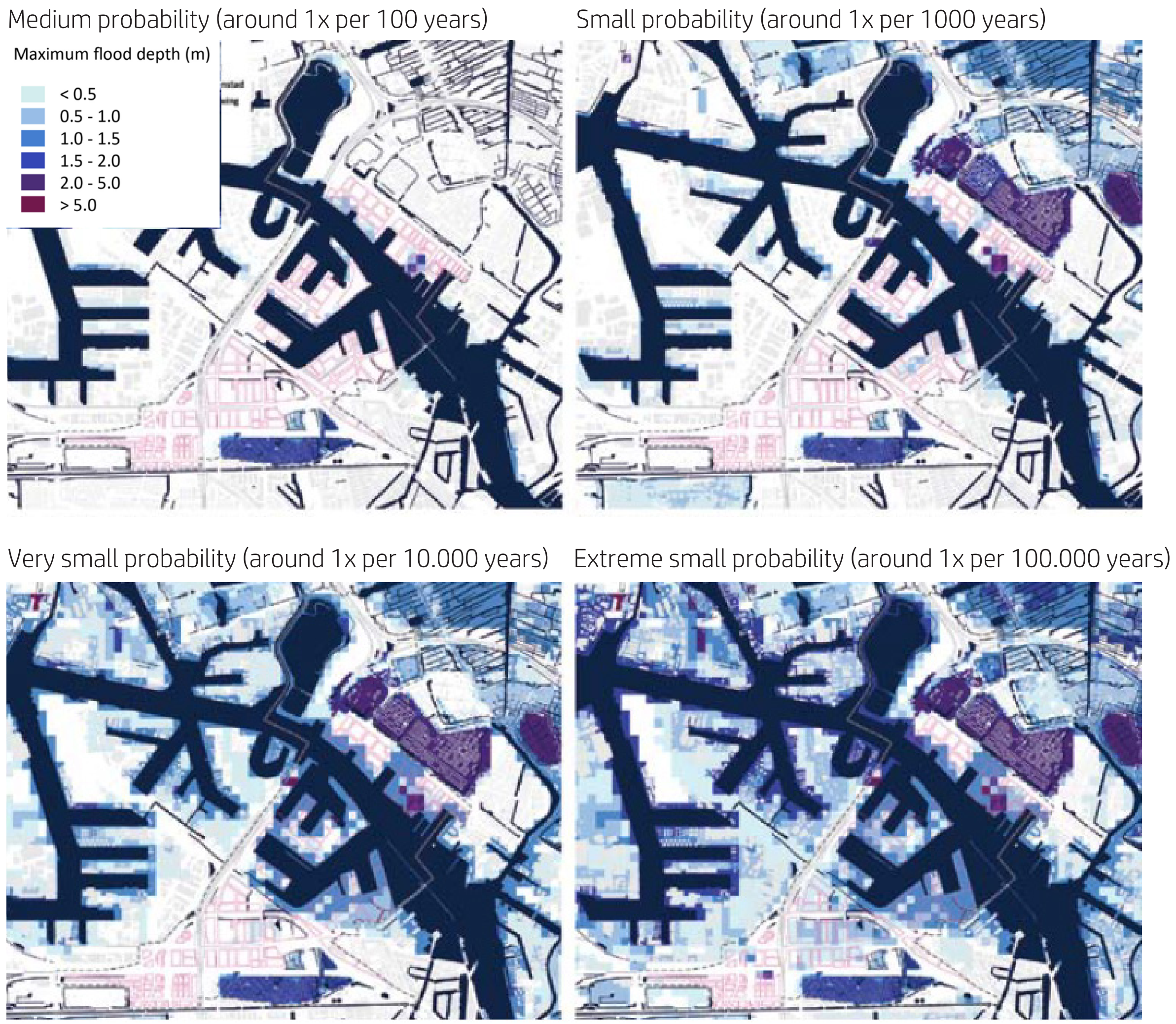



*Figure 4.26.* Maximum flood depth at different flood probabilities for Haven-Stad. Adapted from "*Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid*", by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

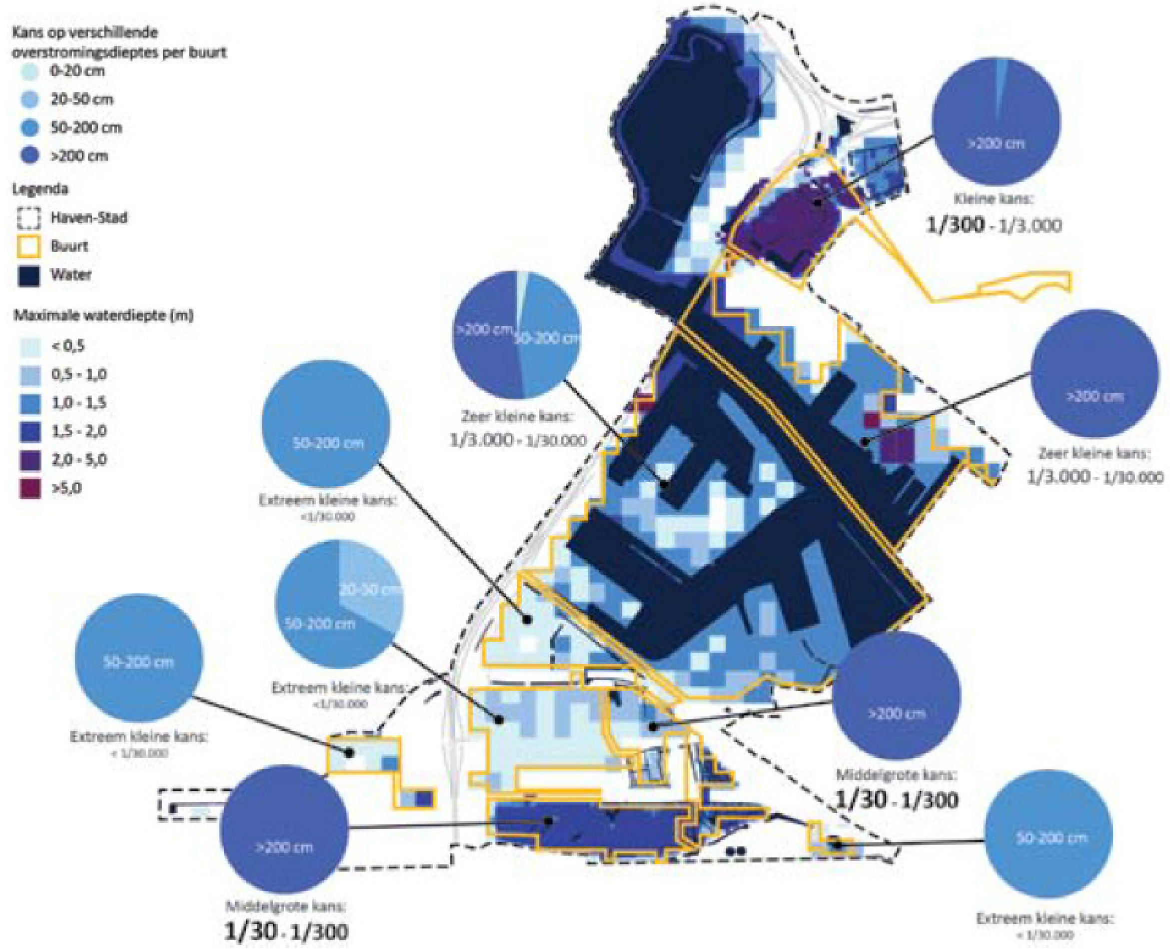



*Figure 4.27.* Risk scan Haven-Stad: Probabilities of different flood depths per neighbourhood. Reprinted from "*Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid*", by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

Figure 4.28 shows the relative heights of Haven-Stad and the surroundings. Relative to the surrounding areas, the Haven-Stad area is high. In the past, the city of Amsterdam is hightened with sand, which still gives benefits to the city nowadays. Big parts of Haven-Stad are hightened even more, for the construction of the harbor. The lower (green and blue) areas around the city of Amsterdam are polder areas.

Due to the relative height of Haven-Stad, the area could be used as a shelter for surrounding low-lying neighbourhoods. The A10 highway could be used for horizontal evacuation. However, the expected evacuation fraction (percentage of residents that can leave the area on time) is only 0-20% in Amsterdam (Defacto Stedenbouw & RHDHV, 2021). Shelters within the city could thus be important to safe lifes.

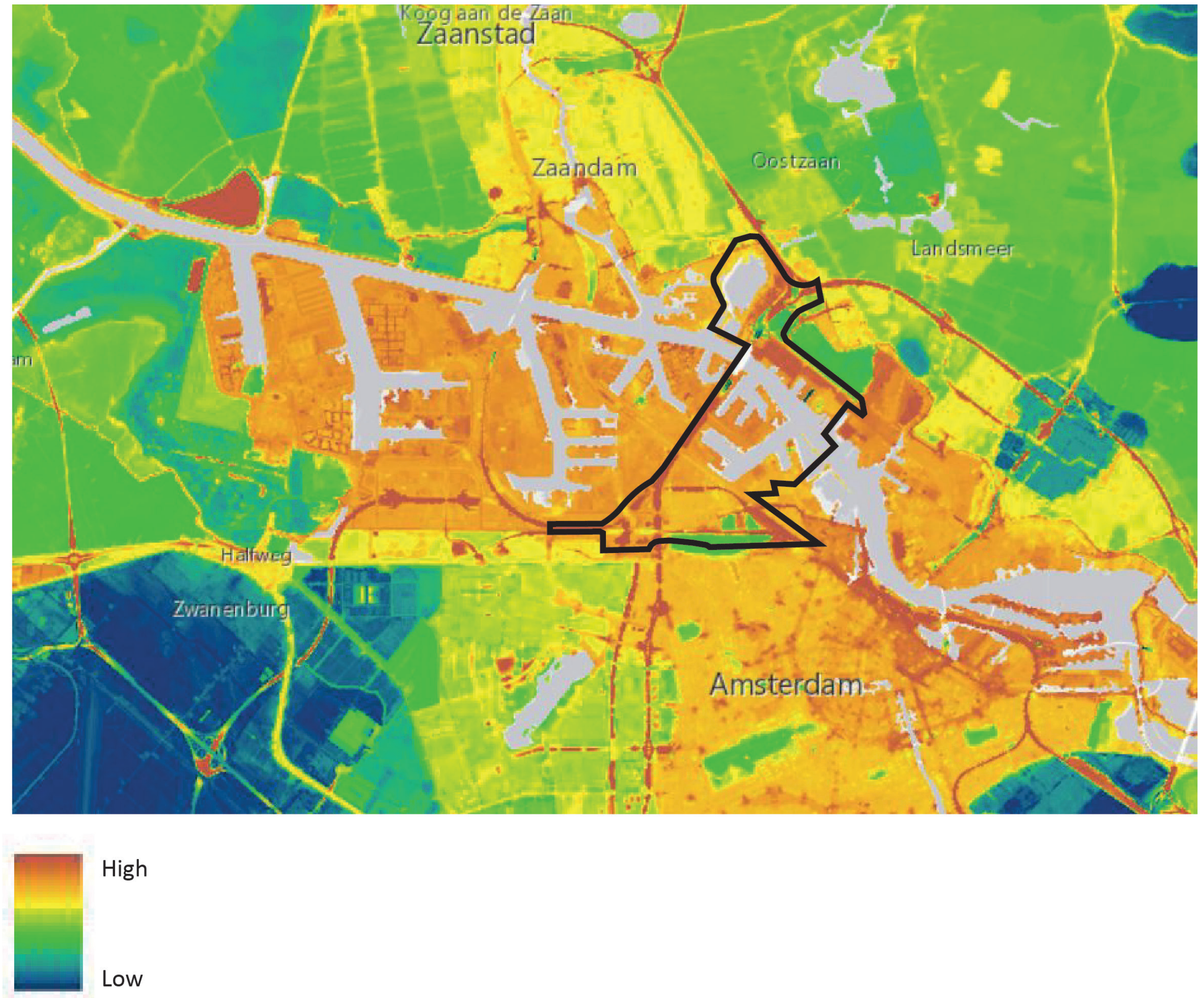



*Figure 4.28.* Relative height map of Haven-Stad and surroundings. Adapted from "AHN-viewer", by Actueel Hoogtebestand Nederland, 2018. (https://ahn.arcgisonline.nl/ahnviewer/). Copyright 2018 by Actueel Hoogtebestand Nederland.

## Consequences

Figure 4.29 shows a selection of consequences of a higher sea level. First of all, a higher sea level causes an increase of salinization of the surface water and the groundwater in coastal regions. This causes changes in ecosystems and a decrease of the freshwater availability. Secondly, a higher sea level causes higher waterlevels. This can give problems for shipping and the drainage of water. As the sea level gets higher, less water can be flushed under gravity and more pumping is needed. In addition, the higher levels cause higher flood probabilities.

Fluvial flooding can cause social disruption (Gemeente Amsterdam, 2020; Gemeente Rotterdam, 2013) due to the failure of vital and vulnerable infrastructures, due to damage to buildings and infrastructures (economic losses, inaccessibility), and due to the victims made. Recovery times after floods can be long.


*Figure 4.29.* Selection of consequences of a higher sea level. Adapted from "NAS-Adaptatietool", by Ministerie van I&W, 2016. (https://nas-adaptatietool.nl/). Copyright by Ministerie van I&W.

## Projections & Uncertainties

Figure 4.30 shows the uncertainties in the KNMI'14 projections for sea level rise on the Dutch North Sea Coast in purple (W-scenario) and green (G-scenario). The projected sea level rise is the same for both G-scenarios and both W-scenarios. In 2050 the difference between the lowest projection in the G-scenarios (15cm) and the highest projection in the W-scenarios (40cm) is 25 cm. In 2085 this difference grows to 55 cm (80-25cm).

However, recently new projections are made for the scenario of accelerated sea level rise (orange in figure). These projections put a new perspective on the future. Instead of a maximum of 80 cm in 2085, a maximum of 150 cm is projected, which is almost the double. And this value can rise till a maximum of 3 m in 2100. With the addition of these scenarios, also the uncertainty grows a lot; from a difference of 55 cm to a difference of 125 cm for 2085 (and potentially a difference of around 190 cm for 2100).

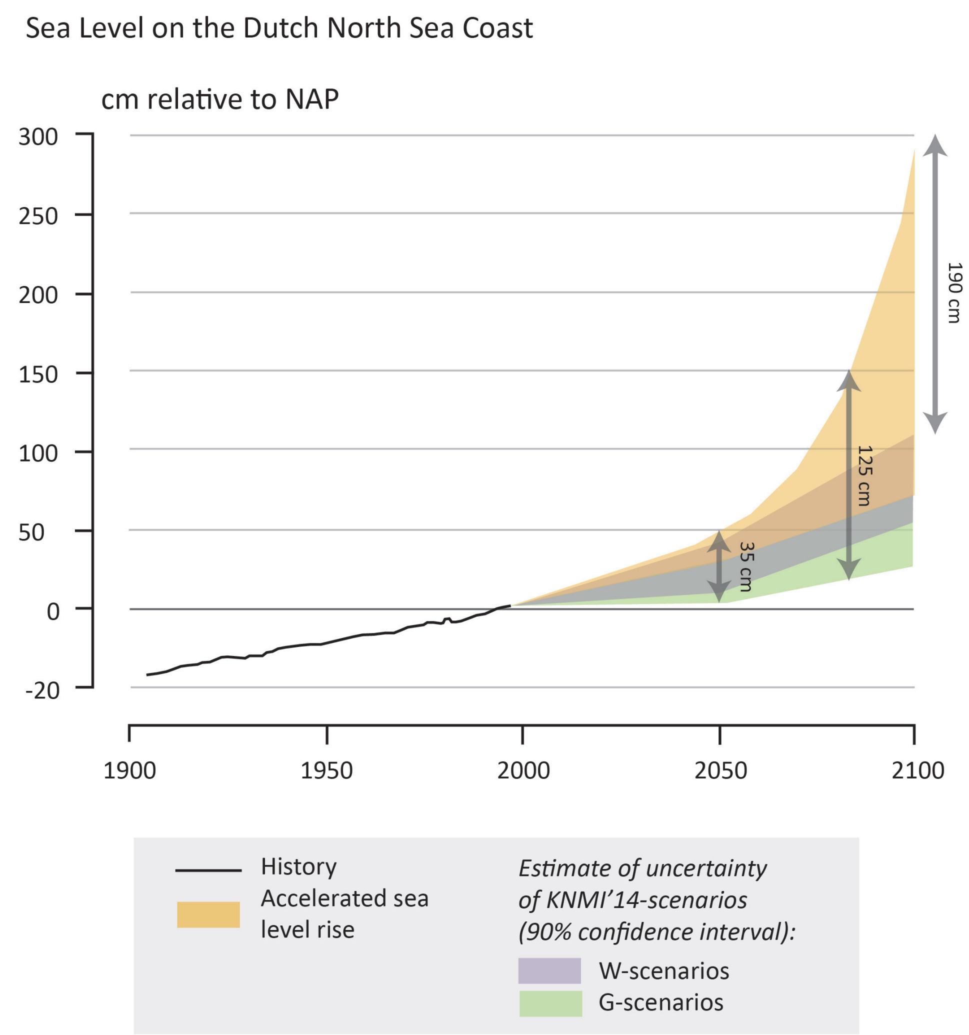



***Figure 4.30.*** Projections of sea level rise at the Dutch North Sea coast. Information from:
- *"KNMI'14 climate scenarios for the Netherlands; A guide for professionals in climate adaptation"*, by KNMI, 2015, De Bilt: KNMI.
- "*Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid"*, by Defacto Stedenbouw & RHDHV, 2021, Amsterdam: Gemeente Amsterdam & Waternet.

## Fluvial flooding in Future Haven-Stad

The uncertainties about the sea level rise are big, especially if also the accelerated sea level rise scenario is considered. The trend is however very clear: the sea level will continue to rise till 2085 at least. Due to higher sea levels, the probabilities of fluvial flooding can increase. It gets harder to maintain the current water systems and the chance of failure increases. In addition, the consequences of a flood are higher as the flood depths increase due to the higher sea levels.

Haven-Stad will change into a residential area with a high density of people and economic value. As a result, the consequences of a flood will increase enormously. The flood risk will thus increase, as both the flood probability and the consequences (flood depths and exposure) increase. Vertical evacuation can easily be implemented, as most buildings will have multiple floors on top of the plinths. The area can potentially also be a shelter area for surrounding low-lying neighbourhoods.

# 5

# CLIMATE ADAPTATION GOVERNANCE

5.3 Main Challenges for Climate Adaptation - Interview Summaries

Barends, M. (2014)

## IV1. Lot Locher

Date: 24-11-2020
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

*Lot Locher is a strategic advisor at Waternet, program manager Climate Adaptation at Metropol Region Amsterdam (MRA). And program strategist at Amsterdam Rainproof.*

### Biggest Challenges of Climate Adaptation?

- Biggest challenge is coping with the longer term. Also, the uncertainty in decisions made now that have a certain lifespan.
- Uncertainty. Too often climate-proof is assumed to be a status you achieve when you have designed for a certain standard.

### Why is Climate Adaptation not yet widely implemented?

- Partly due to uncertainty, technically it is possible to design with an extra margin. However, it can be difficult to justify it financially and politically.
- Not the only challenge that draws attention, also housing, circular economy etc.
- Topic needs to be disseminated, remains too much in the field of water and sustainability
- It helps to inform people by linking the longer-term challenges to the positive impact that the associated measures can have in the short-term. People must be motivated by the need and potential benefits of Adaptation.

### Cooperation Municipality and Waternet?

- Parties work often together
- Both municipality and Waternet often do not look sufficient to the longer term.
- Focus not only on the water system itself, but also on the relationship with the spatial system.

### Which timescale is often used?

- 2050, in the Delta program it is agreed to work towards a climate proof society.
- In spatial and policy system thinking, 2050 is already far ahead. Although the distinction between public/private has often been determined for a longer period.
- The time horizon should be linked to the lifespan of the decisions that are now made.
- The used timescale could be shifted to the longevity of the choices made. Transition of real estate to 'fluid estate' ('losgoed'): the development that buildings last for shorter lifetime, perhaps shorter due to circular building and climate adaptation.

### How are multiple future scenarios considered, with a continuous timescale?

- Adaptation pathways, scenarios with tipping points, where choices affect further paths
- For Haven-Stad, study done for sea level rise, also look at other three themes (heat, drought, rainfall).

### What are the financial considerations in Climate Adaptation?

- Which resources to use to cover the investment costs of measures, for example resources like land development, or via sewerage taxes or water taxes.
- Investors and insures can impose certain requirements on land developers. Include feedback on the performance of an area.
- Investors have financial risks, for example 'stranded assets' which are assets that are not future proof and can rapidly depreciate.
- Climate adaptation in the public space is more cost-effective. If there is not enough space for Climate Adaptation in public space, private area can also be investigated. Heat adaptation requires adjustment of the (property's) building style.

### Role division of Climate Adaptation?

- Water sector took the lead in Delta Program, water authorities see themselves as having a major role in this, is that valid?
- The desirable division of roles for climate adaptation: the Municipality is the main actor who is developing the area. Secondly, urban developers are involved. Thirdly, water authorities, Province and Rijkswaterstaat are involved in the project.
- Opinions that the role of water authorities should change to a more pro-active role in the land development, instead of tests.
- Need to consider the whole building chain, from investor to the final buyer (resident) of the house.



## IV2. Rob Koeze

Date: 25-11-2020
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

*Rob Koeze is strategic Advisor at Waternet, working on Climate Adaptation, flood control and sustainable urban development. He is also member of Delta Program Spatial Adaptation and of the national work group for flood consequence control.*

### What are biggest challenges for Climate Adaptation?

- Depending on the climate theme. And the challenge is above all to consider all other challenges (energy transition, agriculture, and housing), now still sectoral.
-Therefore, more centralized control is needed to oversee the choices. Omgevingswet is more a decentralized approach. National spatial vision (NOVI) is a useful framework to ask municipalities to avoid increasing risks.
- Much is already known about pluvial flooding and quite some concrete measures have now been taken. However, generally it has not yet widely implemented in Municipalities, but Amsterdam is a step ahead.
- For heat and drought, awareness is growing because of the the past hot and dry summers. The responsibility for heat lies more with the Municipality.
- Impact mitigation for fluvial floods, however, has not yet landed well.

### Task of Regional Water Authorities to put water risks on the Municipal agenda?

- Yes, Flood control has always been the knowledge domain of regional water authorities. From the perspective of policy advice, water test focuses mainly on flooding, but examinations should also cover water safety. Furthermore, proactive involvement in location choices would be good.
- Water test is originally about authorize permits (allowable near dike), now more towards multi-layered safety.
- Awareness is really missing (OESO study). In the City Deal Climate Adaptation a decision matrix has been created for different actors in the risk dialogue.

### What typical timescale is used?

- Delta program, 2050, has set the target of maintaining the flood defenses in good condition to be flood proof in the future. Flood defenses are also tested every 12 years. Pragmatic to also have the same timescale for Spatial Adaptation.
- After 2050? Research in the knowledge program Sea-level rise. Meanwhile try to give good requirements for new developments.

### Difficult to inform other actors?

- No long-term National Spatial vision including Climate Adaptation yet
- Adaptation strategies of Deltares, implementing adaptative Delta Management in Delta program. Useful to have a strategy that leaves different pathways open and include both short term decisions and long-term thinking.
- In Waternet regional area, polders are vulnerable (subsidence, salinization, flooding risk). Considerations for new developments.

### Adaptive Pathways Approach and tipping points?

- Values needed to calculate tipping points
- In thematical studies, more global view using expert opinions and estimations.
- Tipping points can be technical (dimensions of dike), but also in terms of time (too less time or capacity to prevent damage).

### Water systems and Haven-Stad?

-Technical lock-in, meaning that systems are being optimized, but thereby there is a chance of increasing the vulnerability. Robust solutions are needed.
- Information systems are created for considering larger areas. Large systems can be valuable by including flexibility.
- North Sea Canal system is reaching the limits, can partly be technically solved. But the solution is in buffering water in the system.
- Research by design works for development adaptive pathways.

## IV3. Karlijn Kokhuis

Date: 16-12-2020
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Karlijn Kokhuis is an advisor and researcher in sustainable urban development at the Municipality of Amsterdam. In addition, she leads the program Sustainability for Haven-Stad.***

### Relevance of Climate Adaptation (pathways)

- Climate Adaptation is relevant because of the long development time of Haven-Stad
- Main water system: Current rule = 60 mm/h, for Haven-Stad = 90 mm/h. Plus extra space in system for extra water buffers in case the rainfall will intensify.
- Space reservations are not yet designed for Haven-Stad. However, locations are already appointed in the Integraal Raamwerk Openbare Ruimte (Integral Framework for Public Space).
- Space reservations are also relevant on the regional scale (North Sea Canal area): Can extra water buffers be made? It is also still the question to what extent Haven-Stad has influence on the regional system.

### What is the typical timescale for urban developments?

- Most urban developments follow the KNMI climate scenarios with a 2050-horizon.
- Haven-Stad development has a long timespan, sometimes developments start in 2045 or later.
- More specific public space frameworks are made for areas where we can already see initiatives/developments.
- In addition, things are also put on the agenda for the long term.

### Why is 2050 typically used? There are also KNMI scenarios for 2085.

- Not sure which timescale is used in other areas.
- Often consideration of municipal/regional agreed calculation methods and norms - which are by definition a bit behind.
- There is a need of hard norms, but also of bandwidths to show higher ambitions (a glimpse into the future).
- There are no hard norms for heat and drought, let alone more ambitious norms.
- It is not really important if it is 2050 or 2085 - the climate can suddenly change much faster, bringing the decision moments closer.
- More buffering or raising costs money. Always the trade-off: How certain is something, how much are we willing to pay for it now and how much in the future?

### What is the biggest challenge for climate adaptation?

- Challenge is uncertainty and robustness, how robust do you want to prepare?
- Becomes a serious topic: More conversations with insurers and investors on how they integrate adaptation into investment decisions.

### Is there a period of return on public investments?

- Municipality is responsible for the public space, and carries the costs for construction, which is funded from the land exploitation (GEX) - Municipality also has an Urban fund, to cover development costs or to reimburse the fund of different projects.
- Payback period of measures: Developers can build and resell quickly, owners then have to pay for adjustments. Municipality always pays for the costs of public space.
- In Haven-Stad there are few municipal properties, so cannot use tenders - but can ask for requirements for changing the zoning plan (to make development possible)
- The legal norm is the starting point. Additions to the norms are settled with the land value.

### Are there stress tests for Haven-Stad?

- Waterbestendig Westpoort and we work on the rainwater challenge.
- Stress tests are usually based on GIS data. This data is not available yet for the future design of Haven-Stad.
- For Heat: model check on small scale, qualitative on bigger scale (design sessions about orientation and heights with experts).

### How is Climate Adaptation organized?

- Experts from Engineers Office (IB) examine and help designing water systems. They cooperate with Waternet experts (knowledge about main water system).
- Designers from Urban Planning & Sustainability (R&D) consider green, water and public space - but do not have time to stay 100% up to date with the latest standards - my function for Haven-Stad is to integrate sustainability [including climate adaptation] in the projects.

### Does water have enough saying power in development?

- Climate adaptation, especially with natural solutions, must be considered in early stage.
- Topic is area overarching because systems are interconnected. Challenge is to design at an appropriate scale, and prevent that individual projects block the future main water system.
- Maybe more attention needed for a longer timescale and to go beyond the minimum [norms].

### How are areas subdivided, who is responsible for the central thread?

- R&D does explorations, makes plans and policy, and designs. G&O does the land exploitation. V&OR does the infrastructure (for instance Transformatorweg).
- Projects have own project organizations which develop within certain boundaries.
- Water systems are interconnected and ask for a separate project, a team that evaluates it integrally.
- Waternet has a more regional viewpoint - could maybe do more [on water/climate on the cross-project scale].

*Note: Haven-Stad organisation (team thinking about long term for different sub-areas) is not typical for the whole of Amsterdam.*



## IV4. Wieke Pot

Date: 12-01-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Dr. Wieke pot has a MSc and PhD in Public Administration. Her PhD 'Deciding for tomorrow today' was about forward-looking decision making in water infrastructure. She works as an assistant professor at Wageningen University & Research and studies the governance of social-ecological-technical systems for improving resilience.***

### Why has the long term not yet been properly considered in Water Management?

- Regional water authorities (functional democracies) are legally required to focus on their core tasks = water-related tasks; therefore, they are reluctant to go 'out of the box'. For long-term tasks, margins are investigated because they can play an important role for climate adaptation.
- Investment budgets are often fixed for the long term; it is complicated to deviate from it later. Budgets provide a guideline for when to invest and which parties to invest.

- Double role of politics, positive and negative.
- Positive: Politicians are very active in the 'outside world' and are good in observing new developments. They help to bring new insights and knowledge into the organization and to react to the developments (responsiveness). Also political leadership and entrepreneurship can positively influence the consideration of the long term. Politicians and civil servants want to be sure to make good decisions, so they investigate options and ask for extra support/arguments for a decision. This is positive for the foresight.
- Potential negative:
The politics are driven by electoral cycles (typical short periods) and both politicians and civil servants can be focused on risk reduction. Politicans often seek some sort of certainty and want to avoid putting pressure on their electoral position. The civil servants can be reluctant when making decisions. They often go for proven solutions and this could yield less innovation.

- Long term is about uncertainties, flexibility is required, and space is needed to let go of initial plans. This topic is still in its infancy, there is something to gain.

### There are many risks associated with long-term uncertainties, so isn't more research being done?

- On the one hand: risks often lead to additional research, and they also lead to making robust decisions.
- On the other hand: there is little discussion about uncertainties and associated flexibility. The scenarios are often flattened.
- Government tries more to limit risk as much as possible instead of embracing uncertainty. For instance, by providing answer to uncertainty by implementing flexibility.

### What is the municipal status of embracing flexibility and the testing of robustness?

- 40 municipalities involved in research about urban water management. Slowly towards more disconnecting, buffering, etc. (has flexibility in it). But not explicitly mentioned as flexibility.
- In terms of substantiation, often use of cost-benefit analyses (again about risks). Less robustness testing for different scenarios.
- Need for broader robustness/stress tests. Including multiple scenarios and stresses (also heat/drought). It starts to grow but looking for guidance from Delta Program.
- Municipality of Amsterdam is active with Rainproof. In general, larger municipalities perform better, more departments to study the long term.

### What timescale is typically used?

- Different timescales are used. 2050 was the furthest point of reference for long-term visions/objectives found in the PhD research.
- KNMI Scenarios are often summarized, but this should not be the goal of scenario studies. Testing/scenarios not always linked to decision-making.
- Can use regulations to anchor future thinking and for preparing investment decisions. Request substantiation based on future scenarios, in addition to monitoring and possible reconsiderations.

### Relation Water Management (WM) and Spatial Planning (SP) for forward-looking decisions?

- WM looks at the longer term due to long lifespan of infrastructure, prospect needed.
- SP is thinking more about the future functions. What value/purpose does a certain area have now and then?

### How can adaptive pathways contribute to forward-looking decisions?

- Value-based asset management. Can be useful to include different assets, and to include the relations. Furthermore include values to determine when to invest.
- Think about which actors would have an opinion about something and when [planning, politics, asset management, policy department].

## IV5. Mark Koelman

Date: 04-03-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Mark Koelman is consultant sustainable urban development at the Municipality of Amsterdam. He also leads the project Basisweg/Transformaterweg at Koppelkansen.***

### Definition of Climate Adaptation?

- Adaptation, ability to cope with changing environmental conditions
- Climate themes: raising water level, heat, intense rain, etc.

### Function and department at Municipality?

- Consultant sustainable urban development for New-West, translating policy and ambitions into projects for new-build and existing urban areas.
- Koppelkansen, bring together different actors, and learn about effective cooperation
- Department strategy Space & Sustainability. (R&D), Team New Challenges (TNO).
- Cooperation with Traffic & Public Space (V&OR), Land Development (G&O), Engineer Office (IB) and Project Managers (PMB).

### Role of Municipality for Climate Adaptation?

- Municipality is responsible for creating a safe living environment, preparing the public space for the consequences of climate change.
- Municipality of Amsterdam is aware of the consequences, but the translation to projects must grow.
- At the level of plots, Municipality has less control than over public space, it needs to convince other parties. Also, in the financial contribution for development. Unless the plots are municipal properties that are leased to other parties.
- Municipality looks far ahead, but in politics a period of 4 years is seen as the long term
- Need to look more integral.
- For example, design capacity of 60 mm/u, flexibility required for more intense rainfall, but limited resources available to demand to design beyond the minimum.

### What happens if hard requirements are set, for example rainfall capacity of 120 mm?

- Parties will likely tender for assignment, the question is whether the requirements can be met. Alderman must account to council, asking the market too much can cause political tensions. And there are various other requirements (energy, social housing) which also need to be considered.

### Which spatial scale for sustainable development?

- Municipality works on plot level, land allocated to different parties, per plot sustainable requirements can be set.
- For other topics like mobility and utilities, the regional level scale is common.
- In the case of land allocation, regional area development ambitions can be translated into specific measures per plot.

### What typical timescale is used?

- Goals for 2050 are used, far prospects for roadmaps, timescales are based on a mix of national and municipal policies
- Vision documents as starting points, translated into projects, resources now available and what is needed in the future?

### Which actors are involved in Climate Adaptation, where is the responsibility?

- Cooperation with regional water authorities and Waternet, and internal organizations for public space.
- Early involvement of Waternet in urban development is useful, water regulations etc.
- Adaptation is a vital and shared task for government, private parties, and consumers
- Water Management is not only flood protection, but also urban design.

### Are there any issues or improvements?

- If tension arises, then mainly during execution, because of difficulties.
- Mobilizing funds can be difficult for urban design of public space, or can be used from the land exploitation.
- Less project based, more area focused.
- Managing one scale level higher for efficiency, or via government/ministry.



## IV6. Valerie Deckers

Date: 05-03-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Valerie Deckers is an advisor in sustainable urban development at the Municipality of Amsterdam. She is responsible for sustainability within the urban development of Amsterdam East.***

### Definition of Climate Adaptation?

- Adaptation measures to buffer the negative consequences of climate change as much as possible, so that the quality of (urban) life is preserved.
- Climate themes: heat, drought, rainwater, waterlevel increase.

### Function and department at Municipality?

- Department Urban Planning & Sustainability (R&D), Team Strategic Development.
- Cooperation with Traffic & Public Space (V&OR), Land Development (G&O), Engineer Office (IB) and Project Managers (PMB).

### Role of Municipality for Climate Adaptation?

- Crucial role, it owns a lot of plots, and it can challenge developers in land allocation.
- Municipality creates ambitions and frameworks, to guarantee future proof quality of housing and public space.
- Previously, strong municipal control was more common. With new laws coming up for spatial development, participation of residents and other stakeholders will be much more important in the proces of urban development. How does the municipality carry out its climate adaptation tasks?

For new-build via tenders. Ambitions in Strategy Climate Adaptation and translation to measures in Implementation Agenda (for municipality and stimulation inhabitants).

### Which spatial scales, for Municipality, and Climate Adaptation team?

- Different municipal teams look at different scales, often the teams complement each other. It is a challenge for the different teams to cooperate throughout these different scales and to coordinate all 4 aspects of climate adaptation on all scales.
- The Program Climate Adaptation creates the strategic vision and policies. Vision and policies are implemented in the projects. The urban advisors couple the policies to projects and other relevant teams.

### What is a typical timescale used?

- 2050, based on climate projections, designers are limited to available data.
- In urban development, areas are being built to last 100 years and beyond, therefore you want to look beyond 2050. Despite the uncertainties, Haven-Stad will therefore also be evaluated until 2100.
- Developers who remain owner of the building, have other (future) interests.

### How long is your team involved in projects?

- Area development takes long, +- 15-20 years.
- The team of advisors in sustainable urban development has been founded 2,5 years ago. Since then, the advisors are more and more involved in the projects. The team is involved from the start of projects until the final design. Attempt to better monitor the management and evaluation of ambitions. But, Municipality has not the mandate to do that for every location.

### Which actors are involved in Climate Adaptation, where is the responsibility?

- Waternet, Rijksoverheid, Province and research institutions. Close cooperation with the Metropol region MRA. Waternet puts topic on agenda of politics (e.g., rainproof).
- Municipality is responsible for safety and livability.
- Strategy Climate Adaptation has been set up together with water authorities.

### Internal and external goals/challenges?

- Municipality dependent on governmental decisions (e.g., Bouwbesluit regulations) and water authorities. Municipality has power to set own frameworks, based on private law, and municipal regulations.
- No adaptation rules on national level, also for other themes such as heat and drought.

### Are there any issues or improvements?

- Who will pay for the investments for public space? It influences business cases for developers. Also consider adaptation when redevelop areas. Usually three crucial aspects: organization, money and underground space.
- Design flexibility required for urban development, possibility to go back to certain points in design phase based on new insights.

## IV7. Annebet van Duinen

Date: 08-03-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Annebet van Duinen is a climate adaptation policy advisor at Province of Noord-Holland, she contributed to the Delta Plan Spatial Adaptation and incentive program.***

### Function and collaboration with other departments?

- Climate adaptation, defining the role of Province and National Delta Program.
- Policy department, sector spatial policy (environmental, water, regulations, etc.).
- Integral approach between sectors of Province.

### Role of Province in climate adaptation?

- Pointing out different interests, topic is wide and influences different parties and aspects.
- Connected to the core tasks: embedding climate adaptation and stimulating (e.g., via subsidy schemes).
- Creating regulations, asking municipalities to incorporate climate change effects and measures in urban developments.
- Climate adaptation is broad and of everyone and everywhere (all levels of government are involved). But it has never been agreed who is really in charge.
- Risk is that you agree in ambitions, but then the how-question and who takes which role takes a lot of time and talking.

### Role of Municipalities and Water Boards?

- Municipalities are doing very well, but are often focused on shorter term and focused on pluvial flooding, they remain close to core tasks (e.g., drainage system).
- Water boards are actively involved in climate adaptation, they can advise, but cannot enforce/ensure spatial design decisions (functional democracy).

### Responsibility of Province in climate adaptation and Haven-Stad?

- Province takes care of aspects in living environment, manages (up to a certain scale level) where building is allowed and regulates urban norms.
- Policy boundaries, the Province mainly considers rural areas and the Municipality urban areas.
- Municipality of Amsterdam operates fairly independently (due to strong governance force, 'own water board' (Waternet), more civil servants).

### Challenge of Climate Adaptation?

- Climate adaptation is fairly new; for the future (government) it is important to define who picks up what.
- Climate adaptation is still insufficiently seen as an integral task + It's 'too far from my bed' + delayed processes.
- Actors do not cooperate sufficiently (each for its own).
- A lot is still being looked at with the 'glasses of today'; not much consideration of what the society will look like in the future, with the climate tasks that will come?
- Minister of Spatial Planning - nice aim but diametrically opposed to environmental law + Space scarcity can also not be solved on the national scale.

### How can the role of Province be improved?

- Acceptable risk should be clearer (because consequences and damage are not yet clear)
- Mapping feasible building areas, tools to emphasize risks and required measures.
- Combination of minimum norms and stimulating innovations would be good.
- For a level playing field in regulations between regions, the national government (legislation) is needed.

### Timescale of Province for Climate Adaptation?

- Structural vision till 2050 (revised every 4 years), but big challenges are after 2050, should start with it now already (desirable to extend time scope for climate challenge).
- Municipality administrators in general have a scope of 4 years and no further - but maybe the challenge also needs the scale of the province and national government.

### Province scope, e.g., for Haven-Stad?

- Continuous process of spatial planning on larger scale.
- Housing agreements with municipalities.
- Amsterdam owns a lot of property, able to direct and set requirements - Stacking of requirements, builders are quick to say they can't afford it.

### Integration of water and spatial design?

- Desirable for climate adaptation, integral cooperation between actors - At Province: Different sectors try to work together, but sometimes it is difficult to find each other.
- Focus not only on ambitious concepts, but also on feasible plans.
- National & regional government's focus on climate adaptation is primarily the Water Domain. The working regions also emphasize the relationship with the water chain.

### How is the cooperation with different actors?

- Visions for a shared challenge can be hard to define, but for MRA it seems to be succeeding.
- In a shared challenge, there must be consensus about responsibilities.
- Responsibilities about risks and financial consequences.
- Need to provide insight into the most urgent challenges in the longer term.

### Tensions in cooperation? About what?

- Who does what, who is responsible for it, who guarantees what and financial consequences.
- Climate adaptation is a joint task and there is as yet no consensus on the responsibilities + There are a lot of guidelines , but it stalls when it comes to safeguarding, implementation and execution.

### Suggestions for improvement?

- There should be more clarity and consensus about which risks we do not accept together and who has what role in reducing those risks.
- More control from the government, especially linked to the NOVI.
- There is no overview of the actual urgencies, especially after 2050 and what we, as joint governments, consider to be the most important tasks.



## IV8. Paulien Hartog

Date: 17-03-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

***Paulien Hartog is Strategic Advisor at Waternet. She works as member in the Climate Adaptation team and the national Spatial Adaptation team.***

### Function at Waternet?

- Strategic advisor, rural and urban area.
- System thinking and incorporating uncertainties, strategic at different levels.

### Relevant for Climate Adaptation?

- Governance for climate adaptation (multiple themes) is developing, 2017 Deltaplan Spatial Adaptation, iterative development process.
- Topic can be complex in big cities such as Amsterdam.
- Program team, time needed to grow leadership and to embed the knowledge in organizations.
- Program Sustainable Urban Development, includes important adaptation actions.

Role of Waternet for Climate Adaptation?

- Coordination required between Municipality and Waternet, mutual agreements about requirements between different parties.
- Adaptation knowledge is in transition phase.
- Example, rainproof urban design and financial incentives to cover costs.

### Which spatial scales are considered?

- All scales, interconnected water systems.
- Haven-Stad: IJ river, North Sea canal and Amsterdam Rhine canal as system.
- International cooperation, peer-to-peer transfer of knowledge and tools.
- Knowledge need to be integrated in different frameworks of Municipality.
- National, different development locations where cooperation between region and government will intensify (Haven-Stad).

### Should the costs be divided among the parties involved, e.g., by means of fixed percentages?

- Distribution of costs usually not fixed, different actors and starting points. Defining framework and lead can be useful for development and management.
- Keep contribution to rainproof measures limited to what is allowed from the statutory sewage levy.
- General funds of Municipality, use of water share is subject to regulations and Waternet can contribute from its core task.
- For example, Copenhagen covered a part of development costs for a water resilient city through an increase in water taxes, allowed?

- In case of climate adaptation, the costs and benefits on longer term should be considered.
- Spatial quality is based on multi-functionality, how to define and to improve?

### What are the main barriers to climate adaptation, now and in the future?

- Financing of measures is the largest barrier.
- Need for a management process that is flexible, and can be adjusted based on different climate points and insights in time.
- Not business as usual, ability required to deviate from contracts to improve urban resilience.

- Private actors demand national frameworks including standards, but climate adaptation is also very regionally specific.
- Mitigation and Climate Adaptation are both needed in the future. Mitigation is sometimes clearer and there are more resources available. However for Climate Adaptation, tailor made solutions are needed.

- Example space reservation, IJ-meer dike, extra wide dike. Ability to elevate the dike in the future. Now multifunctional (e.g., recreation uses).
- Climate Adaptation requires thinking far ahead in early urban design phase.

### IV9. Sander van der Wal

Date: 14-04-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

*Sander van der Wal is the founder and co-owner of &Flux. He works on a more sustainable Netherlands (climate adaptation, circular economy, raw materials and energy transition), by setting up collaborations and creating impact.*

**Role of &Flux in climate adaptation?**

- Setting up partnerships and agreements. Bringing public and private parties together to tackle the task. Great need from the market for a level playing field.

**Governmental roles in climate adaptation?**

- The implementation of Climate Adaptation is decentralized, at municipal level together with regional water authorities. Land often not owned by municipality, then municipal requirements are imposed on developers.
- Provinces have the (regional) scale and can facilitate uniformity in their area. They have no control over how to build. Provinces facilitate the cooperation of municipalities, developers, and regional water authorities.

**Do current roles need to change?**

- Now too much public, should be more towards public-private. Decide together how to do it. Working together with market can allay fear and increase mutual ambitions.
- Climate Adaptation is in the exploratory stage in urban development (know-how, processes, KPIs). Municipalities must embed sustainability better in urban organization.
- Municipalities are careful and point to market, but market often wants to act faster.
- Too little communication, especially public-private. Sometimes bubbles or conservative.

**Do we think far enough ahead?**

- No, the bar is set on 2050. But climate change does not stop after 2050. However, the problem lies in:
- 1. Administrative agreements say 2050 (DPRA). No initiative to look any further.
- 2. Problem too far away: 'We don't have to do anything today, there is plenty of time'
- 3. Future, the action perspective becomes more complicated, of what should be done.

**Uncertain future, has enough been studied?**

- Work efficiently (time, money), want to design for real case, difficult to determine.
- Lack of ownership. Which actors have a problem in the long term?
- Lack of creativity. Reserve space (e.g., 5% area). But who is prepared to invest now to prevent higher costs in the future?

**Are private actors long enough responsible?**

- Depends on whether they have long-term land position or build and sell quickly.
- Many buildings are in the portfolio of institutional real estate investors (clients of developers). They are aware of climate risks, and want to reduce risks. If investors and municipalities ask for climate adaptation, the market will follow.
- Market failure, reserve space not in interest of market or municipalities. Therefore, governmental land fund: Buy land, do nothing, temporary function, sell when space is needed for new functions in the future.

**Biggest challenges for climate adaptation?**

- Non-commitment must disappear. Climate adaptation must become business as usual.
- Until 2050: Make the costs clear, and that it does not have to take longer. Instruct urban developers to implement in policy and design.
- After 2050: Solve the missing action perspective together. Making goals and agreements, offering a perspective for action, and create performance requirements.

**Do agreements also include adjustments for climate adaptation in existing areas?**

-MRA agreements are about new building and not existing. Also working on existing. Use intervention moments wisely and include climate adaptation.
- Agreements about/till 2050. Targets are adjusted every 2 years (for new construction).



### IV10. Steven Slabbers

Date: 17-05-2021
Interview was conducted in Dutch and is translated.
Consent for audio recording and use in thesis.

*Steven Slabbers is the PARK (Provincial Advisor Spatial Quality) of the province North-Holland and he is landscape architect at his own company BoschSlabbers.*

**Role of the province for climate adaptation? Should this change?**

- Yes. North-Holland is sensitive to climate change, surrounded by sea. The sea level rise is tricky, in every scenario there is an acceleration in the period of 2050-2100.
- Province should direct from a regional level and from a longer-term perspective.
- Vision is needed more than ever, an alternative to vision is adaptive planning.
- Developments are happening faster and the changes are more drastic. Planning cannot be done without a dot on the horizon, you can't steer if you don't know the destination. Planning that only says which conditions must be met is fundamentally different.

**Long-term vision for adaptation pathways?**

- Deltaplan 1958, both a dot on the horizon and an addition of flexibility to include experience gained in any adjustments.
- 'I see adaptation paths as a maze, no, I want an inviting perspective that people support.'
- The challenge lies in combining tasks: space claims and multiple users of space.

**Relationship between water management and spatial planning?**

- Everything must be integral, priority to safety & quality. Solutions with added value.
- Mainly technical solutions have been used in NL in the water system, sometimes missed potentials to add value. NL is experienced at fine-tuning, but limits have now been reached. New (more robust) layout is needed.
- Water management is based on agricultural wishes; more differentiation is needed.

**Time scale used for climate adaptation?**

- Urbanization challenges. Unfavorable to make decisions that seem logical in the short term. Need a longer-term mindset to set out strategic lines. Accompany each coalition agreement (of 4 year) with a long-term vision.
- Real question is: What kind of society do I want to live in and how to contribute to that?

**How to decide which measures are no-regrets? Could a temporary function lead to problems in the future?**

- How to make investments so that they are no-regret? Believe in use technologies, e.g., underwater technology Hafen-City Hamburg.
- Space reservation. Leaving plots empty is a waste of space, the pressure on the space is too big. Temporary function can be useful.
- Citizens must participate in the planning in a different way. Involve earlier and make clear what decisions can mean for society.

**Do you have tips for flexible design, from a landscape architect to an urban planner?**

- Landscape architect is more than urban planner aware that the world is continuously developing. Urban planner thinks more: a city is built and that's it. Not quite right, because e.g., mobility and housing will develop.
- Developing actors can be very conservative in building housing. They should realize what the conditions can be over 50 years.
- Everything is going to change so quickly and radically, adaptive planning is necessary.
- Requires a different type of planning, a different type of citizen involvement, possibly also a different governance composition.

**Does something have to change in the current governance and financial world?**

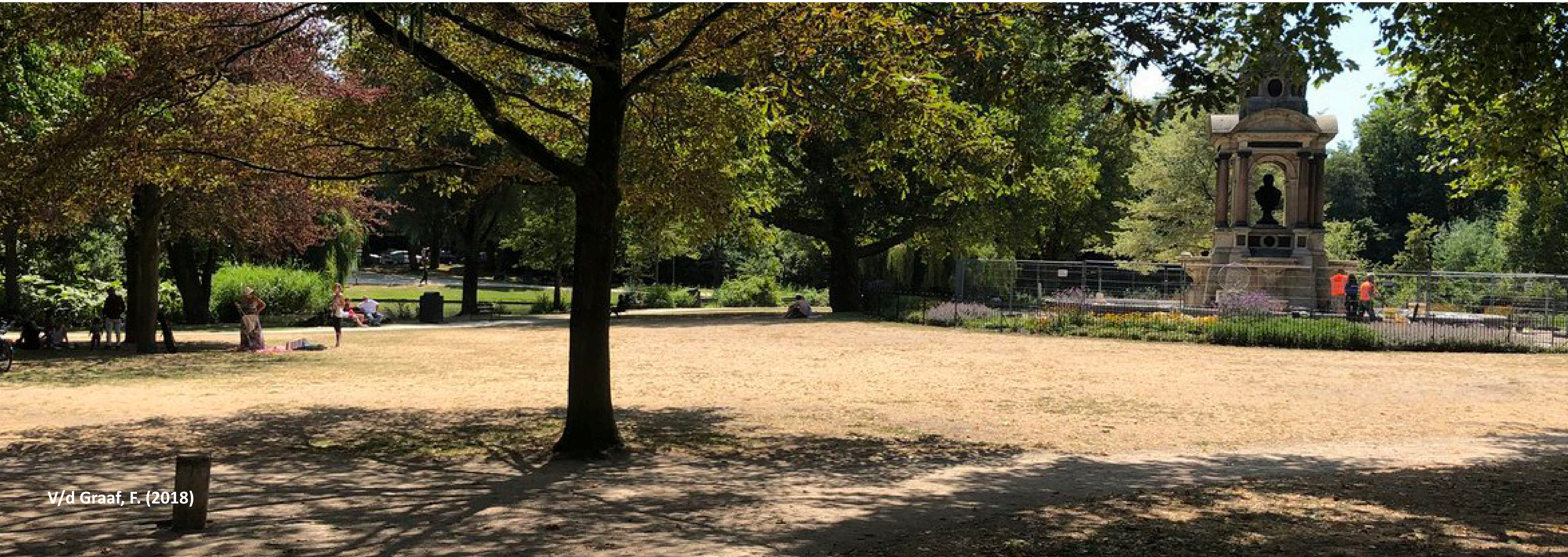
- Organization of the regional water authorities is quite old-fashioned. Seats have been retained for agriculture and industry.
- Regional water authorities exist to attune water to agricultural use. It does not meet the tasks the rural area has for the future.
- Not in favor of abolishing regional water authorities. They are long established and highly specialized governmental bodies.
- Different financial actors will look more at the effects of investments on biodiversity.
- Get an overview of social costs and benefits.

# APPENDIX IDENTIFICATION

6

# FRAMEWORK

6.3 Climate Objectives



V/d Graaf, F. (2018)

# 6.3 CLIMATE OBJECTIVES

## PLUVIAL FLOODING

### Objective

Indicative for pluvial flooding in urban areas are short and heavy local rainstorms of 1 hour (MRA & Inbo, 2021) and an acceptable return period of exceedance of 1/100 years.

For the 'basic safety level' (basisveiligheidsniveau) the MRA defined the following objectives concerning pluvial flooding:
- *'Heavy rainfall (1/100 years) does not cause damage in and to buildings, infrastructure and services.*
- *'With heavy rainfall (1/250 years) vital and vulnerable infrastructure and facilities remain functional and accessible'* (MRA & Inbo, 2021, p.10).

In this research the 1/100 years event is used to define the tipping points for pluvial flooding. In the current climate the 1/100 years event has an intensity of 53-64 mm in 1 hour (Beersma, Hakvoort, Jilderda, Overeem, & Versteeg, 2019). However, the intensity is projected to increase in the future.

To prevent pluvial flooding after short and heavy rainfall, fast storage is needed. The needed storage capacity depends on the future rainfall intensities.

*Objective:*
***The fast storage objective changes over time, depending on the future 1/100 years precipitation event. It is possible to store all rain of this event within Haven-Stad.***

### Calculation

To calculate the intensity of the future 1/100 precipitation event, the table from the STOWA statistics (Beersma, Hakvoort, Jilderda, Overeem, & Versteeg, 2019) is used, see Figure 6.1.

FUTURE PRECIPITATION EVENT [1/100 yrs] =
64 mm/h + 64*(%/100) [% from KNMI scenarios]

FAST STORAGE OBJECTIVE (m3/h) =
FUTURE PRECIPITATION EVENT (m/h) * TOTAL AREA (m2)

STORAGE [water] (m3) = LENGTH * WIDTH * DEPTH
STORAGE [soil] (m3) =
LENGTH * WIDTH * (DEPTH * POROSITY [soil])

In the calculation for the tipping points for Haven-Stad, three main assumptions are made:
- The risk perception and the acceptable risk remain the same in the future;
- All rain is stored (no (natural) discharge);
- The 1 hour rainstorms stay a good indicator for pluvial flooding in the future

| Scenario | Verandering tov 2014 [%] | | |
|---|---|---|---|
| | Lower | Center | Upper |
| 2030 | 3,9 | 5,8 | 7,7 |
| 2050_GL | 3,9 | 5,8 | 7,7 |
| 2050_GH | 4,9 | 7,4 | 9,8 |
| 2050_WL | 10,2 | 14,9 | 19,6 |
| 2050_WH | 11,1 | 16,2 | 21,3 |
| 2085_GL | 6,4 | 9,6 | 12,8 |
| 2085_GH | 7,2 | 11,2 | 15,2 |
| 2085_WL | 20,1 | 30,6 | 41,1 |
| 2085_WH | 20,1 | 30,6 | 41,1 |

***Figure 6.1.*** Change of the extreme precipitation in the KNMI'14 climate scenarios. Reprinted from *"Neerslagstatistiek en -reeksen voor het waterbeheer 2019"* (p.45), by Beersma et al., 2019. Copyright 2019 by STOWA.



## DROUGHT

### Objective

The objective is adapted from the principles of the 'basic safety level' (basisveiligheidsniveau) of the Metropoolregio Amsterdam (MRA) (MRA & Inbo, 2021):

*' During prolonged drought (once every 10 years) damage to buildings, roads, greenery and vital- and vulnerable functions is prevented.'* (MRA & Inbo, 2021, p.10).

For this research the assumption is made that the acceptable return period of exceedance is therefore 1/10 years. Also the KNMI made projections about the increase of the highest precipitation deficit exceeded once in 10 years.

To prevent drought, slow storage is needed. The needed storage capacity depends on the future precipitation deficits.

*Objective:*
***The slow storage objective changes over time, depending on the future 1/10 years precipitation deficit. It is possible to store the complete deficit within Haven-Stad.***

### Calculation

To calculate the future 1/10 precipitation deficit, the KNMI' 14 scenarios are used (KNMI, 2015). The calculation uses the 'highest precipitation deficit exceeded once in 10 years' .

FUTURE PRECIPITATION DEFICIT [1/10yrs] =
230 mm [reference period] + 230 * % [KNMI-scenarios]

SLOW STORAGE OBJECTIVE (m3) =
FUTURE PRECIPITATION DEFICIT (m) * GREEN AREA (m2)

STORAGE [water] (m3) = LENGTH * WIDTH * DEPTH
STORAGE [soil] (m3) = LENGTH * WIDTH * (DEPTH * POROSITY [soil])

In the calculation for the tipping points for Haven-Stad, three main assumptions are made:
- The risk perception and the acceptable risk remain the same in the future;
- The urban green area evaporates the same amounts as the reference crop;
- The slow storage is fully filled prior to a 1/10 drought

## HEAT

### Objective

For the 'basic safety level' (basisveiligheidsniveau) the MRA defined the following objective concerning heat:
- *'During heat (minimum 1 heat day) the plan area provides a healthy and attractive living environment and microclimate.'* (MRA & Inbo, 2021, p.11).

The study 'De hittebestendige stad' (Kluck, et al., 2020) describes how this can be reached and formulates the main goals of heat measures as follows:
- *'Decrease the air temperature city-wide, both during the day and at night.'*
- *'Create local cool places with a low comfort temperature to cool off during a hot day.'*
(Kluck, et al., 2020, p.38)
The air temperature is connected to the energy balance of the city and the comfort temperature is connected to the energy balance of the human body.

In this research, the comfort temperature is selected as the temperature to work with, because it represents the impact on humans better than just the air temperature. The comfort temperature is not only influenced by the air temperature, but also by other weather factors (i.e. wind), the environment, and personal factors (Goede, 2020).

The comfort temperature is often expressed as the PET-value (Physiological Equivalent Temperature; in degrees Celcius) and in the Netherlands, the PET value is selected as the main indicator for heat stress (Brolsma, 2020).

Figure 6.2 shows the thermal perception and degree of physiological stress for each PET-class. It can be noticed that moderate heat stress starts at a PET value of 29 C. A PET value of 29 C thus seems a logical objective. However, the heatmap of Amsterdam shows that during a hot day, this value is almost everywhere exceeded (Brouwer et al., 2020). Therefore Brouwer et al. suggest to set the objective to a maximum PET value of 36 C (Brouwer et al., 2020). Kluck et al. indicate that a maximum of 35 C is a logical objective, as it prevents strong and extreme heat stress (Kluck et al., 2020). In this research, a maximum PET value of 35 C is used, as this is the start temperature at which strong heat stress occurs. To prevent heat stress, cooling measures are needed. The needed temperature reduction depends on the future temperature rise.

*Objective:*
*The cooling objective changes over time, depending on the temperature rise. The maximum PET value in Haven-Stad is 35 C.*

| PET (°C) | Thermal perception | Degree of physiological stress |
|---|---|---|
| < 4 | Very cold | Extreme cold stress |
| 4 – 8 | Cold | Strong cold stress |
| 8 – 13 | Cool | Moderate cold stress |
| 13 – 18 | A little cool | Light cold stress |
| 18 – 23 | Pleasant | No thermal stress |
| 23 – 29 | A little warm | Light heat stress |
| 29 – 35 | Warm | Moderate heat stress |
| 35 – 41 | Hot | Strong heat stress |
| > 41 | Very hot | Extreme heat stress |

***Figure 6.2.*** PET-classes, thermal perception and degree of physiological stress. Adapted from "*De hittebestendige stad. Een koele kijk op de inrichting van de buitenruimte*" (p.31), by Kluck et al., 2020. Copyright 2020 by Hogeschool van Amsterdam.



### Calculation

For the calculation of the PET temperature, the calculation tool of the 'Klimaatbestendige Stad (KBS) Toolbox' can be used (Deltares et al., n.d.). This tool calculates the reduction of PET temperature after the implementation of climate adaptation measures.

The toolbox makes use of the PET values from de 'klimaateffectatlas' (Stichting CAS, n.d.-b). These are the mean (12:00-18:00) PET values on 1 July 2015. This day is considered as the representative 1 in 1000 heat day for the summer period (April-September) and is selected by the RIVM for the heat stress tests. In the current climate, the chance for this day to occur is 1 in 5.5 years (RIVM, 2019).

To calculate the future PET values, three steps are made. First, the future PET-value without measures is calculated by adding 1.25 * the temperature rise (as can be seen from Figure 6.3, this calculation is very simplified). The factor 1.25 orginates from the formula of PET from the RIVM, see Figure 6.3. The temperature rise is adopted from the KNMI projections about the temperature on the warmest summer day (KNMI, 2015).

PET_FUTURE (C) =
PET_2015 + 1.25 * TEMPERATURE RISE

TEMPERATURE RISE = + ...C [depending on scenario]

Second, the effect of the implementation of adaptation measures is calculated with the KBS Toolbox. The reduction in PET is determined by the reduction factor of the measure and the difference between the local PET-value (2015) and the minimum PET-value (2015) in the 2 km2 surrounding the project area (Brolsma, 2020):

PET_REDUCTION (C) = (PET_local - PET_minimum) * RF
PET_local = Local PET-value (= PET_2015 Haven-Stad)
RF = Maximum reduction factor of climate adaptation measures

PET_minimum = the minimum PET-value in the 2 km2 surrounding the project area (= PET_2015 2 km2)

The future PET-values after implementation of adaptation measures is calculated as follows:

PET_FM (C) = PET_FUTURE - PET_REDUCTION

In the calculation for the tipping points for Haven-Stad, four main assumptions are made:
- The thermal perception stays the same in the future (connected to PET-classes);
- The future PET-value (without measures) increases with the (air) temperature rise * 1.25;
- The PET_REDUCTION values do not change over time (the reduction factors do not change + the PET-values (PET_local and PET_minimum) increase with the same value (temperature rise))
- Without measures, the fully developed Haven-Stad area has the same PET values (in 2015) as the current area.

$$PET_{sun} = -13.26 + \boxed{1.25T_a} + 0.011Q_{gl} - 3.37\ln(u_{1.2}) + 0.078T_w + 0.0055Q_{gl}\ln(u_{1.2}) + 5.56\sin(\varphi) - 0.0103Q_{gl}\ln(u_{1.2})\sin(\varphi) + 0.546B_b + 1.94S_{vf} \quad (12)$$

Waarbij $T_a$ de 2m luchttemperatuur is (°C), $u$ de windsnelheid op 1.2 m hoogte (m $s^{-1}$), $\sigma$ de Stefan Boltzmann constante, $T_w$ de natteboltemperatuur, $Q_{diff}$ is de diffuse straling (W $m^{-2}$), $S_{vf}$ is de sky-view factor, $Q_{gl}$ is de globale straling (W $m^{-2}$), $\varphi$ is de zonshoogte hoek en $B_b$ de Bowen verhouding.

***Figure 6.3.*** Formula for calculating PET temperatures. Reprinted from *"Ontwikkeling Standaard Stresstest Hitte"* (p.33), by RIVM., 2019. Copyright 2019 by RIVM.

## FLUVIAL FLOODING

### Objective

The objectives are adopted from the principles of the 'basic safety level' (basisveiligheidsniveau) of the Metropoolregio Amsterdam (MRA). The objectives concerning fluvial flooding are to prevent damage, limit damage, and/or prevent victims (MRA & Inbo, 2021):

- *'In the event of flooding, no damage may occur to buildings and electrical installations in public spaces and main roads remain passable.'*
- *'Measures must be taken to limit damage in a case of flooding, provided it is efficient.'*
- *'Precautions must be taken to ensure safe shelter or to evacuate in the event of a flood.'*

(MRA & Inbo, 2021, p.12)

In Haven-Stad flooding can have multiple causes, a.o. the failure of the IJmuiden complex and failure of the Lek dike. In the report 'Kansen voor Meerlaagsveiligheid in Amsterdam - Thematische studie waterveiligheid' (Defacto Stedenbouw & RHDHV, 2021) flood maps of Amsterdam and Haven-Stad can be found. In this research the focus is on the coupling of flood depths with sea level rise. The focus is thus mainly on the failure of the IJmuiden complex.

In the future, the water levels (exposure; thus also the flood depths) are expected to increase due to sea level rise. This increases the flood risk. The assumption is made that both the acceptable risk and the acceptable probability of failure (return period) will remain the same in the future. Techniques (such as the IJmuiden complex and the dikes) will be updated according to the acceptable probability of failure. If the acceptable risk and probability of failure remain the same, the vulnerability must be reduced as the exposure (water level) increases.

*Objective: Depending on the flood depth and probability of flooding, different objectives are relevant. The MRA developed a table that sets out flood depths and flood probabilities against each other and indicates which objectives are reasonable (Figure 6.4).*

### Calculation

The risk of fluvial flooding can be defined as the product of the probability of flooding and the consequence. The consequence is related to the water level (the exposure) and the vulnerability of the flooded Haven-Stad area (spatial design).

RISK = PROBABILITY OF FLOODING X CONSEQUENCE
RISK = PROBABILITY OF FLOODING X EXPOSURE (water level) X VULNERABILITY (spatial design)

The flood depth in an area depends mostly on the height of the area. The situation of the area in the landscape can also influence the flood depth, for instance, if the area is protected from the high water by surrounding higher areas.

FLOOD DEPTH (m) = WATER LEVEL - HEIGHT AREA

In the calculation for the tipping points for Haven-Stad, three main assumptions are made:
- The risk perception and the acceptable risk remain the same in the future;
- The probability of flooding stays the same over the years (update of techniques);
- The water level of the North Sea canal (after failure) increases linearly with the sea-level rise; the flood depth in Haven-Stad increases with increasing water level of the canal.

The calculation starts from the current water levels in the North Sea canal (after failure), as presented in the study 'Kansen voor Meerlaagsveiligheid in Amsterdam - Thematische studie waterveiligheid' (Defacto Stedenbouw & RHDHV, 2021). The future water levels (after failure) are calculated by adding (a percentage of) the sea-level rise from the KNMI scenarios (KNMI, 2015). From this new expected water level in the canal, the flood depth in Haven-Stad can be calculated with the heights of the area.

*Because the flood depths do not necessarily increase with the same amount of meters as the sea level rise, a percentage of the sea level rise can be used. The greatest chance of failure is for instance overtopping (overslag), but this causes only small amounts of extra water in the North Sea canal (Defacto Stedenbouw & RHDHV, 2021).*

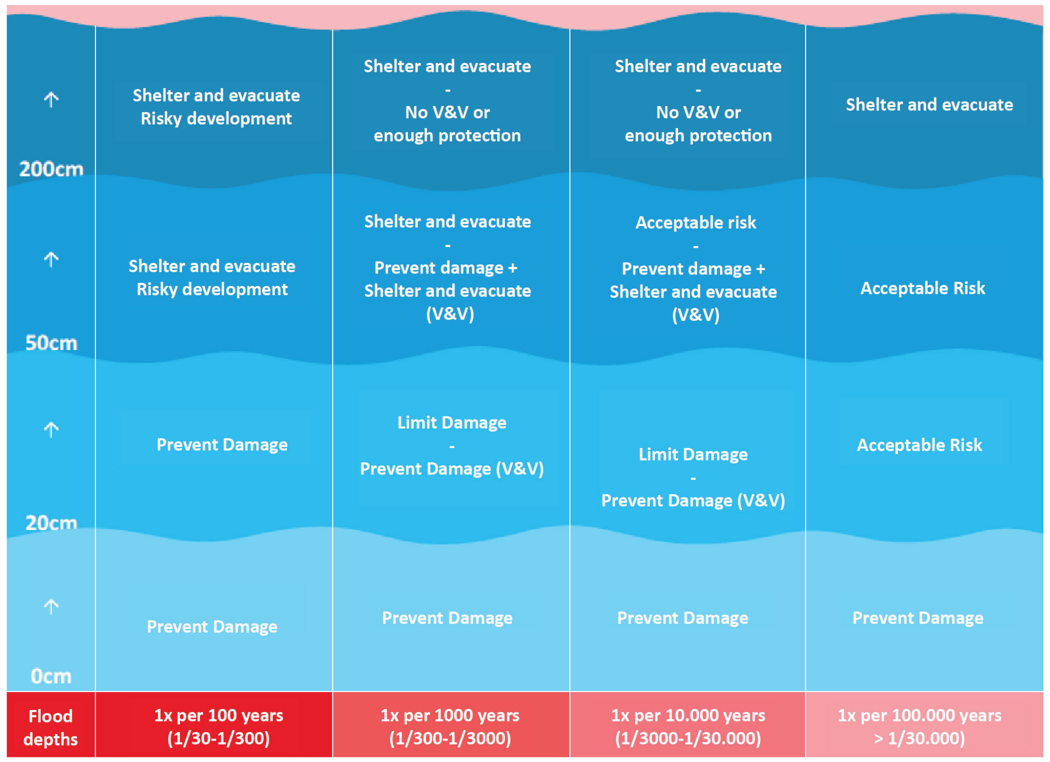


FUTURE WATER LEVEL (after failure, m) =
CURRENT WATER LEVEL (after failure, m) +
(% of) SEALEVEL RISE (m)

SEALEVEL RISE (m) = +...m
[depending on KNMI scenario]

FUTURE FLOOD DEPTH (m) =
FUTURE WATER LEVEL - FUTURE HEIGHT (of areas in Haven-Stad)

From these flood depths, Figure 6.4 can be used to find out the reasonable objectives.




V&V = Vital and Vulnerable

***Figure 6.4.*** Requirements in relation to probability of flooding and flood depth. Adapted from *"Concept Basisveiligheidsniveau Klimaatbestendige Nieuwbouw 2.0"* (p.12), by MRA & Inbo, 2021. Copyright 2021 by MRA.

# 7

# ADAPTATION MEASURES




NRC (2019)

## CONNECTIONS BETWEEN ADAPTATION PRINCIPLES

The climate adaptation principles can often be combined. This is possible when adaptation measures are combined, but also when a certain adaptation measure works for different principles.

Figure 7.1 shows a crosstable of the eleven climate adaptation principles. The table shows whether two principles could influence each other (positively/ negatively) or not.

The text inside the boxes explains why the influence is considered potential positive ( ‘koppelkans’ ) or potential negative ( ‘pay attention’ ). In order to determine this influence, only the combination of the principles is considered. Competition for space is not considered.

| | Ventilation | Shading | Evaporation | Materialization | Storage | Flexible water levels | Infiltration | Re-use | Protection | Robust urban design | Evacuation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ventilation | | Orientation both for shad. and ven. | More evap. possible with more ven. | | | | | | High structures can prevent ventilation | | |
| Shading | | | Trees both give evap. and shad. | | | | | | | | |
| Evaporation | | | | More green (mat.) = more evap. | Sto. to water plants for evap. | More evap. with higher g.water levels | Inf. adds to groundwa-ter, used for evap. | Use stored water to water plants for evap. | | | |
| Materialization | | | | | Green areas (mat) can store more water | Plants that can handle different waterlevels | Soiltype + topsoil (mat) influence inf. | Green areas (mat) can store more water | | | |
| Storage | | | | | | Lower levels = more storage | Inf. stored water, store water in ground | Stored water for re-use | Difference between open or closed systems? | Partial elevation, lower for storage | Higher grounds for evac. lower for stor. |
| Flexible water levels | | | | | | | More inf. capacity with lower waterlevels | | Protection that can cope with different waterlevels | Design quays/banks- to handle flex. water levels | |
| Infiltration | | | | | | | | Infil. water for r-u or r-u water for infil. | | | |
| Re-use | | | | | | | | | | | |
| Protection | | | | | | | | | | Green areas (mat) can store more water | High prot. structures for evac. |
| Robust urban design | | | | | | | | | | | Partial land elevation + safe building types |

Positive influence or koppelkans

No influence

Pay attention

*Figure 7.1.* Crosstable of Climate Adaptation Principles.

# 7.2 DESIGN LAYERS

## DESIGN LAYERS & MAATREGELENMATRIX

Figure 7.2 shows the clusters of the Maatregelenmatrix (MWH, 2012) and the design layers that are inspired by the clusters. Figure 7.3 shows the connections between the adaptation principles and the design layers.

| Maatregelenmatrix<br>*Main- & sub-clusters* | Design Layers<br>*Layers & Content* |
|---|---|
| **Soil**<br>Soil & Subsoil<br>Groundwaterlevel management<br>Infiltration<br><br>**Paved Surface**<br>Reduction of paved areas<br>Greening of paved areas | **Soil**<br>Soil & Subsoil<br>Infiltration<br>Reduction/greening of paved areas<br>+ Elevation (height strategy) |
| **Vegetation & Crops**<br>Construction of greenery & nature<br>Agriculture & crop choice | **Vegetation**<br>Construction of greenery & nature<br>Urban agriculture & crop choice |
| **Waterdischarge- & Storage**<br>Waterstorage (watersystem)<br>Waterstorage (urban)<br>Rainwater drainage<br>**Transport rainwater & sewage water**<br>**Maintenance of waterways**<br>Optimise watersystem<br>**Waterquality**<br>Purification of overflow water | **Watersystem**<br>Waterstorage (watersystem)<br>Waterstorage (urban)<br>Groundwaterlevel management<br>Rainwater drainage<br>Optimise watersystem<br>Purification of water / Waterquality |
| **Design & 'Furnishing'**<br>Shading<br>Spraying<br>Promote wind circulation<br>**Indoor air quality**<br>Building and architecture<br>Waterproof building<br>Area layout / design<br>**Elevations**<br>'Move along' | **Urban Design**<br>Shading<br>Spraying<br>Promote wind circulation<br>Building and architecture<br>Waterproof building<br>Area layout / design<br>'Move along' |
| **Flood Defences & Calamities**<br>Flood defences<br>Prioritizing<br>Prepare for calamities | **Flood Defences & Calamities**<br>Flood defences<br>Prioritizing<br>Prepare for calamities |

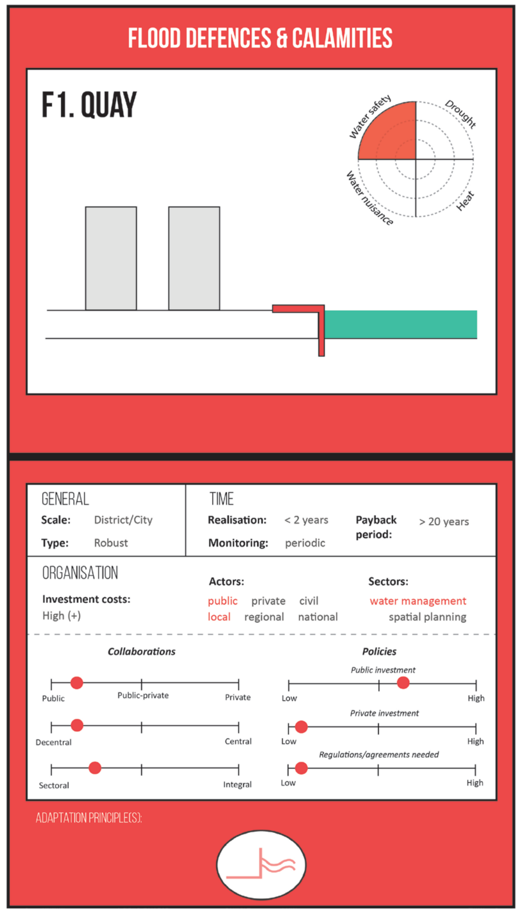
*Figure 7.2.* From Maatregelenmatrix-clusters to Design Layers
Information from MWH (2012).

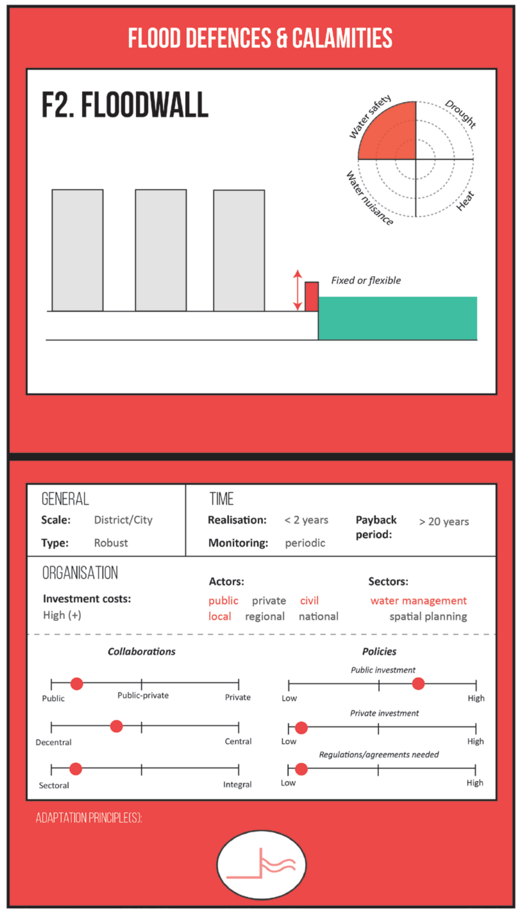
**Design Layers**

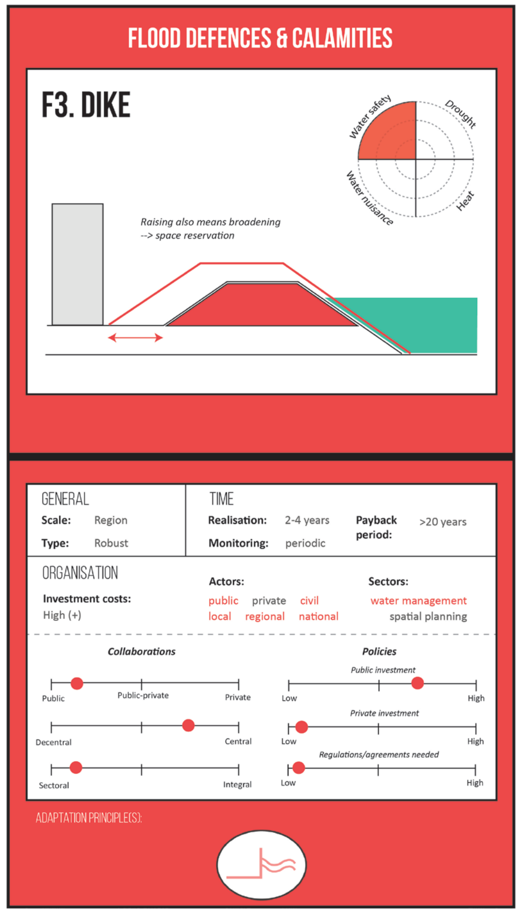
| Adaptation Principles | Soil | Water System | Vegetation | Flood Defences & Calamities | Urban Design |
|---|---|---|---|---|---|
| Ventilation | | | | | *Orientation* |
| Evacuation | *Elevated evacuation routes* | | | *Flood defence for evacuation* | *Vertical evacuation* |
| Robust urban design | *Height strategy* | | | *Buildings as flood defence* | *Water robust buildings* |
| Shading | | | *Shading trees/plants* | | *Shading architecture* |
| Evaporation | *Soil evaporation* | | *Transpiration* | | *Active evaporation (sprays)* |
| Protection | | | | *Flood defences* | *Buildings as flood defenses* |
| Materialization | *Soil types* | | *Greening & Vegetation types* | | *Building materials* |
| Re-use | *Purification & storage* | *Circular system* | *Water purification* | | *Re-use in buildings* |
| Infiltration | *Infiltration facilities* | *Infiltration facilities* | *Infiltration facilities* | | |
| Storage | *Soil storage* | *Open water & storage facilities* | *Storage in vegetation* | | *Storage in buildings* |
| Flexible waterlevels | | *Flexible levels open water* | | | |

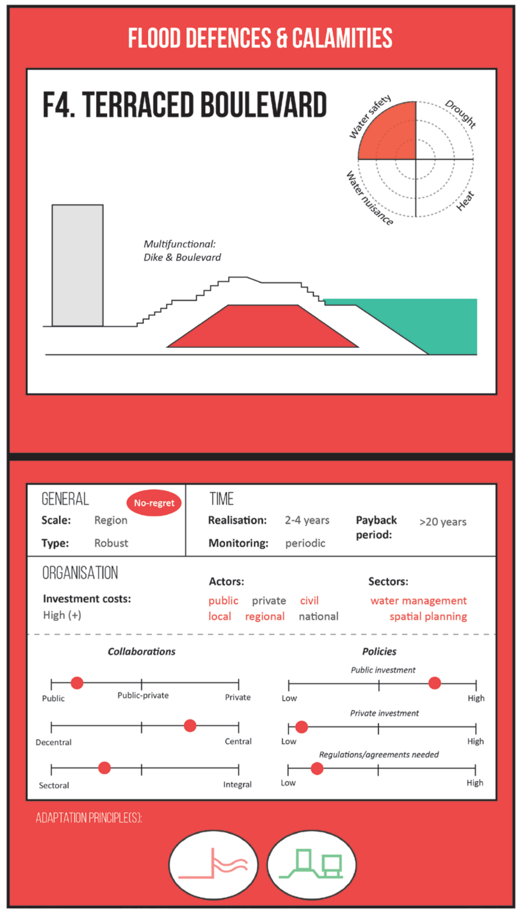
*Figure 7.3.* Connections between the design layers and adaptation principles.

Adaptation Tiles - Flood Defences & Calamities

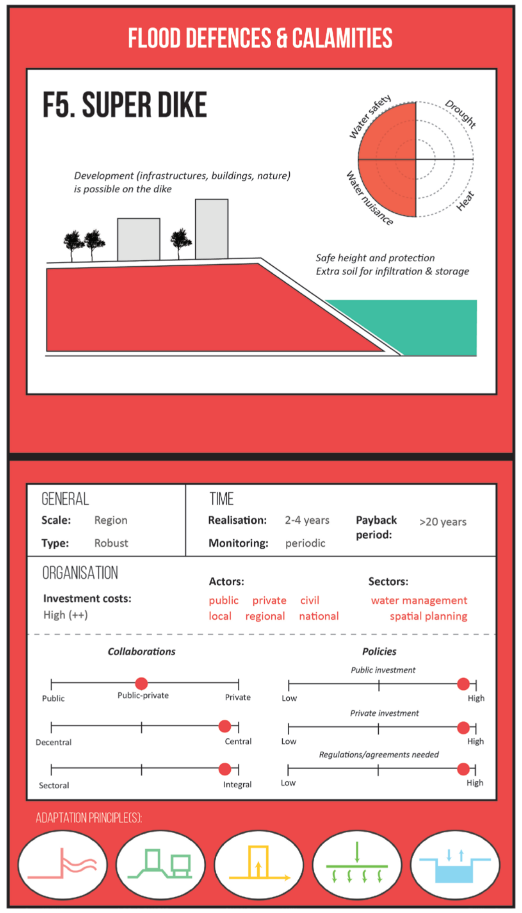


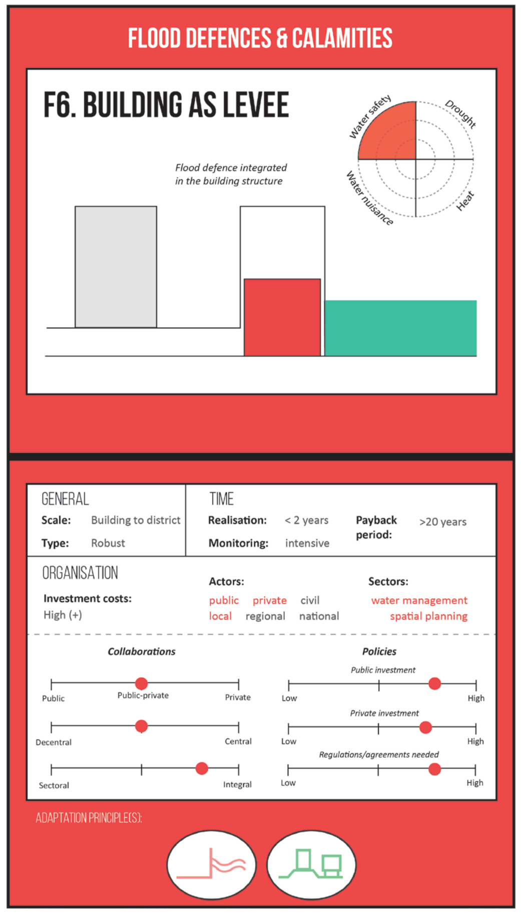



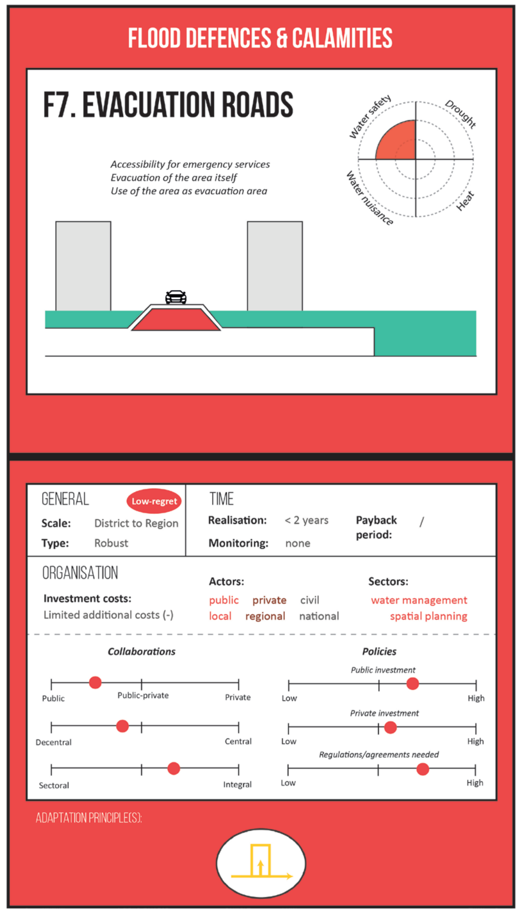



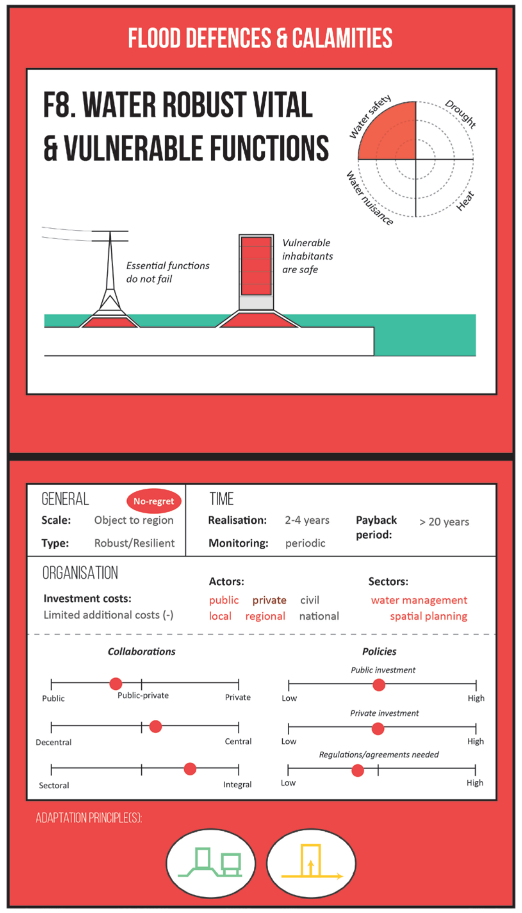





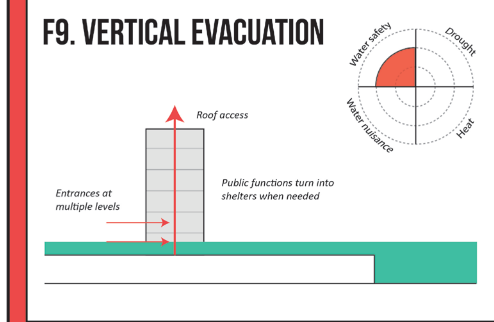



# 7.3 ADAPTATION TILES



## FLOOD DEFENCES & CALAMITIES

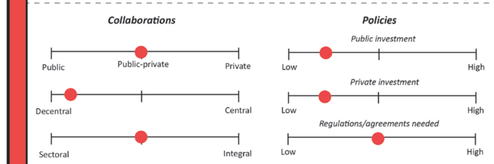
### F9. VERTICAL EVACUATION




**GENERAL** No-regret
**Scale:** Building/ neighbourhood
**Type:** Resilient

**TIME**
**Realisation:** <2 years
**Monitoring:** none
**Payback period:** /

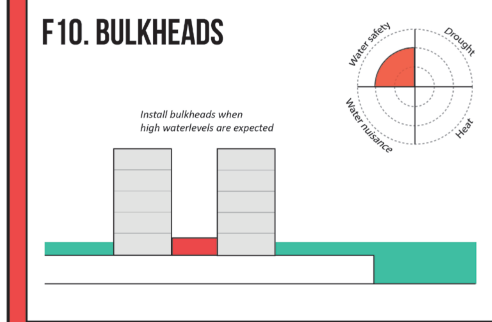
**ORGANISATION**
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## FLOOD DEFENCES & CALAMITIES

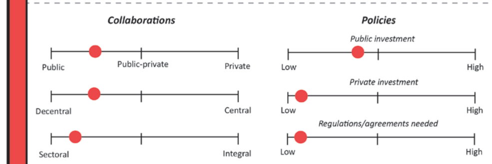
### F10. BULKHEADS




**GENERAL**
**Scale:** Neighbourhood
**Type:** Robust/Ad-hoc

**TIME**
**Realisation:** <2 years
**Monitoring:** none
**Payback period:** /

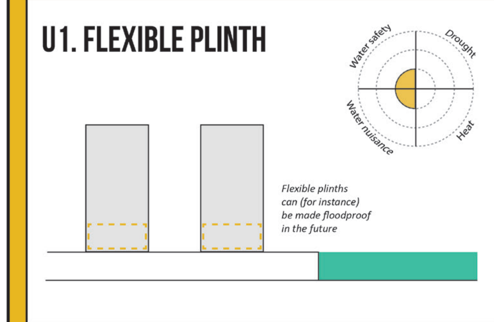
**ORGANISATION**
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## URBAN DESIGN

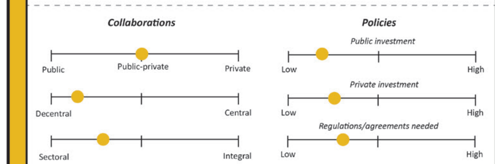
### U1. FLEXIBLE PLINTH




**GENERAL** No-regret
**Scale:** Building
**Type:** Flexible

**TIME**
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** /

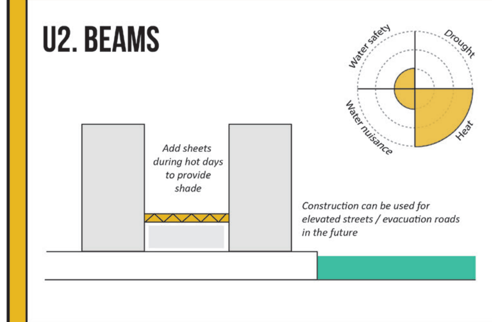
**ORGANISATION**
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## URBAN DESIGN

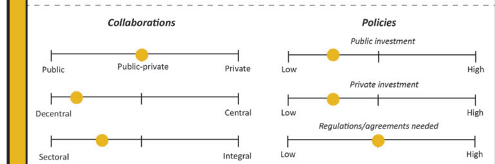
### U2. BEAMS




**GENERAL** No-regret
**Scale:** Building
**Type:** Flexible/Ad-hoc

**TIME**
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** <10 years

**ORGANISATION**
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

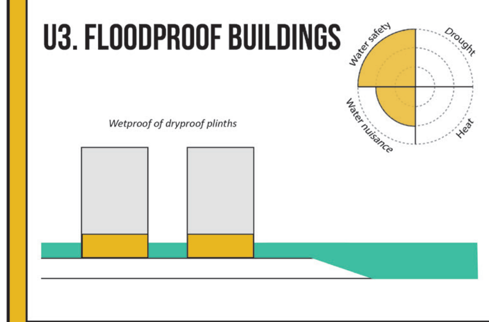



ADAPTATION PRINCIPLE(S):



## URBAN DESIGN

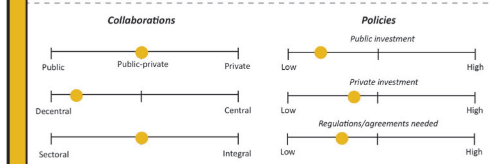
### U3. FLOODPROOF BUILDINGS




**GENERAL**
**Scale:** Building
**Type:** Robust

**TIME**
**Realisation:** 2-4 years
**Monitoring:** periodic
**Payback period:** 10-20 years

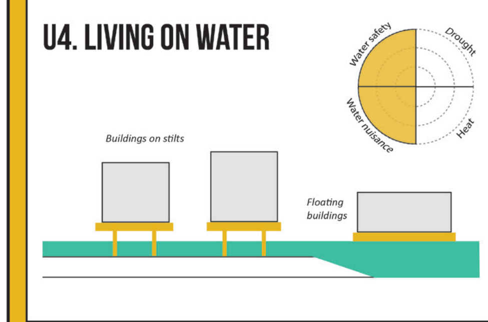
**ORGANISATION**
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## URBAN DESIGN

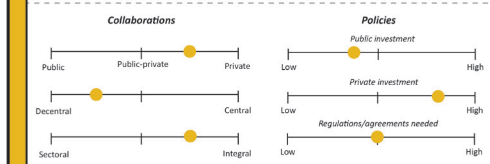
### U4. LIVING ON WATER




**GENERAL**
**Scale:** Building
**Type:** Robust/Flexible

**TIME**
**Realisation:** 2-4 years
**Monitoring:** periodic
**Payback period:** 10-20 years

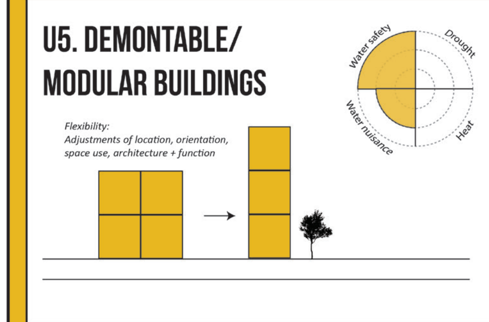
**ORGANISATION**
**Investment costs:** Stilts: Low additional costs (-) Floating: High costs (+)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## URBAN DESIGN

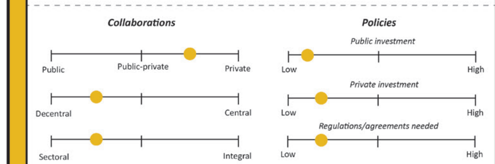
### U5. DEMONTABLE/ MODULAR BUILDINGS




**GENERAL** Low-regret
**Scale:** Building
**Type:** Flexible

**TIME**
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** 10-20 years

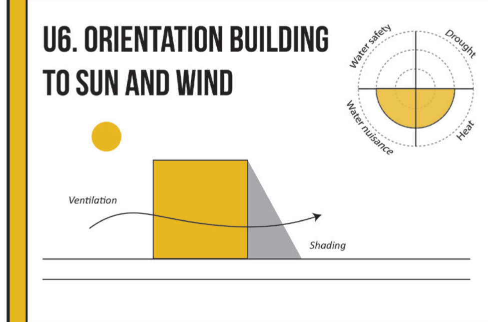
**ORGANISATION**
**Investment costs:** Cheaper / Low costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




ADAPTATION PRINCIPLE(S):

## URBAN DESIGN

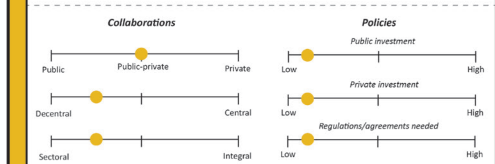
### U6. ORIENTATION BUILDING TO SUN AND WIND




**GENERAL** No-regret
**Scale:** Building
**Type:** Robust

**TIME**
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** >20 years

**ORGANISATION**
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

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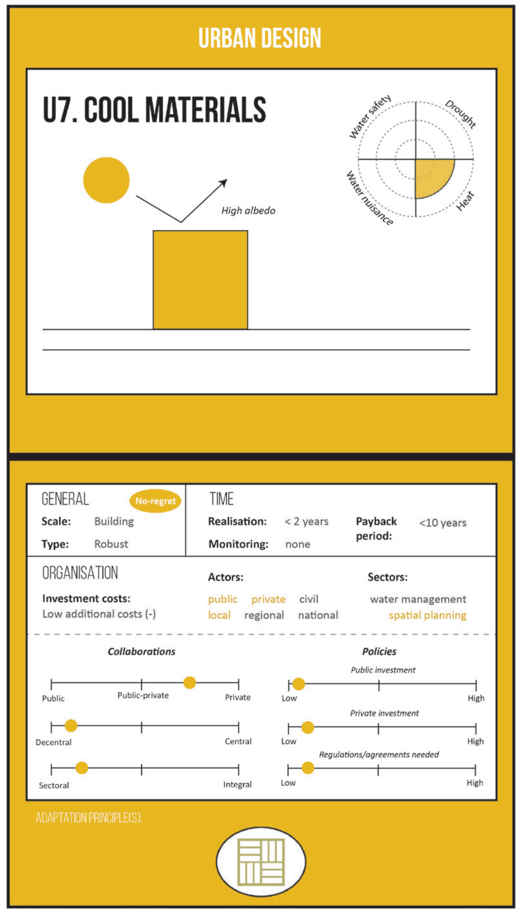
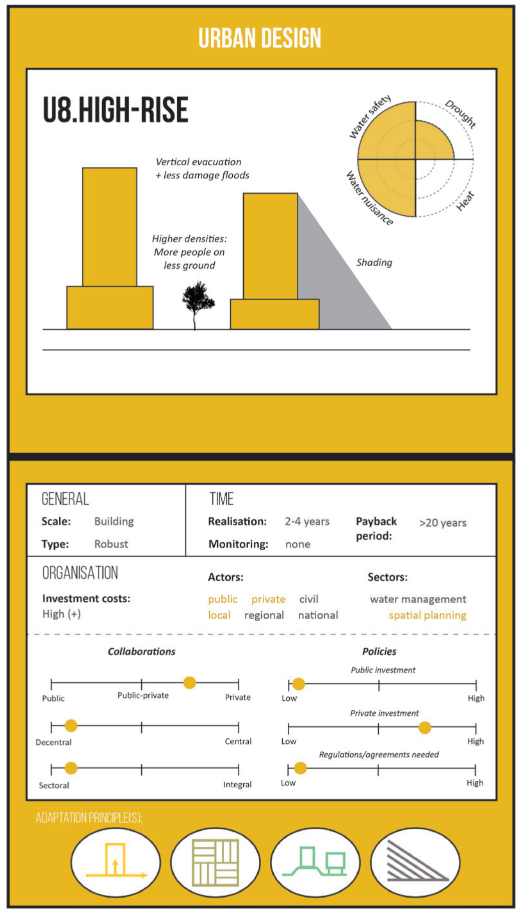
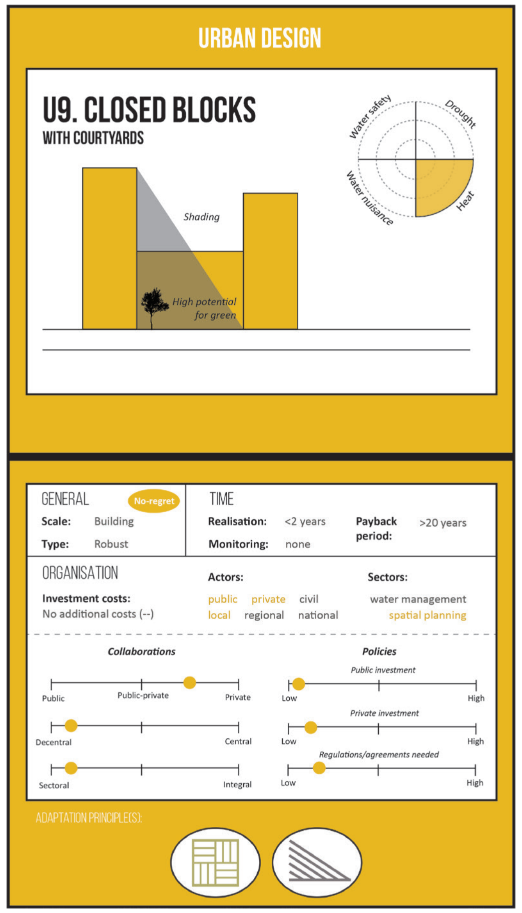
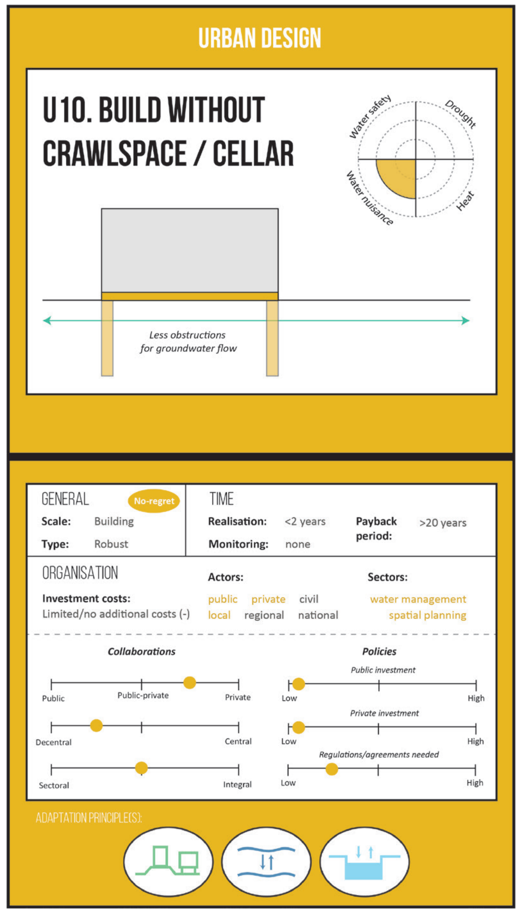


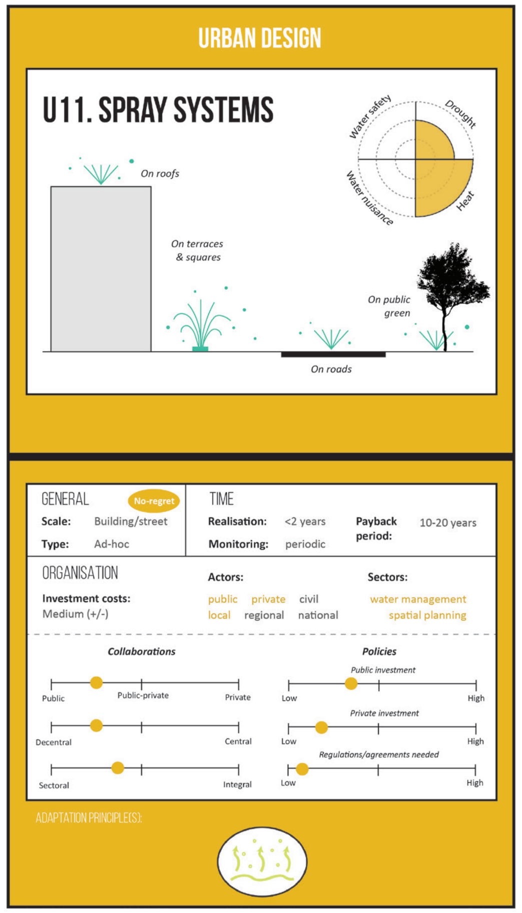



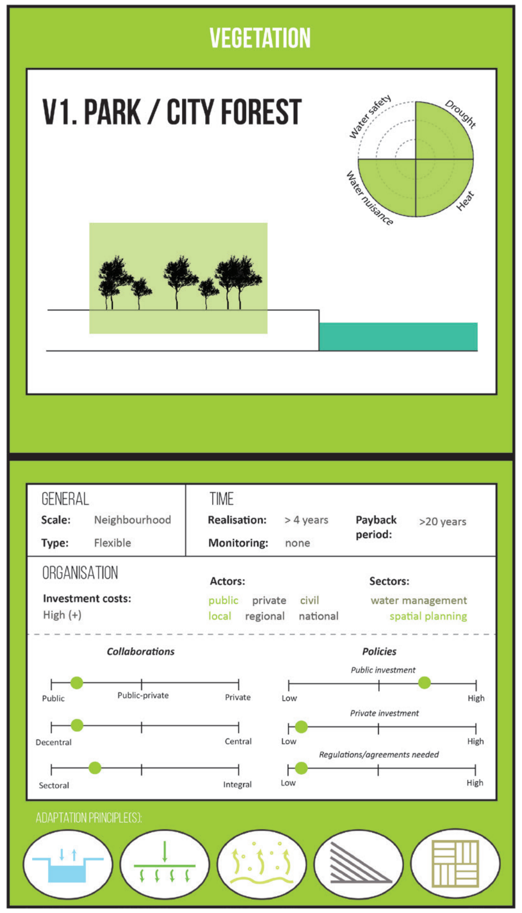



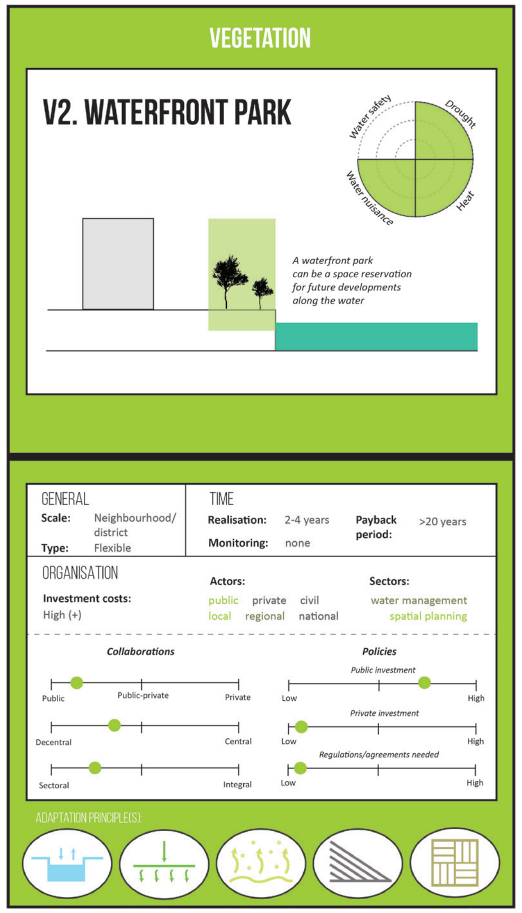






Adaptation Tiles - Vegetation

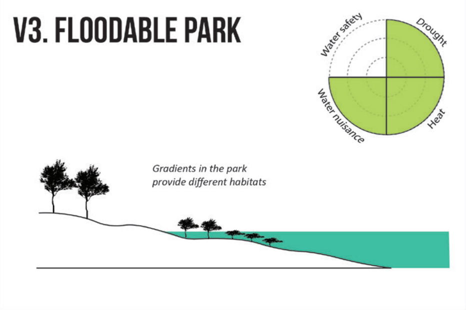


## VEGETATION

### V3. FLOODABLE PARK




**GENERAL**
Scale: Neighbourhood/ district/region
Type: Flexible

**TIME**
Realisation: >4 years
Monitoring: none
Payback period: >20 years

**ORGANISATION**
Investment costs: High (+)
Actors: public private civil local regional national
Sectors: water management spatial planning

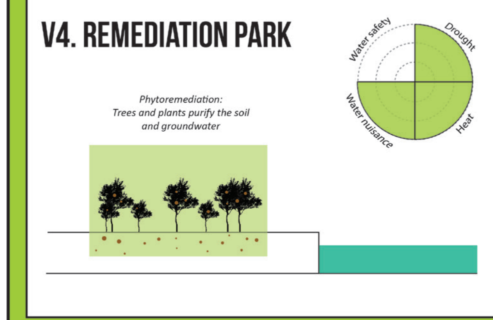
*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):

## VEGETATION

### V4. REMEDIATION PARK




**GENERAL**
Scale: Neighbourhood
Type: Flexible

**TIME**
Realisation: > 4 years
Monitoring: periodic
Payback period: >20 years

**ORGANISATION**
Investment costs: Medium (+/-)
Actors: public private civil local regional national
Sectors: water management spatial planning

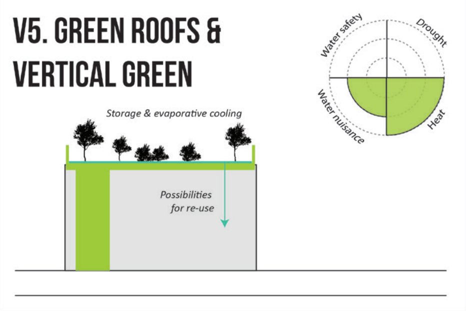
*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):

## VEGETATION

### V5. GREEN ROOFS & VERTICAL GREEN




**GENERAL** No-regret
Scale: Building
Type: Robust/Flexible

**TIME**
Realisation: <2 years
Monitoring: periodic
Payback period: >20 years

**ORGANISATION**
Investment costs: Low additional costs (-)
Actors: public private civil local regional national
Sectors: water management spatial planning

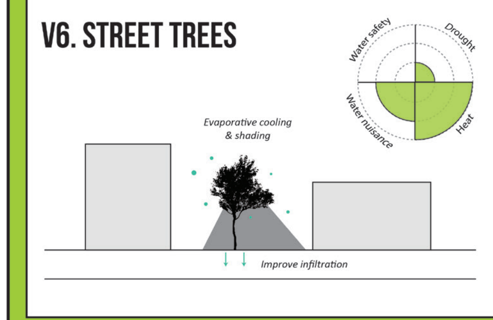
*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):

## VEGETATION

### V6. STREET TREES




**GENERAL** No-regret
Scale: Street
Type: Robust

**TIME**
Realisation: <2 years
Monitoring: none
Payback period: >20 years

**ORGANISATION**
Investment costs: Low/medium costs (-/+)
Actors: public private civil local regional national
Sectors: water management spatial planning

*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

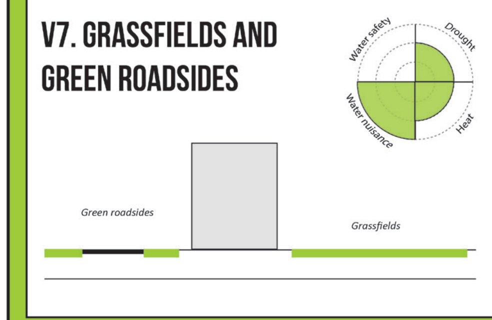
*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):



## VEGETATION

### V7. GRASSFIELDS AND GREEN ROADSIDES




**GENERAL** No-regret
Scale: Street to neighbourhood
Type: Robust

**TIME**
Realisation: <2 years
Monitoring: none
Payback period: /

**ORGANISATION**
Investment costs: Cheaper (--)
Actors: public private civil local regional national
Sectors: water management spatial planning

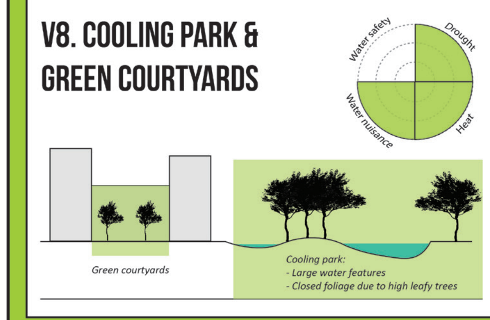
*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):

## VEGETATION

### V8. COOLING PARK & GREEN COURTYARDS




**GENERAL**
Scale: Neighbourhood
Type: Robust

**TIME**
Realisation: 2-4 years
Monitoring: none
Payback period: >20 years

**ORGANISATION**
Investment costs: High (+)
Actors: public private civil local regional national
Sectors: water management spatial planning

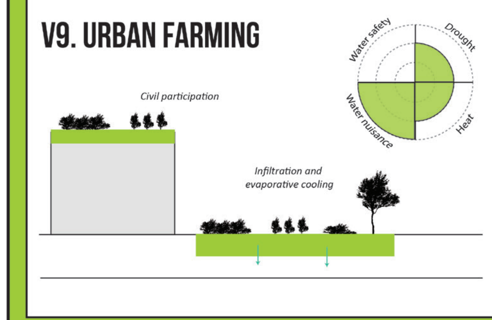
*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

ADAPTATION PRINCIPLE(S):

## VEGETATION

### V9. URBAN FARMING




**GENERAL** No-regret
Scale: Street to Neighbourhood
Type: Robust/Flexible

**TIME**
Realisation: <2 years
Monitoring: none
Payback period: <10 years

**ORGANISATION**
Investment costs: Limited additional costs (-)
Actors: public private civil local regional national
Sectors: water management spatial planning

*Collaborations*: Public – Public-private – Private; Decentral – Central; Sectoral – Integral

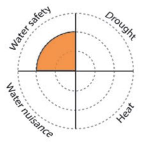
*Policies*: Public investment (Low – High); Private investment (Low – High); Regulations/agreements needed (Low – High)

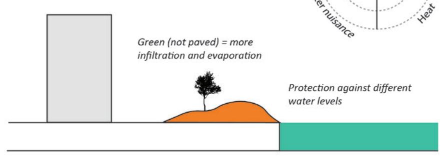
ADAPTATION PRINCIPLE(S):

Adaptation Tiles - Soil

SOIL

## S1. RAISED PARK

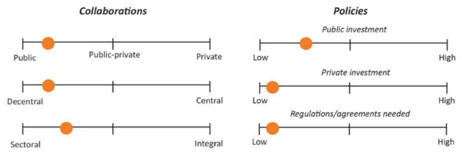


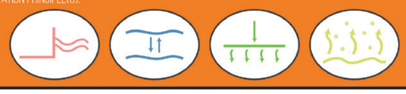

GENERAL
**Scale:** District/City
**Type:** Robust

TIME
**Realisation:** < 2 years
**Monitoring:** periodic
**Payback period:** >20 years

ORGANISATION
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

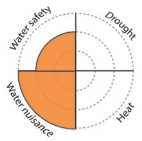


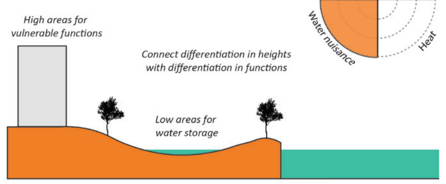

ADAPTATION PRINCIPLE(S):



SOIL

## S2. HEIGHT STRATEGY

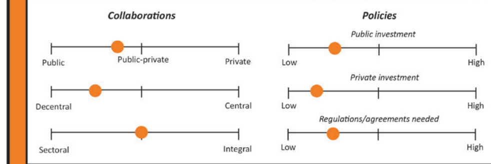


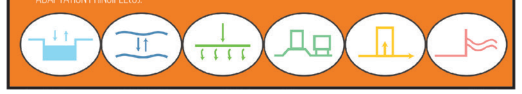

GENERAL No-regret
**Scale:** District/City
**Type:** Robust

TIME
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** >20 years

ORGANISATION
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

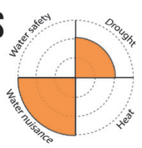


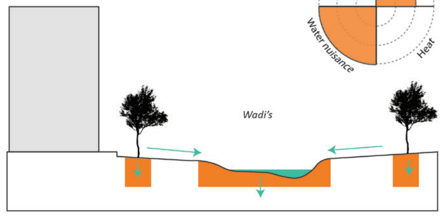

ADAPTATION PRINCIPLE(S):



SOIL

## S3. INFILTRATION FACILITIES

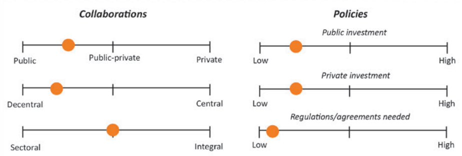


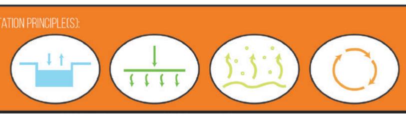

GENERAL No-regret
**Scale:** Street
**Type:** Robust/Flexible

TIME
**Realisation:** < 2 years
**Monitoring:** periodic
**Payback period:** 10-20 years

ORGANISATION
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

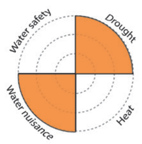


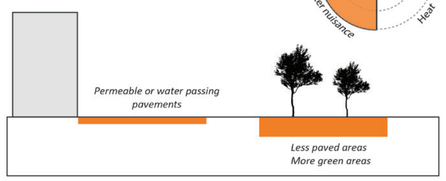

ADAPTATION PRINCIPLE(S):



SOIL

## S4. REDUCE/LIMIT PAVED AREA

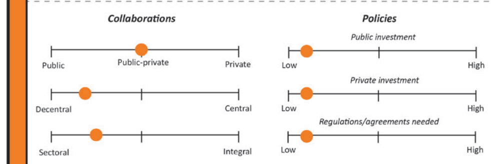


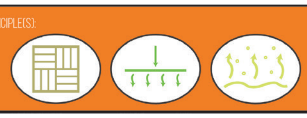

GENERAL No-regret
**Scale:** Neighbourhood
**Type:** Robust

TIME
**Realisation:** < 2 years
**Monitoring:** periodic
**Payback period:** /

ORGANISATION
**Investment costs:** Cheaper / limited costs
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning



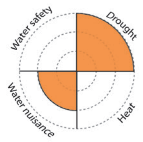

ADAPTATION PRINCIPLE(S):

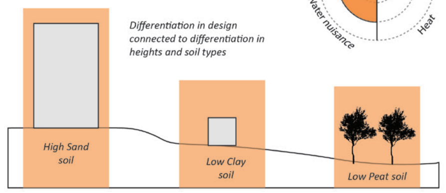




SOIL

## S5. USE GEOMORPHOLOGY AND SOIL FOR DESIGN

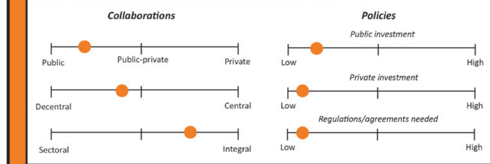


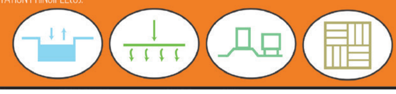

GENERAL No-regret
**Scale:** District to Region
**Type:** Robust/Resilient

TIME
**Realisation:** < 2 years
**Monitoring:** none
**Payback period:** <10 years

ORGANISATION
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

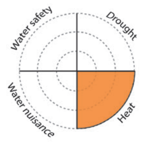


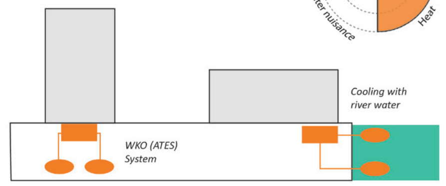

ADAPTATION PRINCIPLE(S):



SOIL

## S6. SOIL FOR COOLING & HEATING

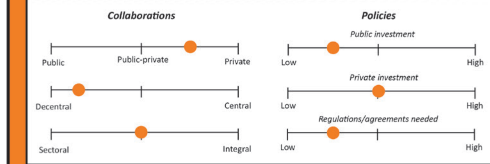


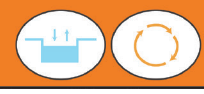

GENERAL
**Scale:** Building
**Type:** Flexible

TIME
**Realisation:** < 2 years
**Monitoring:** periodic
**Payback period:** <10 years

ORGANISATION
**Investment costs:** High (+)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning

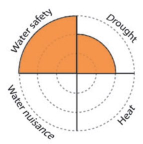


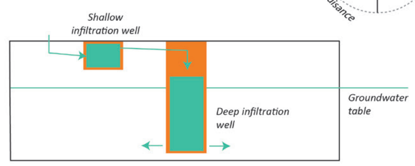

ADAPTATION PRINCIPLE(S):



SOIL

## S7. DEEP INFILTRATION

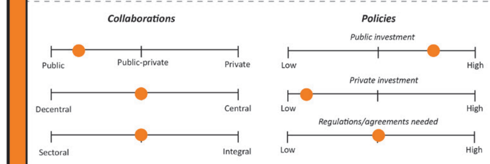


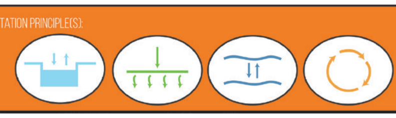

GENERAL
**Scale:** Neighbourhood
**Type:** Robust/Flexible

TIME
**Realisation:** 2-4 years
**Monitoring:** intensive
**Payback period:** >20 years

ORGANISATION
**Investment costs:** High (+)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning



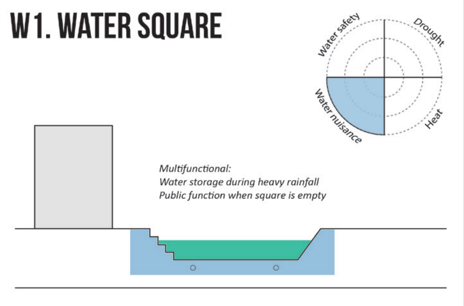

ADAPTATION PRINCIPLE(S):



Adaptation Tiles - Water System

## WATER SYSTEM

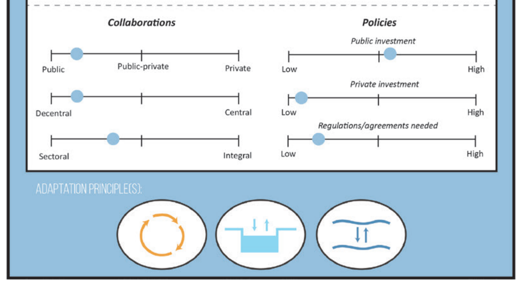
### W1. WATER SQUARE




GENERAL
**Scale:** Neighbourhood
**Type:** Flexible

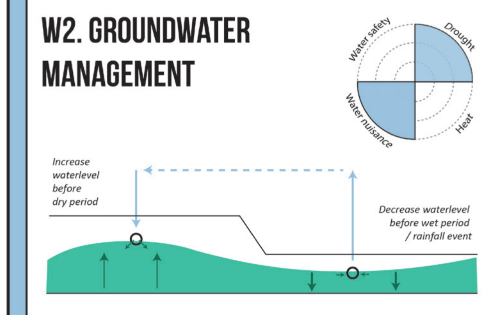
TIME
**Realisation:** > 4 years
**Monitoring:** periodic
**Payback period:** >20 years

ORGANISATION
**Investment costs:** High (+)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

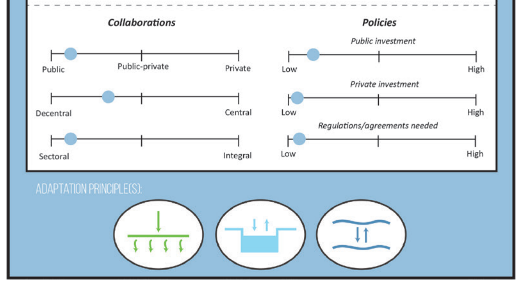
### W2. GROUNDWATER MANAGEMENT




GENERAL
**Scale:** Neighbourhood
**Type:** Robust/Flexible

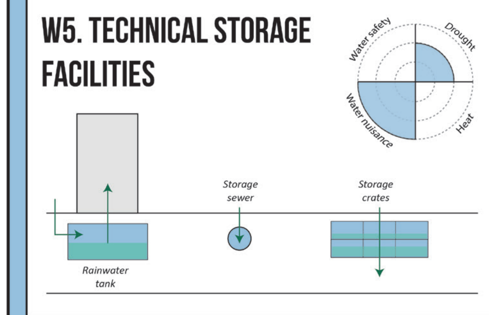
TIME
**Realisation:** <2 years
**Monitoring:** periodic
**Payback period:** /

ORGANISATION
**Investment costs:** No/limited additional costs
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

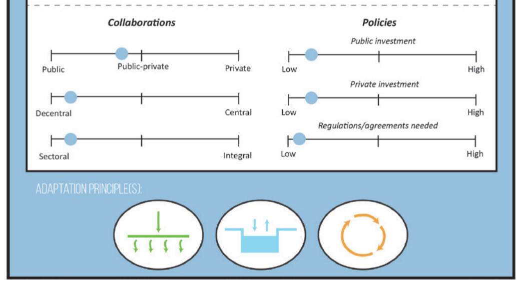
### W5. TECHNICAL STORAGE FACILITIES




GENERAL
**Scale:** Building to Street
**Type:** Robust

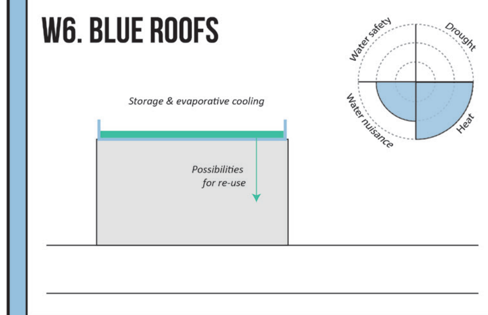
TIME
**Realisation:** <2 years
**Monitoring:** periodic
**Payback period:** > 20 years

ORGANISATION
**Investment costs:** Limited additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

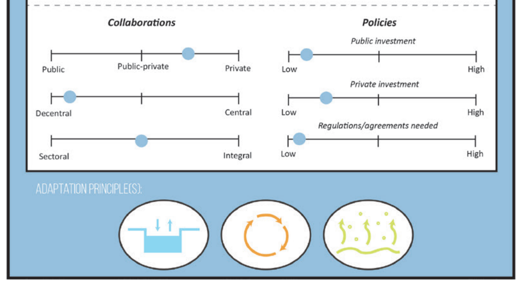
### W6. BLUE ROOFS




GENERAL
**Scale:** Building
**Type:** Flexible

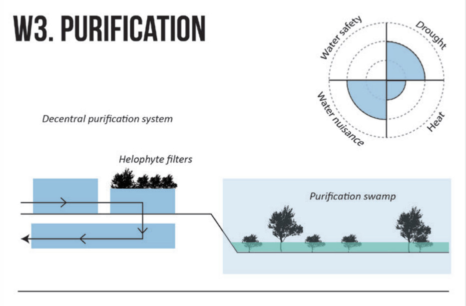
TIME
**Realisation:** 2-4 years
**Monitoring:** periodic
**Payback period:** >20 years

ORGANISATION
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

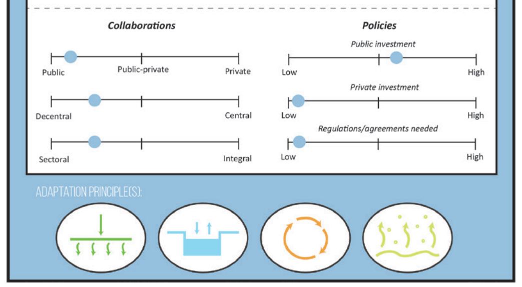
### W3. PURIFICATION




GENERAL
**Scale:** Neighbourhood
**Type:** Robust

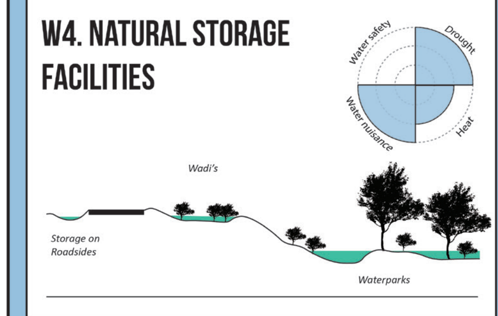
TIME
**Realisation:** <2 years
**Monitoring:** periodic
**Payback period:** 10-20 years

ORGANISATION
**Investment costs:** High (+)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

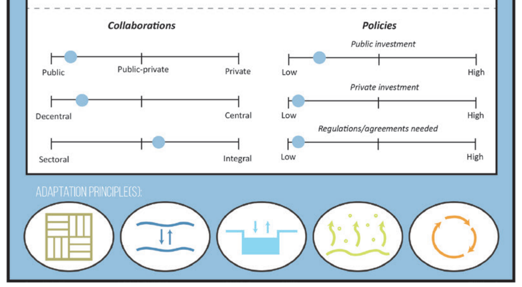
### W4. NATURAL STORAGE FACILITIES




GENERAL
**Scale:** Street to Neighbourhood
**Type:** Resilient/Flexible

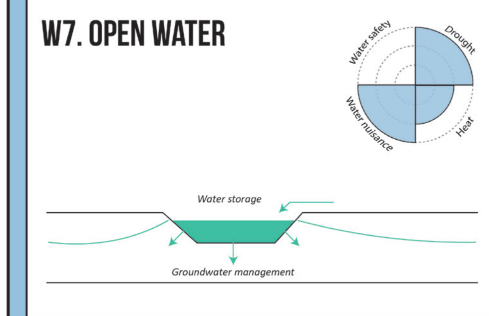
TIME
**Realisation:** <2 years
**Monitoring:** none
**Payback period:** 10-20 years

ORGANISATION
**Investment costs:** Low additional costs (-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning




## WATER SYSTEM

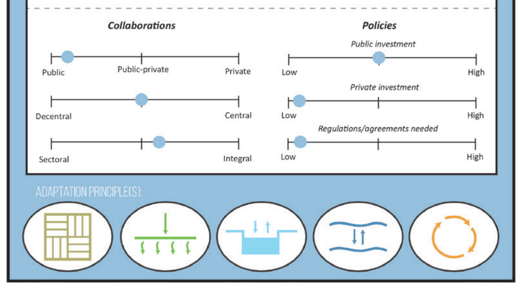
### W7. OPEN WATER




GENERAL No-regret
**Scale:** Neighbourhood to Region
**Type:** Robust/Flexible

TIME
**Realisation:** <2 years
**Monitoring:** none
**Payback period:** <10 years

ORGANISATION
**Investment costs:** Medium (+/-)
**Actors:** public private civil local regional national
**Sectors:** water management spatial planning



# APPENDIX DEVELOPMENT

8

# DESIGN FOR 2050



admin (2019)

## THE CLIMATE IN 2050

To define the design objectives for 2050, the climate in 2050 is of interest. For this, the KNMI'14 Climate Scenarios for the Netherlands are used (KNMI, 2015). For 2050 (actually, the climate between 2036-2065) projections about the change in temperature, sea level, precipitation and drought are made for four climate scenarios. As can be seen from Figure 8.1 (main report), the lowest and highest values of the projections for 2050 can differ quite significantly. To simplify the design objectives, it is chosen to base them on the highest projections.

*Sea Level in 2050*
The KNMI' 14 projections for absolute sea level rise at the Dutch North Sea coast in 2050 range from +15 cm to +40 cm, in comparison with the reference period (1981-2010) (KNMI, 2015). The highest value is thus +40 cm (WL & WH scenarios). As the absolute sea level was +3 cm NAP in the reference period, it is assumed to be 3 + 40 = +43 cm NAP in 2050. This value is used to calculate the flood depths in Haven-Stad after failure of the IJmuiden complex.

*Temperature in 2050*
The projection of the rise in temperature at 'the warmest summer day per year' is used to define the temperature rise during heat waves. The increases in the four climate scenarios are: +1.4C, +1.9C, +2.3C, +3.3C (KNMI, 2015). The highest value is thus +3.3C (WH scenario). This value is used to calculate the PET values in Haven-Stad in 2050 during a heat wave.

*Drought in 2050*
To define the drought objectives, the value of 'the highest precipitation deficit exceeded once in 10 years' is used. This value is projected to increase from the reference of 230 mm with +5%, +17%, +4.5%, or +25% in 2050. The highest value is thus +25% (WH scenario), which gives a precipitation deficit of 288 mm. This value is used to define the need for slow storage in Haven-Stad.

*Precipitation in 2050*
STOWA published statistics for heavy precipitation for the climate scenarios of the KNMI (Beersma, Hakvoort, Jilderda, Overeem & Versteeg, 2019). To calculate the extremes for short rainstorms, the authors used the indicators 'daily amount exceeded once in 10 years' and 'maximum hourly intensity per year' of the KNMI'14 scenarios. For a 1-hour rainstorm with a return period of T = 100 years, the amount is projected to be 70 mm in 2050.

Assumptions Climate 2050

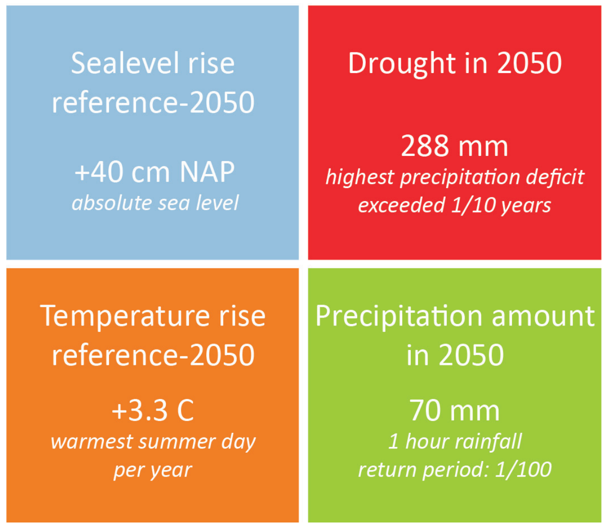



*Figure 8.1*. Assumptions about the climate in 2050.



## OBJECTIVES FOR 2050

### Water safety objective
The water safety objective is defined by the flood depth and probability of flooding (see Figure 6.4 in this Appendix). The assumption is made that the probability of failure of the IJmuiden Complex stays the same in the future. The water level in the North Sea Canal after failure in IJmuiden is calculated as follows:

WATER_LEVEL_2050 (m) =
WATER_LEVEL_2015 + SEALEVEL RISE

According to the study 'Thematische studie Waterveiligheid' (Defacto Stedenbouw & RHDHV, 2021) the water levels of the North Sea Canal are currently projected to be around 1.3 m (1:100.000) after failure. With a sealevel rise of +40 cm, the flood depth can rise to 1.7 m in 2050.

The flood depth in Haven-Stad is dependent on the water level on the North Sea Canal and the height of the areas in Haven-Stad:

FLOOD_DEPTH_2050 (m) =
WATER_LEVEL_2050 - HEIGHT_2050

The current heights of Haven-Stad range from -2 m till +2 m. The flood depths range from 0-3.7 m (1:100.000). Figure 6.4 shows that for depths higher than 2 m (1:100.000), 'shelter and evacuate' is the objective. However, the flood depths differ in each subarea of Haven-Stad. To simplify the objective for the comparison in the research, the objective is set on 'no victims'.

### Cooling objective
The cooling objective is defined by the difference between the PET values in 2050 and the maximum PET value of 35 C. The PET values in 2050 are calculated with the PET values of 2015 and the expected temperature rise. In 2015 the PET values ranged from 34-46 C.

PET_2050 (C) =
PET_2015 + 1.25 * TEMPERATURE_RISE_2050

With a temperature rise of 3.3 C in 2050, the increase in PET is around 4 C. The range of PET values in 2050 is 38-50 C.

COOLING_OBJECTIVE_2050 (C) = PET_2050 - 35

The cooling objective is thus 3-15 C, depending on the location in Haven-Stad.

### Slow storage objective
The slow storage objective is defined by the highest precipitation deficit exceeded 1/10 years in 2050 (288 mm) and the percentage of green in Haven-Stad:

SLOW_STORAGE_OBJECTIVE_2050 (m3) =
PRECIPITATION_DEFICIT_2050 [1/10 yrs] (m)
* GREEN AREA (m2)

The slow storage objective (m3) is: 0.288 * m2green

### Fast storage objective
The fast storage objective is defined by the projected precipitation amount of a 1-hour rainstorm with a return period of 1/100 years in 2050 (70 mm) and the total area of Haven-Stad south (440 ha):

FAST_STORAGE_OBJECTIVE_2050 (m3) =
PRECIPITATION_EVENT_2050 [1/100 yrs] (m)
* TOTAL AREA (m2)

The fast storage objective (m3) is: 0.070 * 4.400.000 = 308.000 m3.

***Section 6.3***
*For more information about the selection/calculation of the objectives*

## SOIL LAYER

### Lithology - Region

As can be seen in Figure 8.2, Amsterdam lies relatively high due to added sand in the past. Underneath, the soil mostly consists out of peat and/or clay. The third sand layer ('old river sands') can be important for the foundation of high buildings (Bakker, Dolmans & Lanting, 2017). In the polder areas around the city, there is no added sand layer, and peat and clay are the most common top soil layers. In Figure 8.3 it can be seen that the polders north of Amsterdam mostly have a peat soil and the polders south of Amsterdam have mostly a clay soil.

### Lithology - Haven-Stad

Figure 8.4 shows the average soil profile in Haven-Stad. The first layer underneath the phreatic zone is the first aquitard. This layer starts in between +1 and -2 meter, and ends between -11 and -24 meter. This layer contains clay, peat and/or fine sand and therefore poorly drains the water. Underneath, there is a layer of sand, which is the first aquifer. In the aquifer, the water can flow easiliy. This aquifer is a confined aquifer, as it is confined from the top and the bottom by low permeable aquitards. Underneath there is another aquitard and a second aquifer.

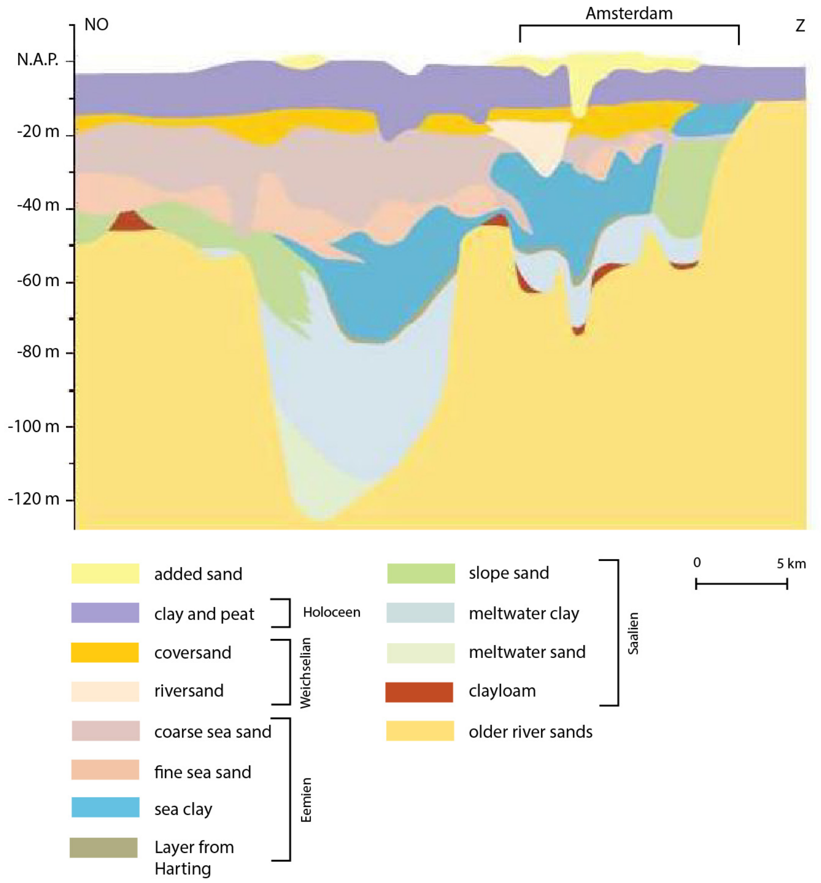



*Figure 8.2.* Soil profile around Amsterdam. Adapted from *"Bijlage 8 Achtergrondrapport Bodem MER Haven-Stad"* (p.11), by A. Bakker, G. Dolmans & N. Lanting, 2017. Copyright 2017 by Municipality of Amsterdam.

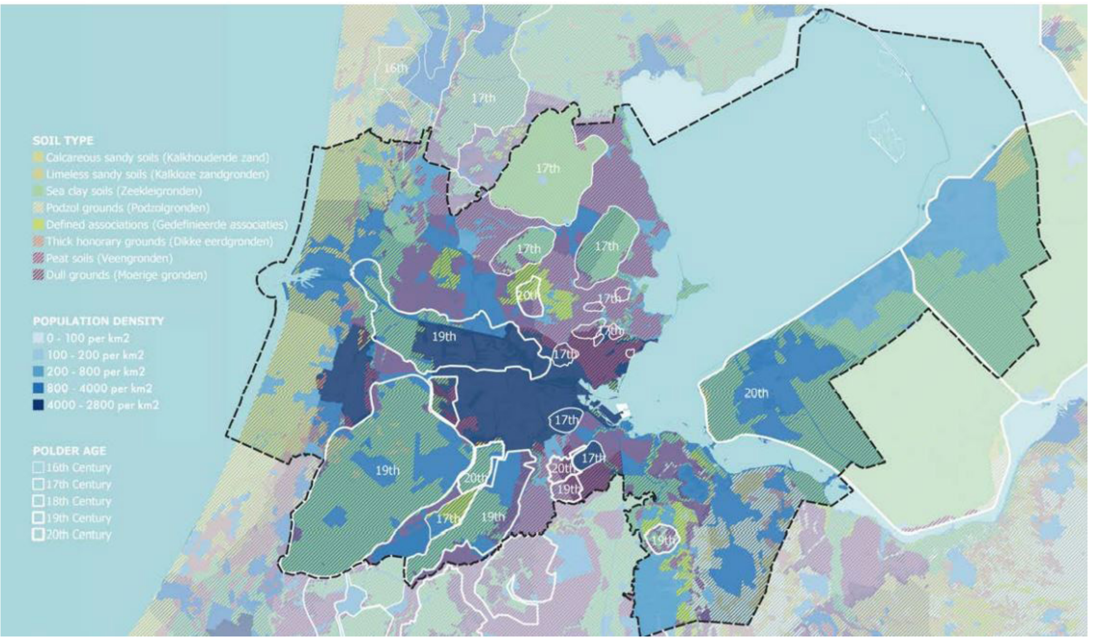



*Figure 8.3.* Soil types in the Metropolitan Region Amsterdam. Reprinted from *"Resilience by Design Metropoolregio Amsterdam"* (p.39), by One Architecture et al., 2020. Copyright 2020 by One Architecture B.V., Amsterdam and One Architecture & Urbanism, New York

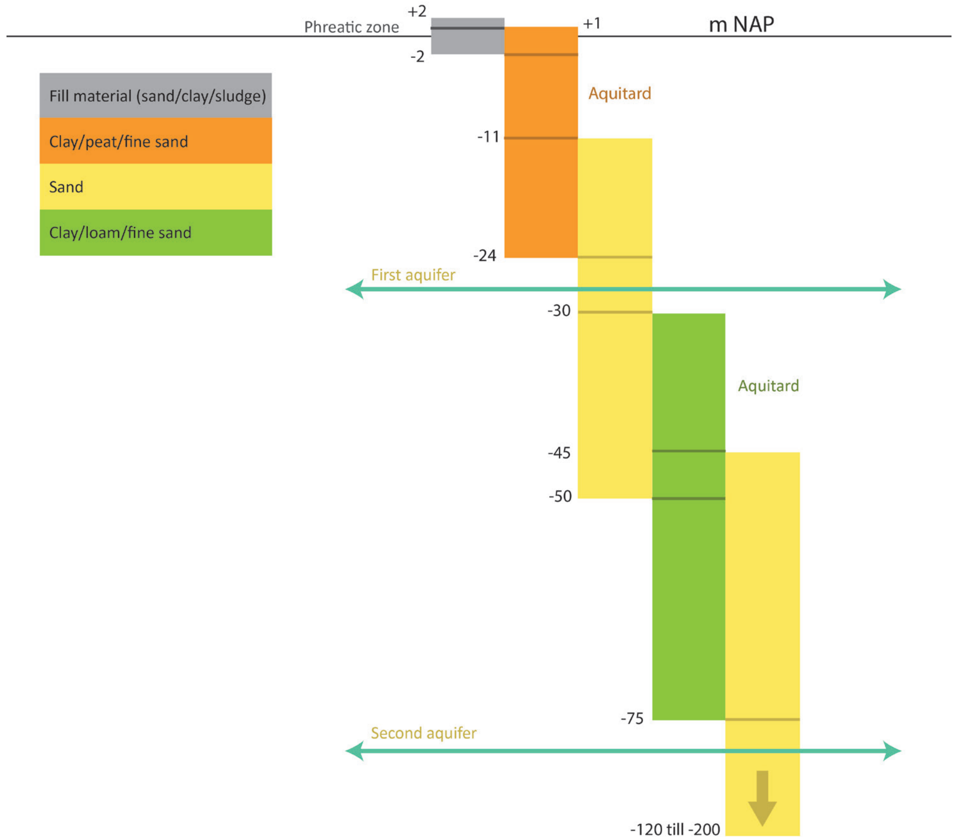



*Figure 8.4.* Average soil profile in Haven-Stad. By author, 2020. Information from (De Jong & Dijkdrenth, 2017).

## Soil Quality

Figure 8.5 shows the soil quality in Haven-Stad. It shows quite some contamination in Haven-Stad, especially in the harbor areas. There is both pollution of the soil and of the groundwater in the area.

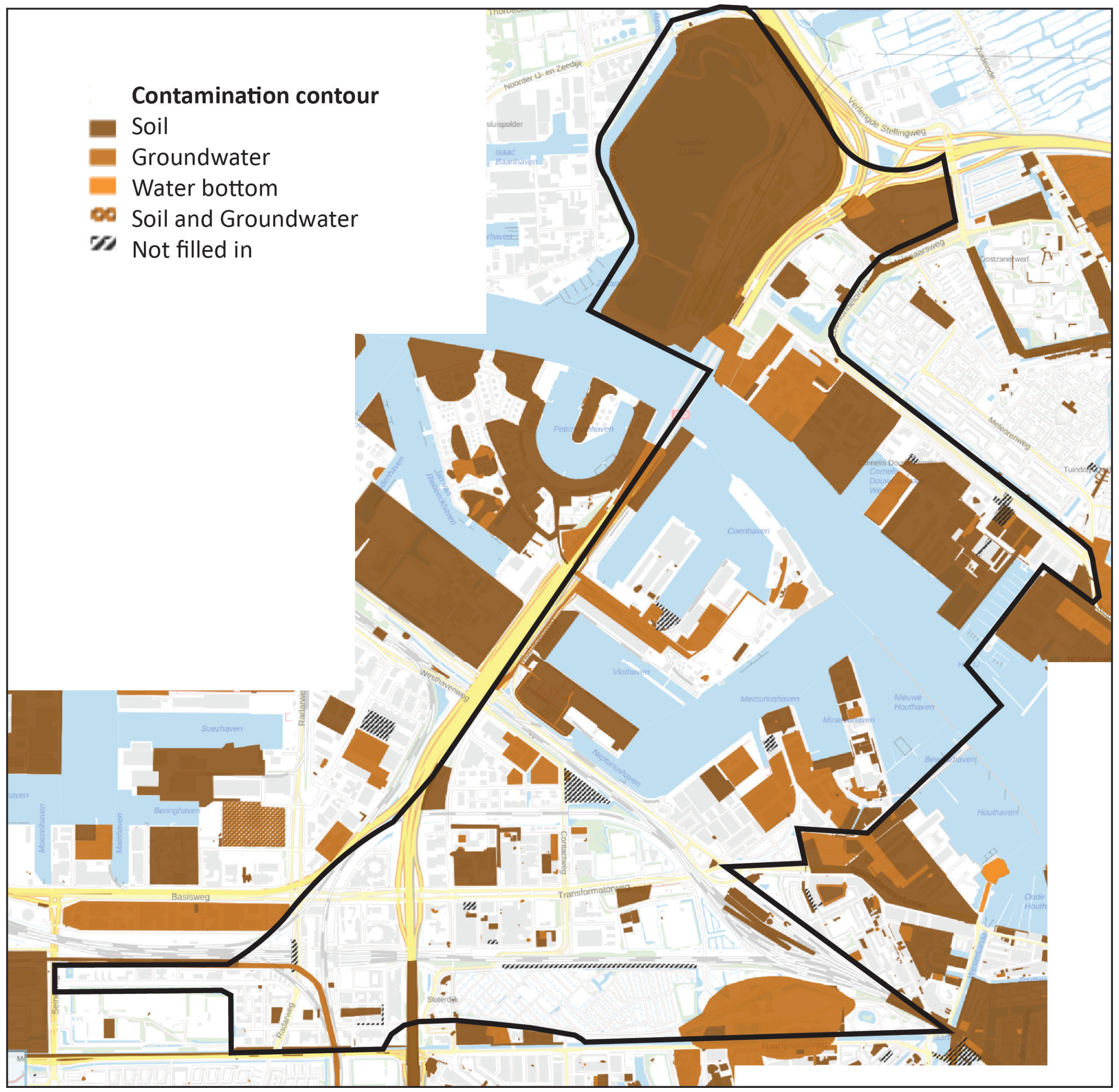



*Figure 8.5.* Contamination in Haven-Stad. Reprinted from "Rapporten", by Omgevingsdienst Noordzeekanaalgebied, n.d. (https://odnzkg.nazca4u.nl/rapportage/viewerLookUp/Geolocator.aspx). Copyright by Omgevingsdienst Noordzeekanaalgebied.



## Soil Subsidence

Figure 8.6 shows the estimated soil subsidence in Haven-Stad from januari 2015 till june 2020. It can be seen that most subsidence can be found in the peat soil park and along the Transformatorweg and A10 highway. The sandy harbor areas show the least subsidence.

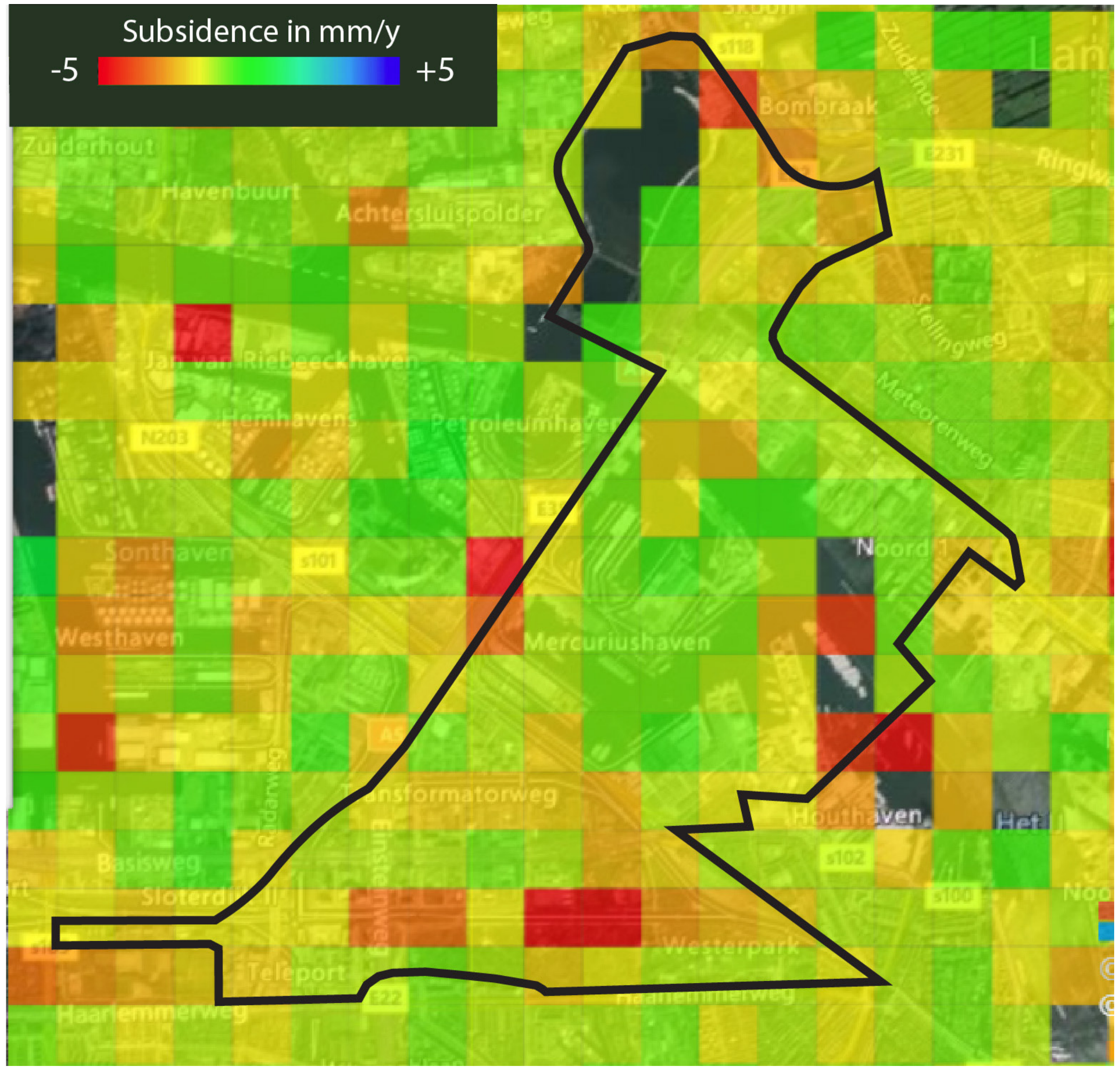



*Figure 8.6.* Soil subsidence in Haven-Stad. Reprinted from "Bodemdalingskaart 2.0", by Bodemdalingskaart.nl, 2020 (https://bodemdalingskaart.portal.skygeo.com/portal/bodemdalingskaart/u2/viewers/basic/). Copyright by Bodemdalingskaart.nl

## WATERSYSTEM LAYER

### Water System - Region

Figure 8.7 presents the regional water system of the Metropolitan Region Amsterdam (MRA). Behind the dunes, an extensive polder system is created. Each polder, with its own water levels, drains into the boezem system, in which two canals are the most important. The Amsterdam-Rhine Canal connects the Rhine river in the south to the IJ River. The IJ River connects to the North Sea Canal, which transports the water to the Ijmuiden complex. Here the water is discharged into the North Sea. The canals drain the system and supply fresh groundwater to adjacent areas (One Architecture et al., 2020).

The water in the system has multiple sources. These are the blue/green lines and arrows in Figure 8.7. The Amsterdam-Rhine Canal, the Hollandse IJssel river and the Lek river supply the system with water from the south. Extra water can be let in from the fresh water lakes IJmeer and Markermeer. This happens at Gemaal Schardam (north MRA), Gemaal Blocq van Kuffeler (Flevoland), Zeesluis Muiden (south MRA) and at Gemaal Zeeburg. Gemaal Zeeburg is the inlet and outlet point for the canal system of the city of Amsterdam.

To discharge the water in the polders, a system of canals and pumps is created. The canals collect the excess water and the pumps transport the water from the low-lying polders to the higher boezem system. In each polder, an own water level can be maintained, which suits the function of the land. These levels are maintained through control systems such as weirs and sluices (One Architecture et al., 2020). In Figure 8.7 the main water outlets (pumping stations/gemalen and sluizen/sluices) are represented by the red arrows. The water is discharged to the Markermeer, IJmeer, and the North Sea Canal. At complex IJmuiden the water is discharged into the North Sea.

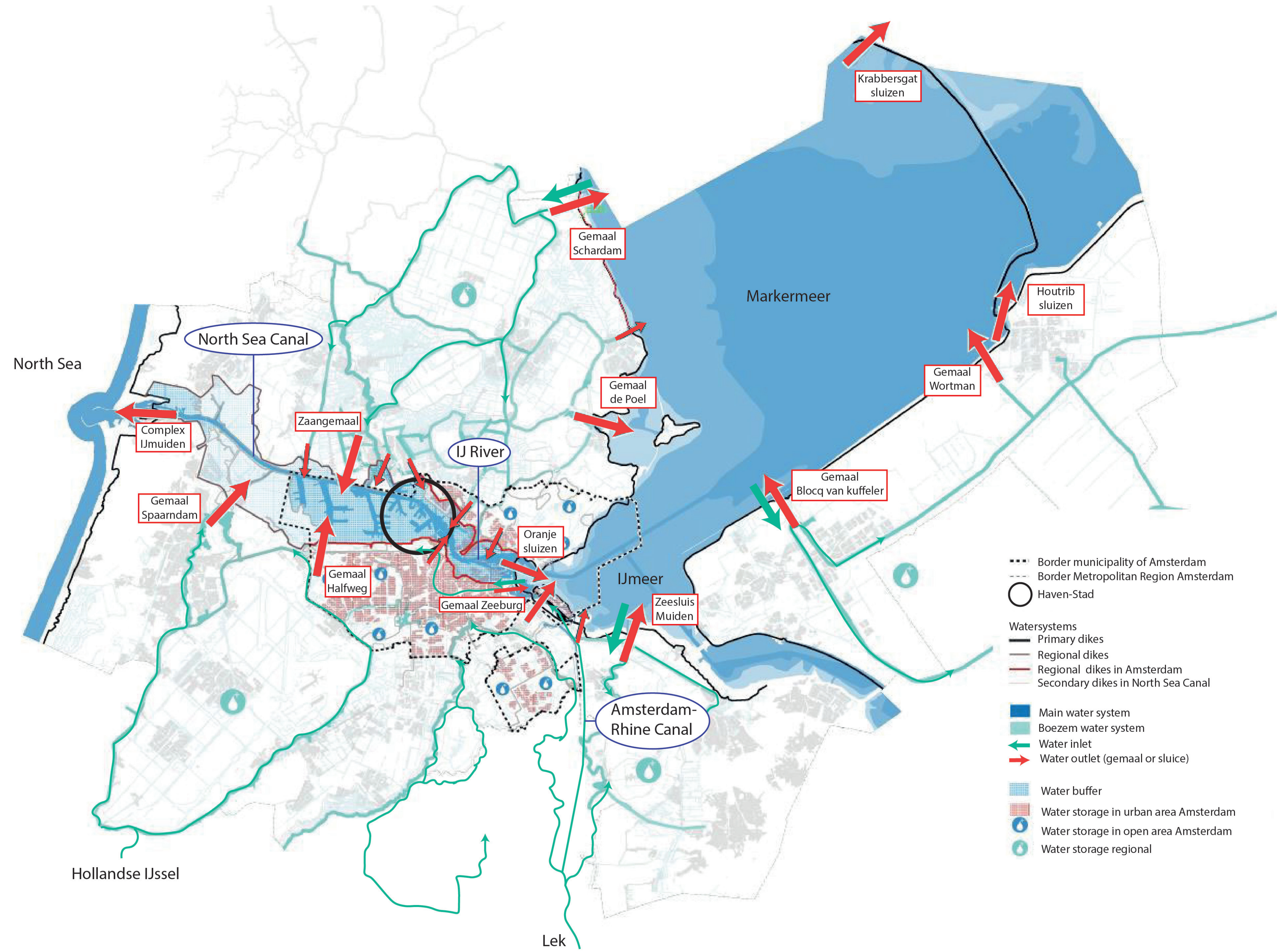



*Figure 8.7.* Regional water system. Adapted from *"Resilience by Design Metropoolregio Amsterdam - Landelijk gebied"* (p.128), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.

### Water System - Haven-Stad

Figure 8.10 shows the water system of Haven-Stad and Figure 8.9 shows a simplified diagram of the system. The primary dike in the north is part of dike ring 13 and the primary dike in the south is part of dike ring 14. The biggest part of Haven-Stad is situated in the North Sea Canal boezem area (grey in Figure 8.10), outside the primary dikes. In the north, the Melkweg-Oostzanerwerf is situated in the polder Tuindorp Oostzaan. In the south, the Zaanstraat Emplacement and the Westerpark are part of the Overbrakerbinnenpolder (De Jong & Dijkdrenth, 2017). Figure 8.8 shows the hydrological units of Haven-Stad.

The water which divides Haven-Stad is part of the IJ Bay (Rijkswaterstaat, n.d.-a). Water from the IJmeer in the east flows to the IJ Bay, and from the IJ Bay it flows further west through the North Sea Canal. The North Sea Canal is the main sailing route from the IJ Bay to the North Sea through the complex IJmuiden. The water of the IJmeer and the IJ is fresh, the water of the North Sea Canal is brackish, due to the influence from the North Sea (Rijksoverheid, n.d.-b).

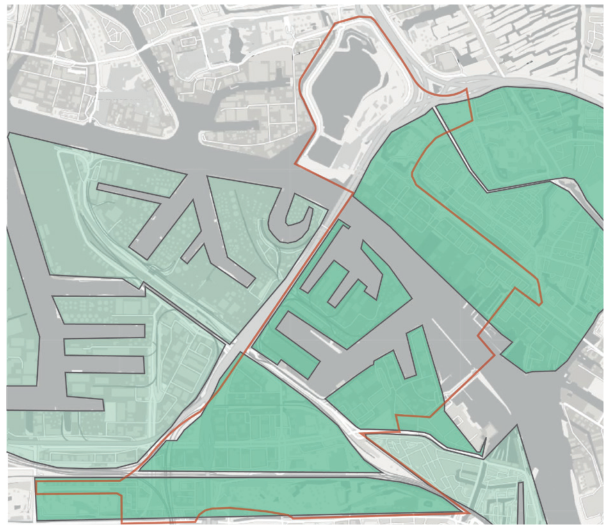


*Figure 8.8.* Hydrological units Haven-Stad. Information from "Amsterdam Rainproof - Hydrologische eenheid", by Gemeente Amsterdam, n.d. (https://maps.amsterdam.nl/rainproof/). Copyright by Rainproof Amsterdam.

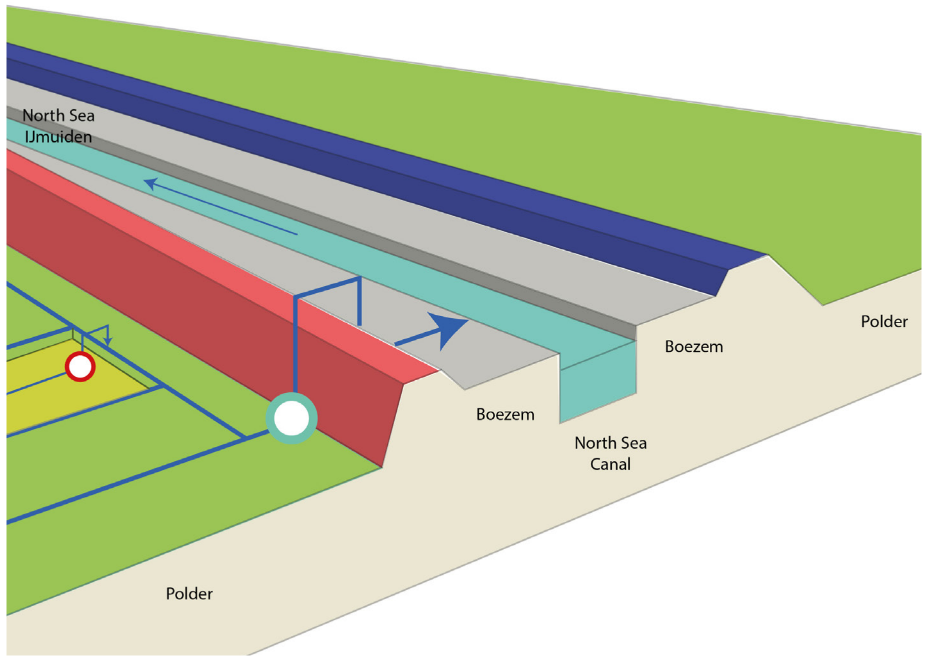



*Figure 8.9.* Polder and boezem system Haven-Stad, simplified.
*The same colours and icons can be found in the map of Figure 4.7.*

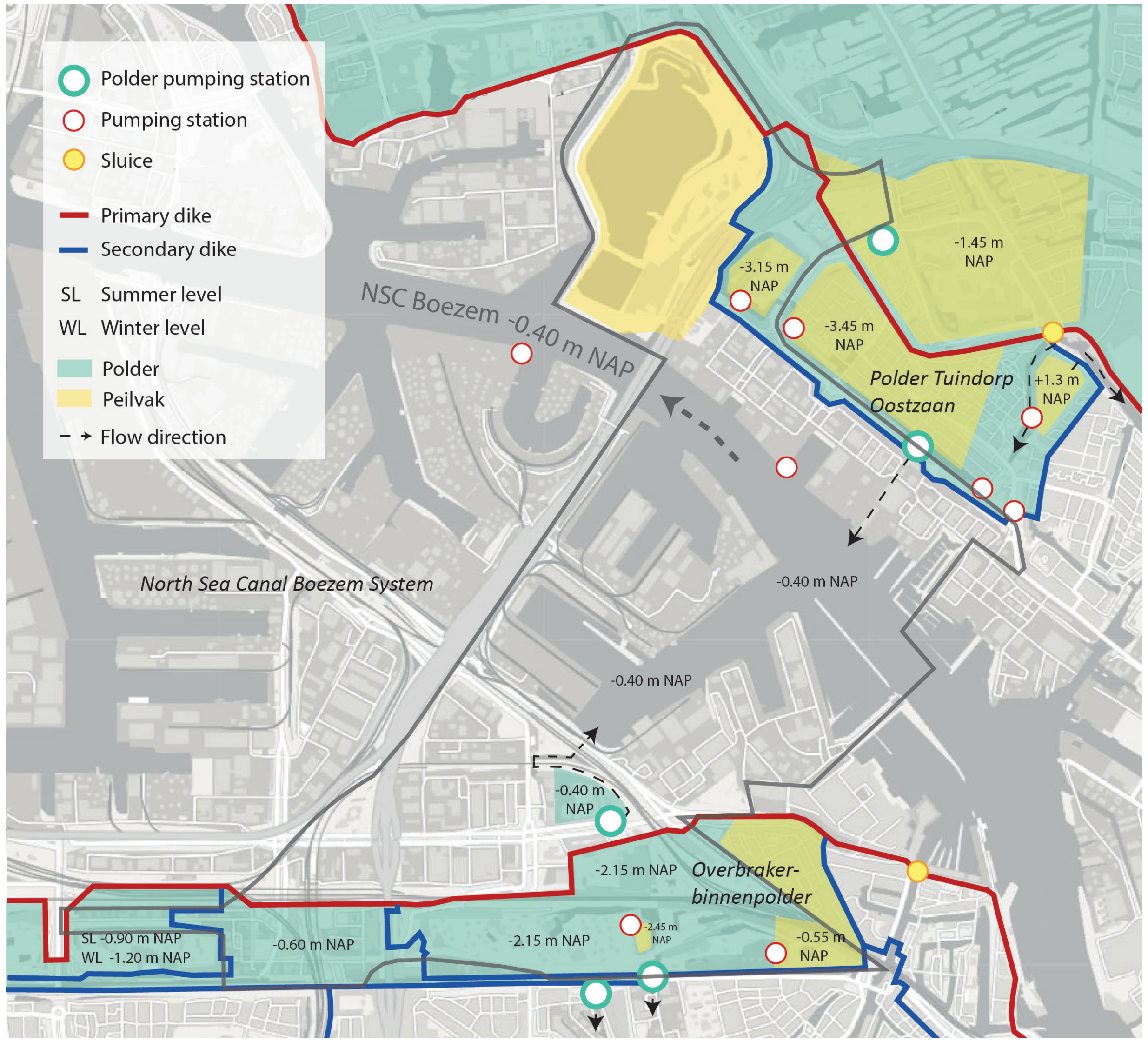



*Figure 8.10.* Water system Haven-Stad. Information from (De Jong & Dijkdrenth, 2017).

The target water level of the North Sea Canal and the connected harbor basins is -0.40 m NAP. In the polders, multiple different peilvakken (areas with a certain maintained water level) can be found. For instance, in the south part of the Melkweg-Oostzanerwerf, the water level is kept at -3.15 m NAP with an own pump (red), while other parts of the same polder have other water level targets. With the polder pumping stations (green/blue), the water from the polders is discharged into the boezem system (De Jong & Dijkdrenth, 2017).

## Traditional Water Level Management

Figure 8.11 explains the tradional Dutch water level management in winter and summer. The diagrams show how the low-lying polders discharge their excess water to the canals of the boezem system, to prevent the polders from drowning. From the boezem system, the water is transported to the sea. In the context of Haven-Stad is the North Sea Canal the important route of the boezem system towards the North Sea. During winter, the Netherlands needs to cope with a precipitation surplus. In the polders the groundwater levels are often high and close to the ground levels. Extra rain can cause a raise of the groundwater levels above the ground levels, which causes water nuisance.

To create extra storage and drainage capacity, the groundwater levels could be lowered in the winter, if this suits with the function of the land. Due to the precipitation surplus, more water infiltrates in the soil, which pushes away brackish water. In summer, there is often an precipitation deficit. Waterlevels can be increased to prevent the soil from drying out. The precipitation deficit can cause salinization problems. As less fresh water infiltrates, the brackish water can come up more easily (seepage). The system can be flushed with fresh water, for instance from Lake IJssel, to 'flush away' the brackish water.

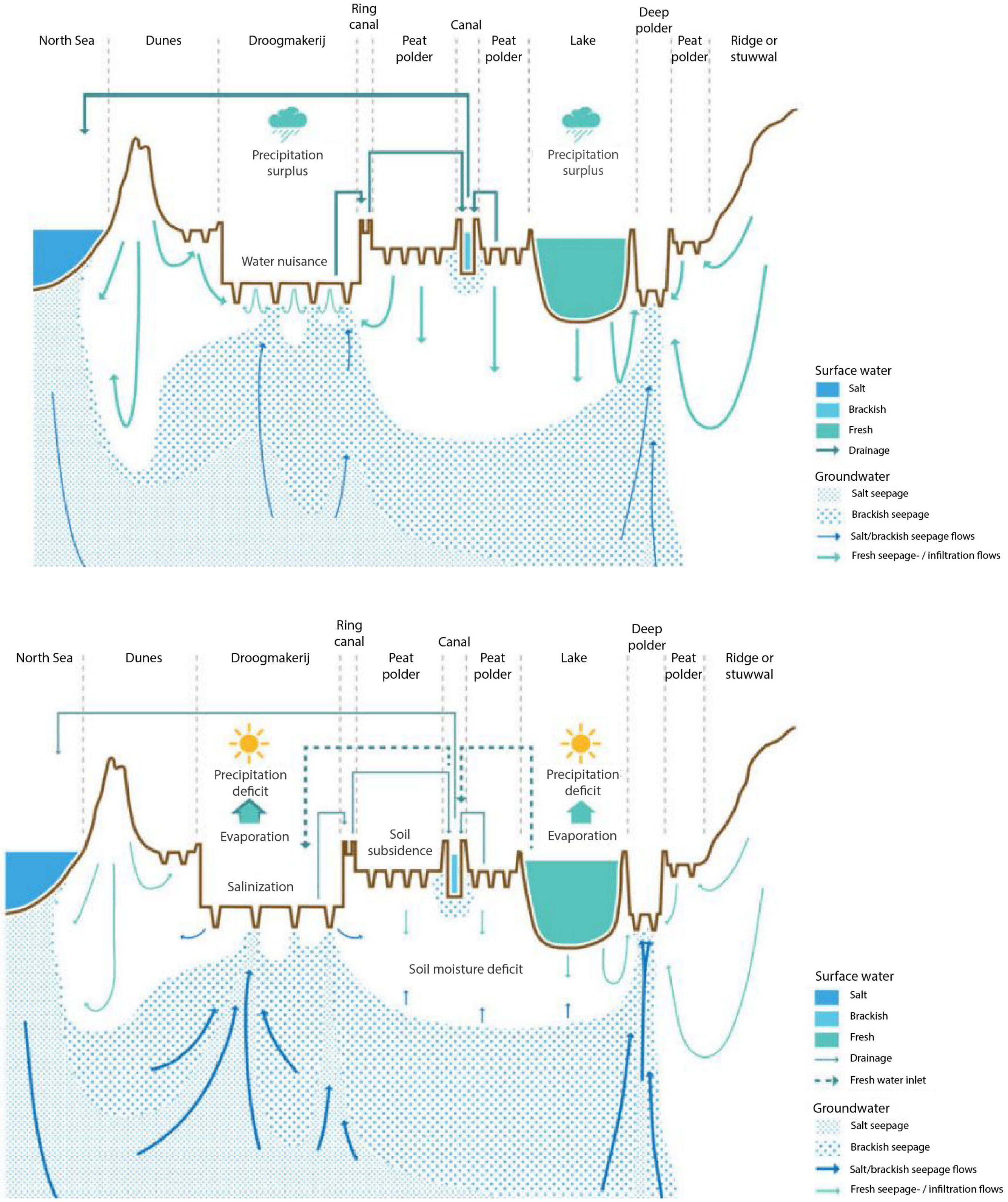



***Figure 8.11.*** Traditional water level management and related challenges in winter (top) and summer (bottom). Adapted from ***"Resilience by Design Metropoolregio Amsterdam"*** (p.129), by Defacto Stedenbouw et al., 2020. Copyright 2020 by Defacto Stedenbouw.

## VEGETATION LAYER

### Vision Ecological Structure Amsterdam

Figure 8.12 shows the vision for the ecological structure for Amsterdam. The park in the south of Haven-Stad is a crucial link for one of the green 'fingers' that connect the city to the rural areas in the west. In addition, the location on the IJ can be an interesting habitat for plants and animals.

The Coenhaven can be an important point to make stepping stones to the north of Haven-Stad, where the Noorder IJ Plas park forms a special habitat and connection to the rural areas in the north.

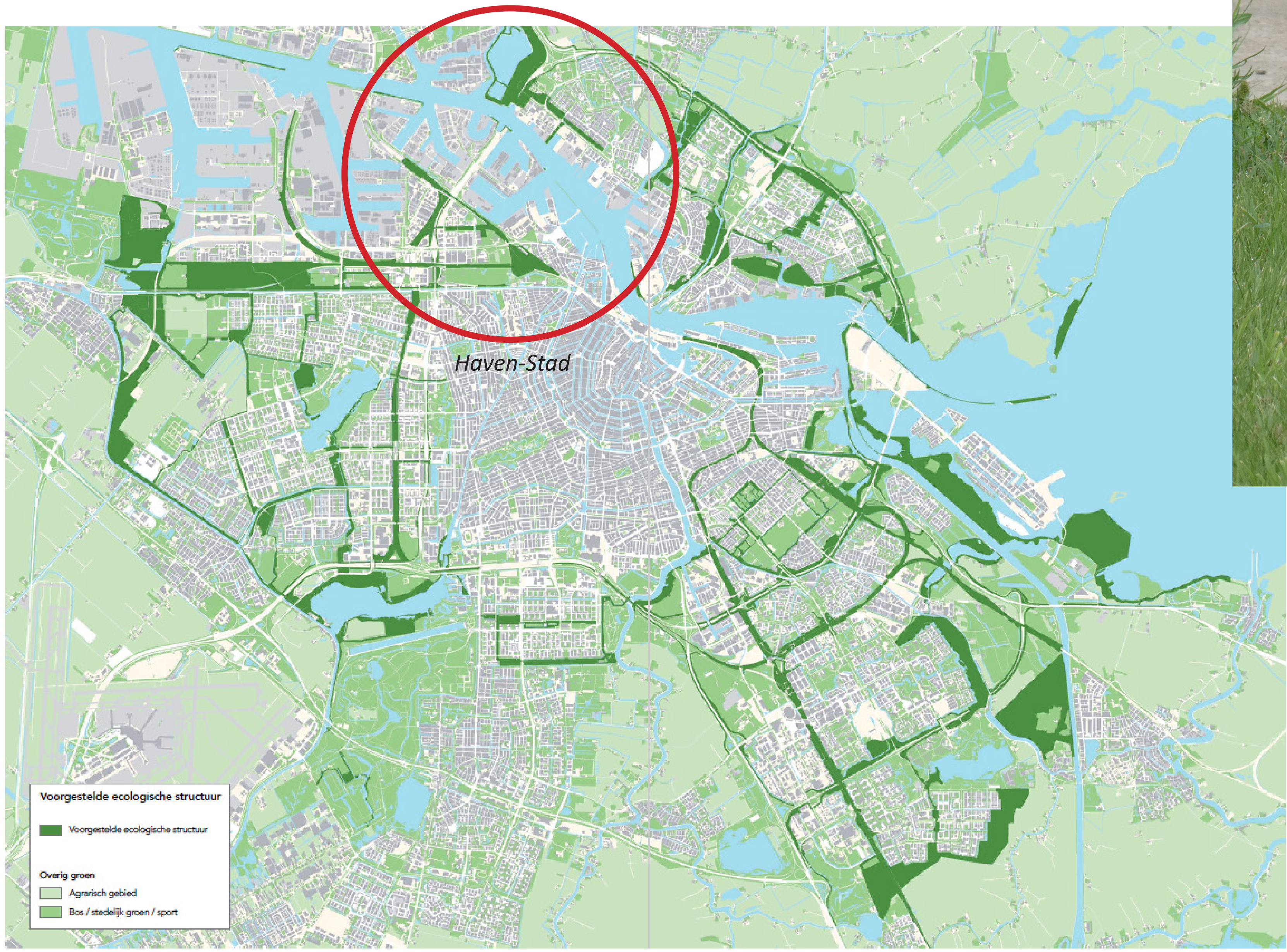



*Figure 8.12.* Vision for the ecological structure of Amsterdam. Reprinted from *"Ecologische Visie. Ecologie, biodiversiteit en groene verbindingen in Amsterdam"*, by Gemeente Amsterdam, 2012. Copyright 2012 by Gemeente Amsterdam.

A fox spotted in the Coenhaven (by author, 2021)

## FLOOD DEFENCES & CALAMITIES LAYER

### Dikes

Figure 8.13 shows the dike rings in the Metropolitan Region Amsterdam. The biggest part of Haven-Stad lies inside dike ring 44. A very small part in the north lies in dike ring 13, and another part in the south lies in dike ring 14. Dike ring 44 lies around the Amsterdam-Rijn Canal and the North Sea Canal, which are important for the discharge of water to the North Sea at IJmuiden. The biggest part of Haven-Stad lies outside the primary dikes of dike rings 13 and 14, and yet it is not an outer dike area. This is because it is part of dike ring 44, which is closed off from the North Sea by the Ijmuiden complex. This area is part of the boezem system; this is the intermediate level to which polders discharge their water and which transports it further to sea (One Architecture et al., 2020).

Recently, however, the system of dike rings has been adjusted. The safety standards and the way in which the standards are set have changed (Kok, Jongejan, Nieuwjaar, & Tanczos, 2017). The safety standards in Figure 8.13 could thus be changed. The dikes in Haven-Stad, which were initially regarded as primary dikes, have been relegated to regional flood defences. It can therefore be assumed that these dikes amply meet the regional standards.

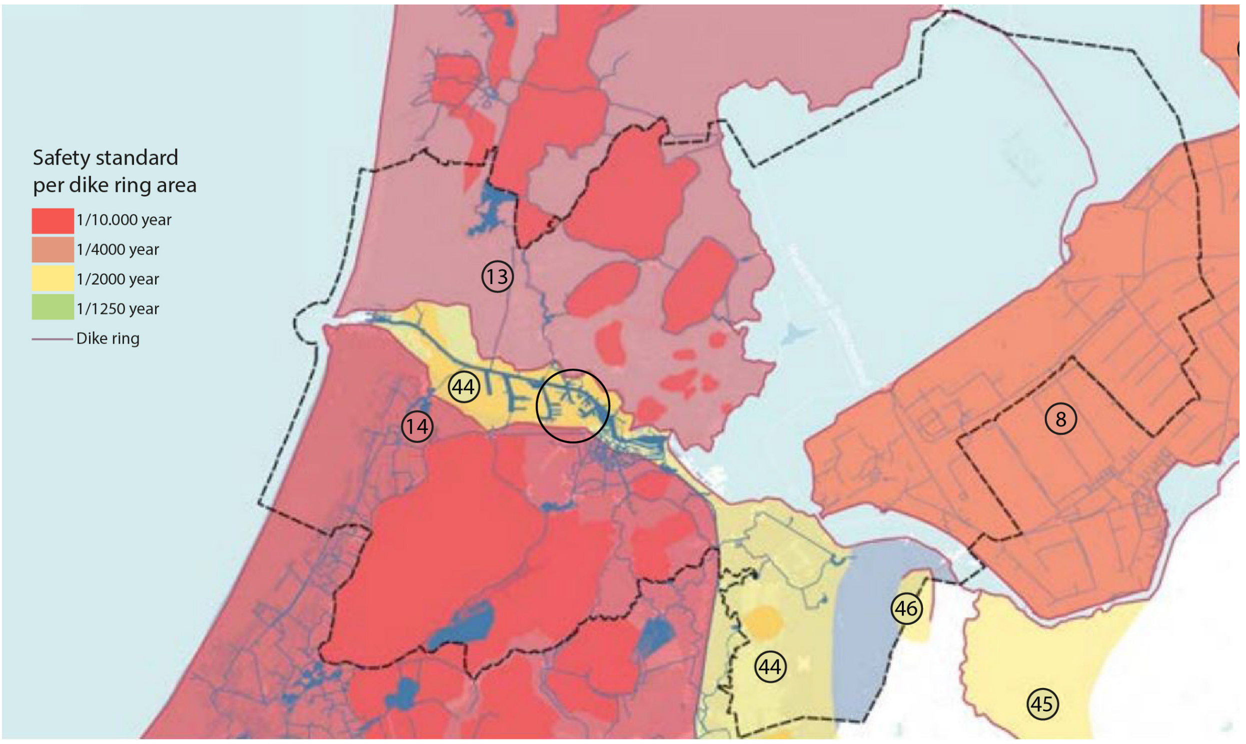



***Figure 8.13.*** Safety standard per dike ring area. Adapted from *"Resilience by Design Metropoolregio Amsterdam"* (p.30), by One Architecture et al., 2020. Copyright 2020 by One Architecture B.V., Amsterdam and One Architecture & Urbanism, New York

### Relative Height

Figure 8.14 shows the relative heights of Haven-Stad and the surroundings. Relative to the surrounding areas, the Haven-Stad area is high. In the past, the city of Amsterdam is hightened with sand, which still gives benefits to the city nowadays. Big parts of Haven-Stad are hightened even more, for the construction of the harbor.

The lower (green and blue) areas around the city of Amsterdam are polder areas. Haven-Stad could thus potentially be the right place to evacuate surrounding low-lying neighbourhoods or to place vital and vulnerable functions (with extra precaution).

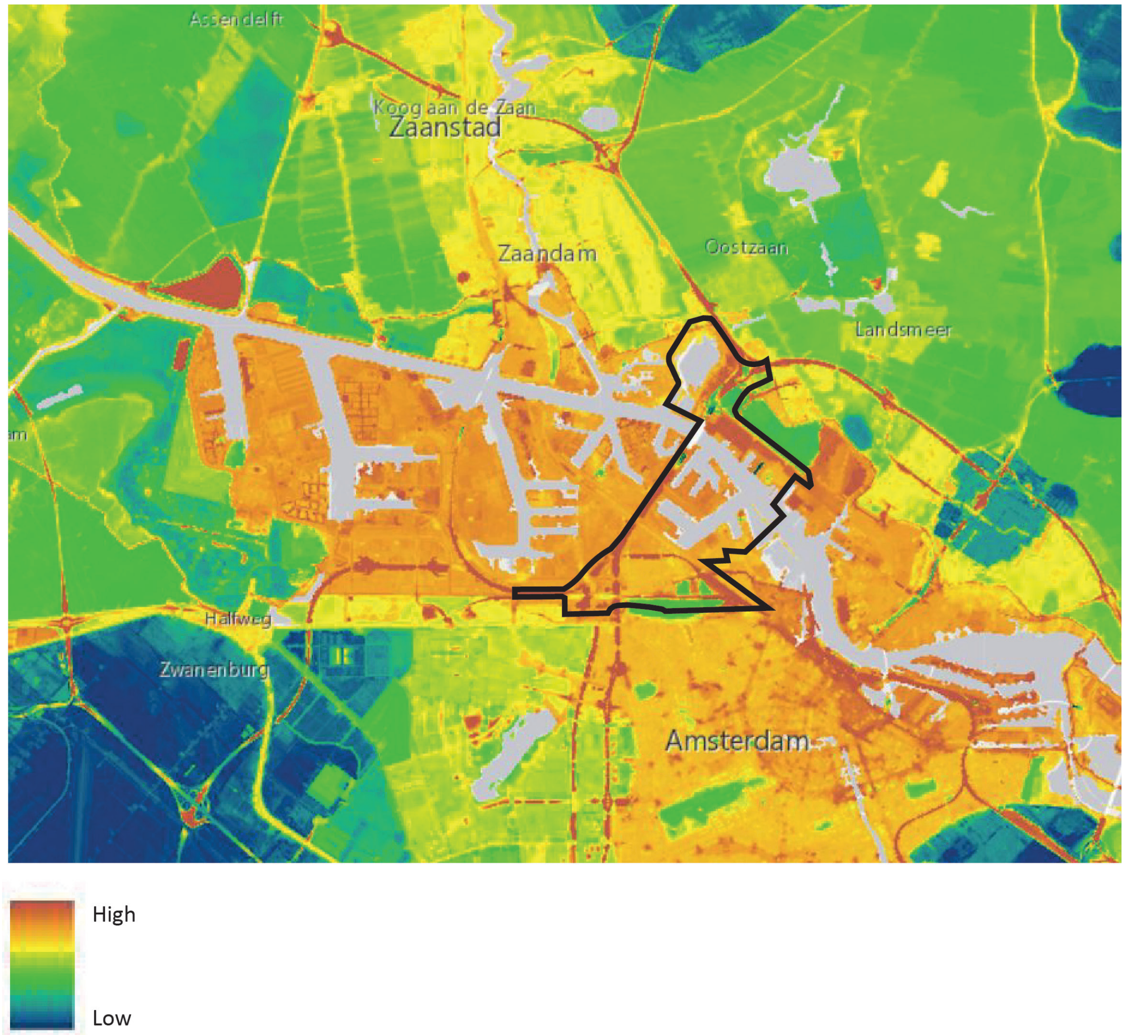



***Figure 8.14.*** Relative height map of Haven-Stad and surroundings. Adapted from "AHN-viewer", by Actueel Hoogtebestand Nederland, 2018. (https://ahn.arcgisonline.nl/ahnviewer/). Copyright 2018 by Actueel Hoogtebestand Nederland.

# 8.2 DESIGN LAYERS & PRINCIPLES

## URBAN DESIGN LAYER

### Current Situation

In Figure 8.15 some 3D views of the area are presented. The industrial character of the harbor and the big scale are clearly visible. There is a lot of pavement and almost no green, except from the two parks.  Water is mostly found on the big scale of the harbor basins and the big lake, and less as a fine grid through the area.

### Site Visit

To get to know the area, a site visit is done.
The Coenhaven is still very industrial and not all areas could be entered. However, a fox was spotted at this very industrial site! The Minervahaven and Houthavens gave an idea of recent developments in and around Haven-Stad.

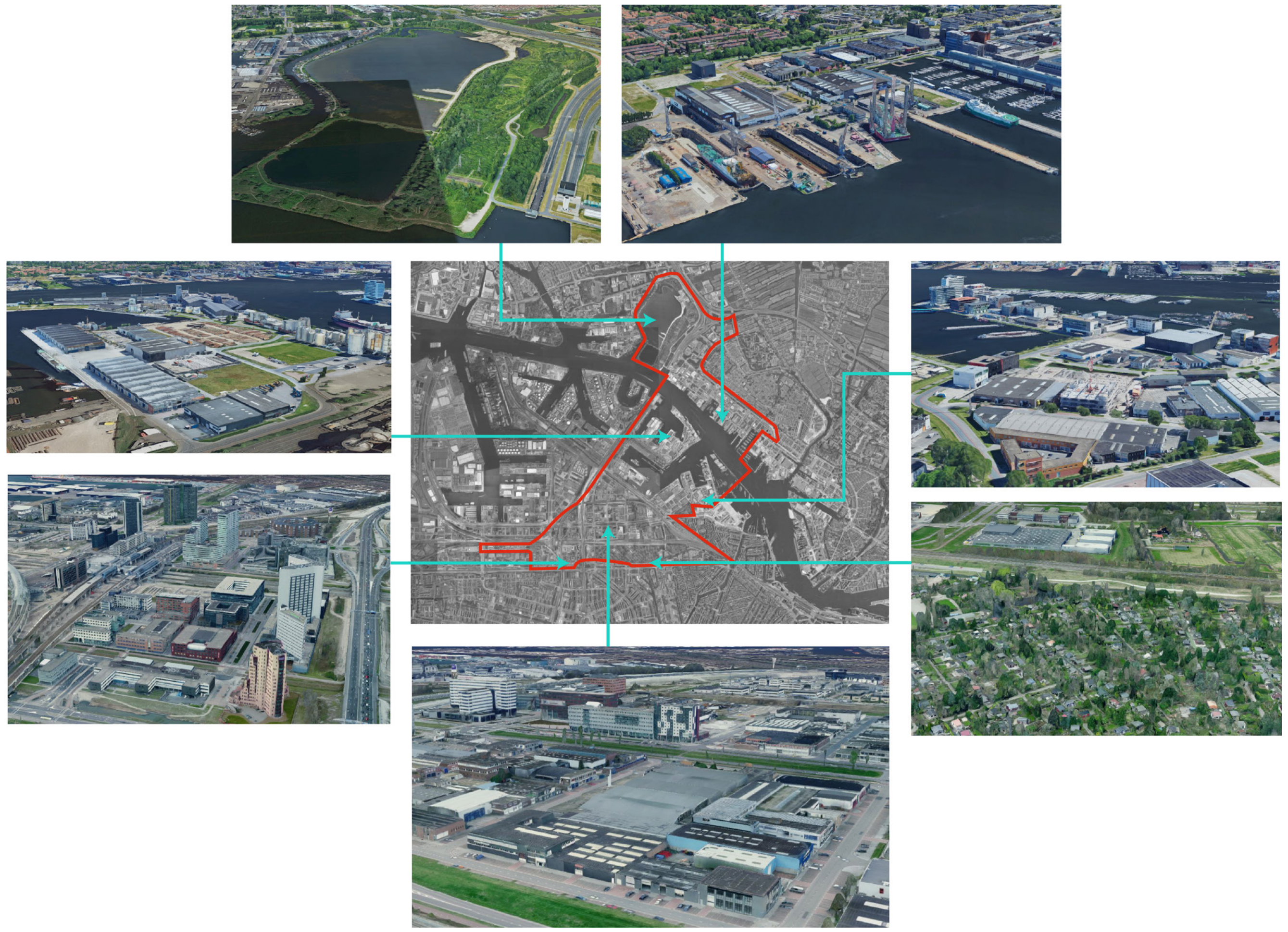


*Figure 8.15*. 3D views of current situation Haven-Stad. Background & 3D views from “Google Maps”, by Google, n.d. (https://www.google.com/maps/place/Amsterdam/). Copyright by Google Maps.

Coenhaven



Minervahaven










Houthavens



# 8.3 2050 DESIGN IN THE FUTURE

## THE CLIMATE IN 2085

To define the design objectives for 2085, the climate in 2085 is of interest. For this, the KNMI' 14 Climate Scenarios for the Netherlands are used (KNMI, 2015). For 2085 (actually, the climate between 2071-2100) projections about the change in temperature, sea level, precipitation and drought are made for four climate scenarios. To simplify the design objectives, it is chosen to base them on the highest projections.

*Sea Level in 2085*
The KNMI' 14 projections for absolute sea level rise at the Dutch North Sea coast in 2085 range from +25 cm to +80 cm, in comparison with the reference period (1981-2010) (KNMI, 2015). The highest value is thus +80 cm (WL & WH scenarios). As the absolute sea level was +3 cm NAP in the reference period, it is assumed to be 3 + 80 = +83 cm NAP in 2085. This value is used to calculate the flood depths in Haven-Stad after failure of the IJmuiden complex.

*Temperature in 2085*
The projection of the rise in temperature at 'the warmest summer day per year' is used to define the temperature rise during heat waves. The increases in the four climate scenarios are: +2.0C, +2.6C, +4.2C, +4.9C (KNMI, 2015). The highest value is thus +4.9C (WH scenario). This value is used to calculate the PET values in Haven-Stad in 2085 during a heat wave.

*Drought in 2085*
To define the drought objectives, the value of 'the highest precipitation deficit exceeded once in 10 years is used. This value is projected to increase from the reference of 230 mm with +3.5%, +17%, +15%, or +40% in 2085. The highest value is thus +40% (WH scenario), which gives a precipitation deficit of 322 mm. This value is used to define the need for slow storage in Haven-Stad.

*Precipitation in 2085*
STOWA published statistics for heavy precipitation for the climate scenarios of the KNMI (Beersma, Hakvoort, Jilderda, Overeem & Versteeg, 2019). To calculate the extremes for short rainstorms, the authors used the indicators 'daily amount exceeded once in 10 years' and 'maximum hourly intensity per year' of the KNMI' 14 scenarios. For a 1-hour rainstorm with a return period of T = 100 years, the amount is projected to be 81 mm in 2085.

Assumptions

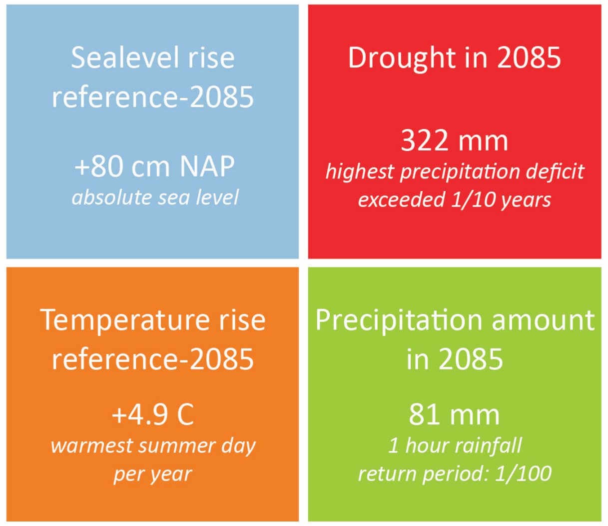



*Figure 8.16*. Assumptions about the climate in 2085.



## OBJECTIVES FOR 2085

### Water safety objective
The water safety objective is defined by the flood depth and probability of flooding (see Figure 3.? in Section 3.2). The assumption is made that the probability of failure of the Complex IJmuiden stays the same in the future. The water level in the North Sea Canal after failure in IJmuiden is calculated as follows:

WATER_LEVEL_2085 (m) =
WATER_LEVEL_2015 + SEALEVEL RISE

According to the study 'Thematische studie Waterveiligheid' (Defacto Stedenbouw & RHDHV, 2021) the water levels of the North Sea Canal are currently projected to be around 1.3 m (1:100.000) after failure. With a sealevel rise of +80 cm, the flood depth can rise to (max.) 2.1 m in 2085.

The flood depth in Haven-Stad is dependent on the water level on the North Sea Canal and the height of the areas in Haven-Stad:

FLOOD_DEPTH_2085 (m) =
WATER_LEVEL_2085 - HEIGHT_2085

De current heights of Haven-Stad range from -2 m till +2 m. The flood depths range from 0-4.1 m (1:100.000). Figure 6.4 shows that for depths higher than 2 m (1:100.000), 'shelter and evacuate' is the objective. However, the flood depths differ in each subarea of Haven-Stad. To simplify the objective for the comparison in the research, the objective is set on 'no victims'.

### Cooling objective
The cooling objective is defined by the difference between the PET values in 2085 and the maximum PET value of 35 C. The PET values in 2085 are calculated with the PET values of 2015 and the expected temperature rise. In 2015 the PET values ranged from 34-46 C.

PET_2085 (C) =
PET_2015 + 1.25 * TEMPERATURE_RISE_2085

With a temperature rise of 4.9 C in 2085, the increase in PET is around 6 C. The range of PET values in 2085 is 40-52 C.

COOLING_OBJECTIVE_2085 (C) = PET_2085 - 35

The cooling objective is thus 5-17 C, depending on the location in Haven-Stad.

### Slow storage objective
The slow storage objective is defined by the highest precipitation deficit exceeded 1/10 years in 2085 (322 mm) and the percentage of green in Haven-Stad:

SLOW_STORAGE_OBJECTIVE_2085 (m3) =
PRECIPITATION_DEFICIT_2085 [1/10 yrs] (m)
* GREEN AREA (m2)

The slow storage objective (m3) is: 0.322 * m2green

### Fast storage objective
The fast storage objective is defined by the projected precipitation amount of a 1-hour rainstorm with a return period of 1/100 years in 2085 (81 mm) and the total area of Haven-Stad south (440 ha):

FAST_STORAGE_OBJECTIVE_2085 (m3) =
PRECIPITATION_EVENT_2085 [1/100 yrs] (m)
* TOTAL AREA (m2)

The fast storage objective (m3) is: 0.085 * 4.400.000 = 374.000 m3.

Objectives for 2085

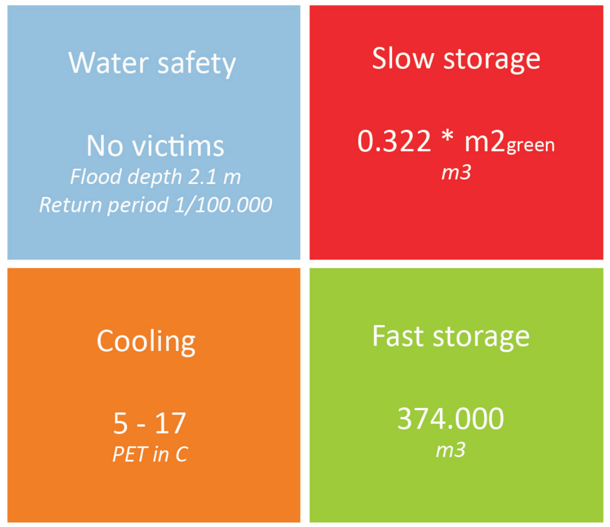



*Figure 8.17*. Objectives for 2085.

**Section 6.2**
*For more information about the selection/calculation of the objectives*

9

# ADAPTATION PATHWAYS




NRC (2018)

# 9.2 FOCUS AREA 1: COENHAVEN WATERFRONT

## TREND (X-AXIS)

*Flood depths - Haven-Stad*

Figure 9.1 shows simulated maximum flood depths at different flood probabilities for Haven-Stad. Multiple failure scenarios are combined to make this map (Defacto Stedenbouw & RHDHV, 2021). As can be seen, flooding occurs in the Coenhaven for all probabilities (1/100, 1/1000, 1/10.000, 1/100.000).

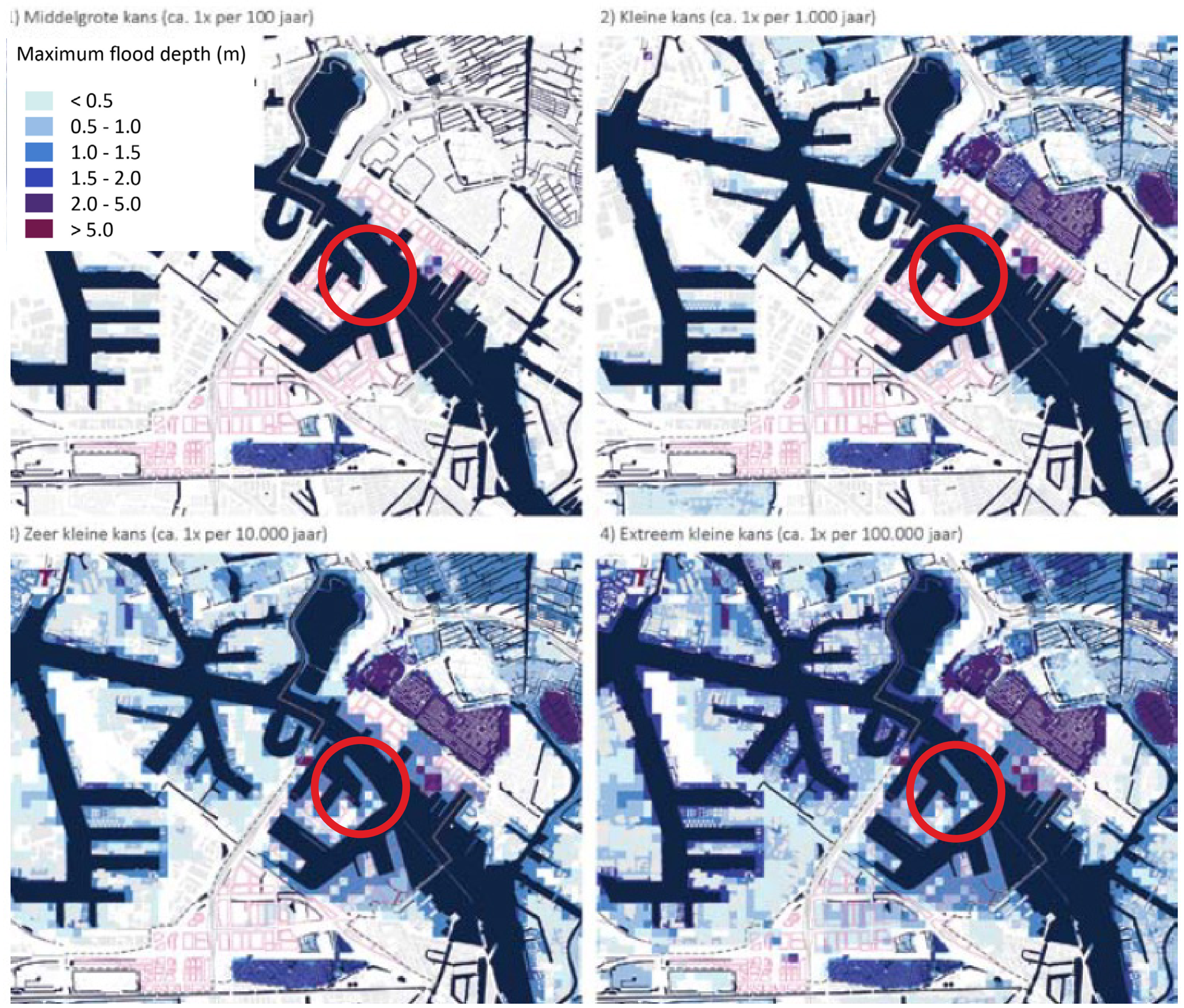



*Figure 9.1*. Maximum flood depths at different flood probabilities for Haven-Stad. Adapted from *"Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid"* (p.92), by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

*Water risk diagram - Coenhaven Waterfront*

Figure 9.2 shows the water risk diagram for the current situation of the Coenhaven Waterfront. It shows 'very serious' flood depths (100-200 cm) for all chances between 1/1000 and 1/10.000.000. A flood depth of 50-100 cm ('serious') has a return period of 1/100 years. The diagram shows that there are a lot of different failures with different chances possible, but that almost all failures cause flood depths between 100-200 cm.

*Water risk profile - Coenhaven Waterfront*

Figure 9.3 shows the water risk profile for the current situation of the Coenhaven Waterfront. It compares the current situation with the expected situation in 2050, with a changed climate and updated dikes. The flood depth connected to a 1/100.000 return period is 1.5 m. The flood depth connected to a 1/10.000 return period is 1.1 m. The acceptable risk of flooding is probably somewhere in between. The mean value is 1.3 m, which is the same value as the flood depth that is considered for Haven-Stad (Defacto Stedenbouw & RHDHV, 2021).

| | Klasse | Zeer extreem | Extreem | Onwaarschijnlijk | Mogelijk | Waarschijnlijk | Veel voorkomend | Vaak | Zeer vaak |
|---|---|---|---|---|---|---|---|---|---|
| | Frequentie | 1/10.000.000 | 1/1.000.000 | 1/100.000 | 1/10.000 | 1/1000 | 1/100 | 1/10 | 1/1 |
| Waterstand | Klasse | | | | | | | | |
| > 300 cm | Catastrofaal | | | | | | | | |
| 200 - 300 cm | Uiterst ernstig | | | | | | | | |
| 100 - 200 cm | Zeer ernstig | 💧 | 💧 | 💧 | 💧 | 💧 | | | |
| 50 - 100 cm | Ernstig | | | | | | 💧 | | |
| 30 - 50 cm | Behoorlijk | | | | | | | | |
| 10 - 30 cm | Matig | | | | | | | | |
| 5 - 10 cm | Klein | | | | | | | | |

*Figure 9.2*. Water risk diagram for the Coenhaven Waterfront (Noorderhoofd, 1013 Amsterdam). Reprinted from "Mijn WaterRisicoProfiel", by Klimaateffectatlas , n.d.. (https://www.klimaateffectatlas.nl/nl/mijn-waterrisicoprofiel). Copyright by Klimaateffectatlas.

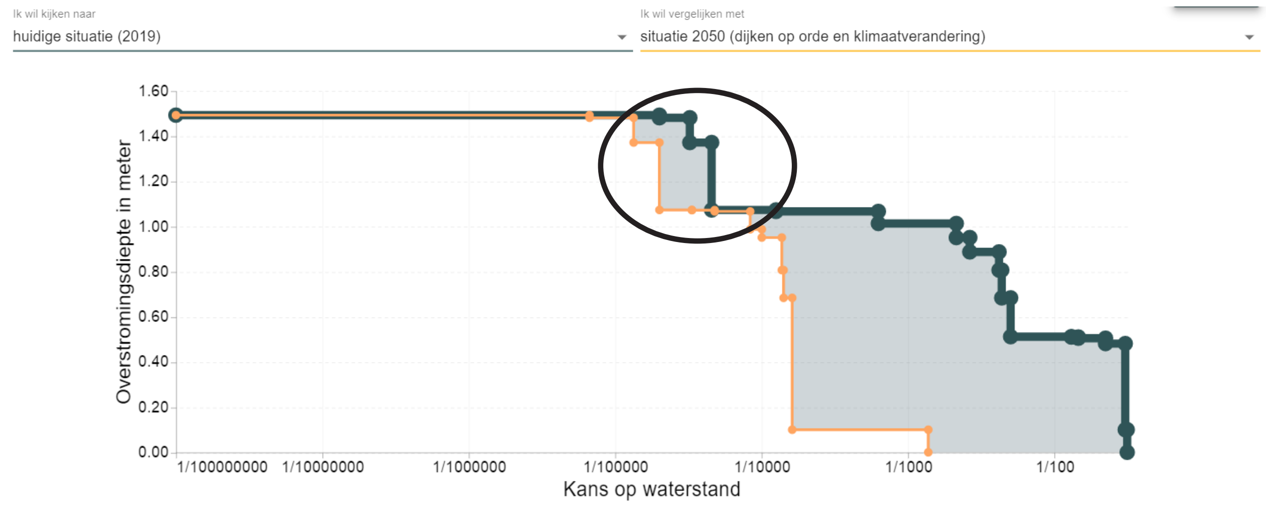



*Figure 9.3*. Water risk profile for the Coenhaven Waterfront (Noorderhoofd, 1013 Amsterdam). Reprinted from "Mijn WaterRisicoProfiel", by Klimaateffectatlas , n.d.. (https://www.klimaateffectatlas.nl/nl/mijn-waterrisicoprofiel). Copyright by Klimaateffectatlas.

*Current sea level rise*
Figure 9.4 shows the sea level rise at the Dutch North Sea coast from 1890 till 2020. In 1995 the sea level was +0.03 m NAP. In 2020 the sea level was +0.06 m NAP. The difference is thus 0.03 m NAP. This value is used for the starting point of the x-axis. It is the current sea level rise, relative to 1995.

*Future sea level rise*
Figure 9.5 shows projections of the future sea level rise, which are used to define the x-axis. As can be seen, a maximum of +3 m NAP is projected in 2100 (relative to 1995). For 2050, a maximum of +0.5 m NAP is projected (relative to 1995).

Figure 9.6 shows the possible change of flood depth in 2100 in Haven-Stad. It shows that the sea level can rise till +6 m NAP during storm in 2100 (assumption of 1.5 m sea level rise). The chance of flooding in Haven-Stad can increase from 1/100.000 to 1/10.000.

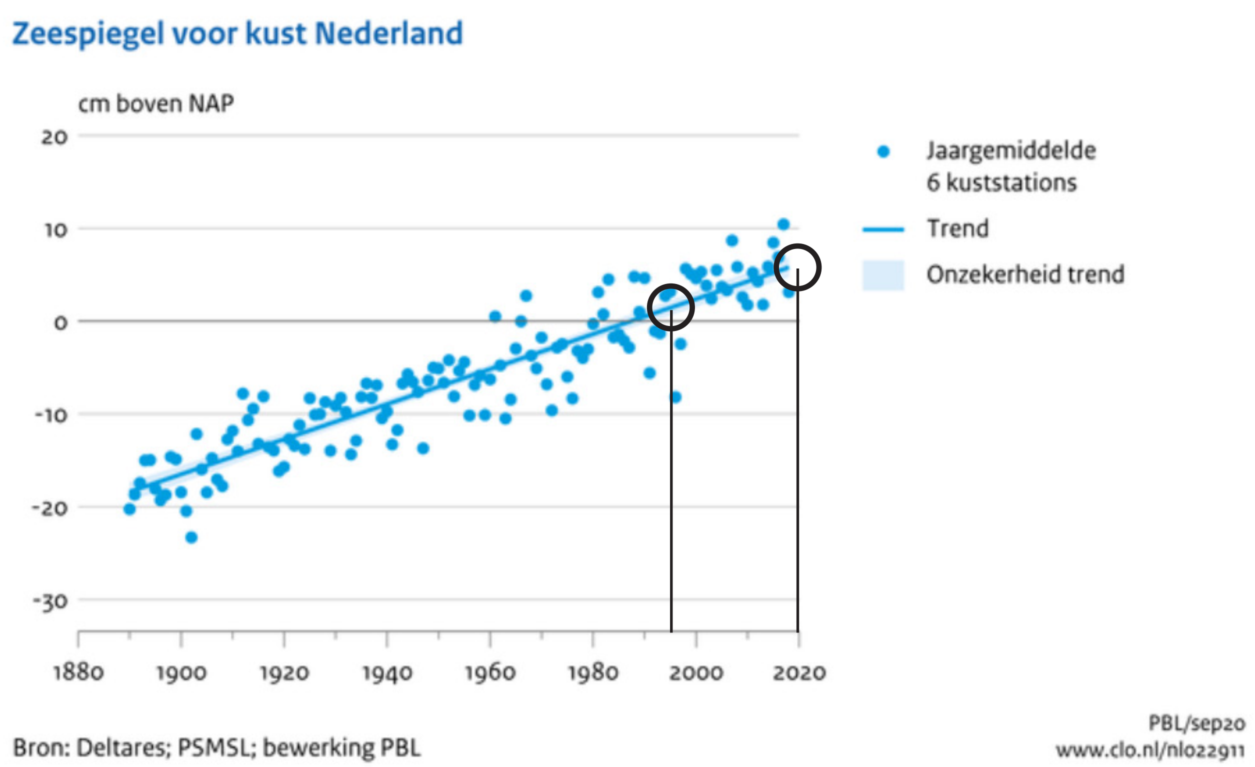



*Figure 9.4*. Sea level at the Dutch North Sea coast. Reprinted from "Zeespiegelstijging langs de Nederlandse kust en mondiaal 1890-2018 (indicator 0229, versie 11, 1 oktober 2020)", by CBS, PBL, RIVM, & WUR , 2020. (https://www.clo.nl/indicatoren/nl0229-zeespiegelstand-nederland-en-mondiaal). Copyright by PBL.

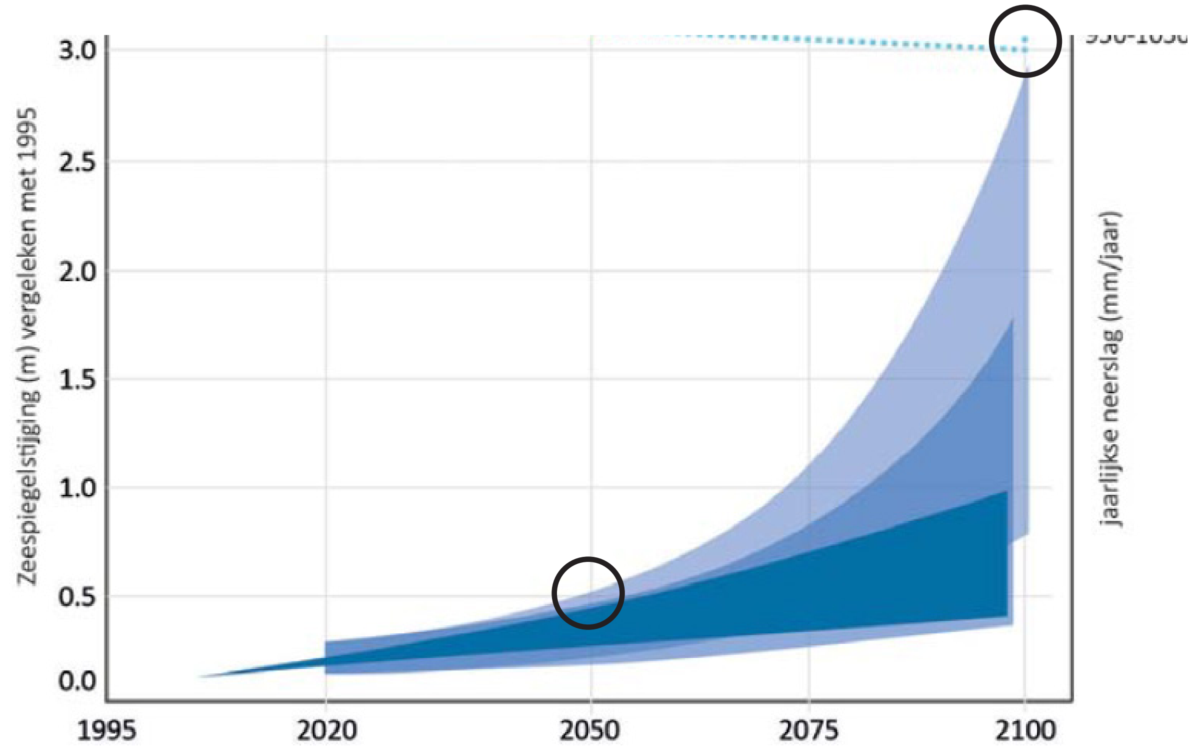



*Figure 9.5*. Projections of sea level rise. Adapted from *"Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid"* (p.30), by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

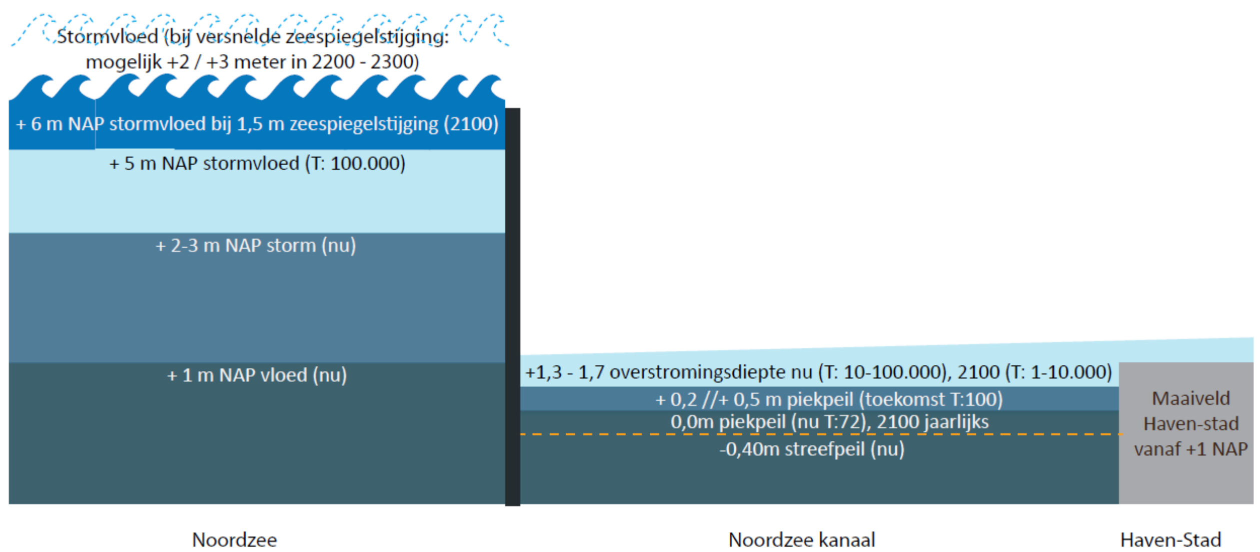



*Figure 9.6*. Possible change of the flood depth in 2100 due to sea level rise and raise of the North Sea canal level, based on expert judgement. Reprinted from "Kansen voor Meerlaagsveiligheid in Amsterdam. Thematische studie waterveiligheid" (p.95), by Defacto Stedenbouw & RHDHV, 2021. Copyright 2021 by Defacto Stedenbouw.

# 9.3 FOCUS AREA 2: SLOTERDIJK I SOUTH

## FOCUS AREA 2: QUICK 2ND TEST SAPP APPROCH

Sloterdijk I South is selected as focus area to do a quick second test of the SAPP approach. In this Appendix section, all steps of the SAPP approach are discussed. The main goals are to find the differences with the development of SAPP for the Coenhaven, and to explicitly share the questions that emerged during the process to make the research-by-design process more tangible.

### Step 1: Analyse the context, climate vulnerabilities, and current governance

In Chapter 4 and Chapter 5, the site analysis of Haven-Stad and the governance analysis are presented. This information gives input to the SAPP development process. In addition, extra information can be sought about the focus area. For instance information about the current situation or about the current plans.

*Questions in this step:*

**Where is the focus area located? [in the district Haven-Stad, in the city of Amsterdam, in the region]**
Sloterdijk I South is located in the south of Haven-Stad and is close to the center of Amsterdam. It is enclosed by the highway A10 in thewest, a large access road (Transformatorweg) in the north and the railway in the south. Parks are located to the south and east of the area. The city, the station and green areas are therefore easy to reach. The water of the IJ River is a bit further away, compared to other neighborhoods in Haven-Stad.

**What kind of characteristics does the focus area have [soil, water, vegetation, urban design, flood defences]**
Sloterdijk I South is located in the boezem of the IJ river and has a clay topsoil to a depth of 10 m, followed by sand. In the current situation there is no open water and little greenery. There are now mainly warehouses and offices [note: use in step 4]. In addition to the desk research, a site visit can be conducted to answer this question.

**What are current and expected climate effects in the focus area?**
Sloterdijk I South already faces problems with pluvial flooding and these are expected to increase due to climate change. But also heat (heat island), fluvial flooding (part of boezem, not protected by a dike), and drought (subsidence) are relevant. [note: use in step 2].

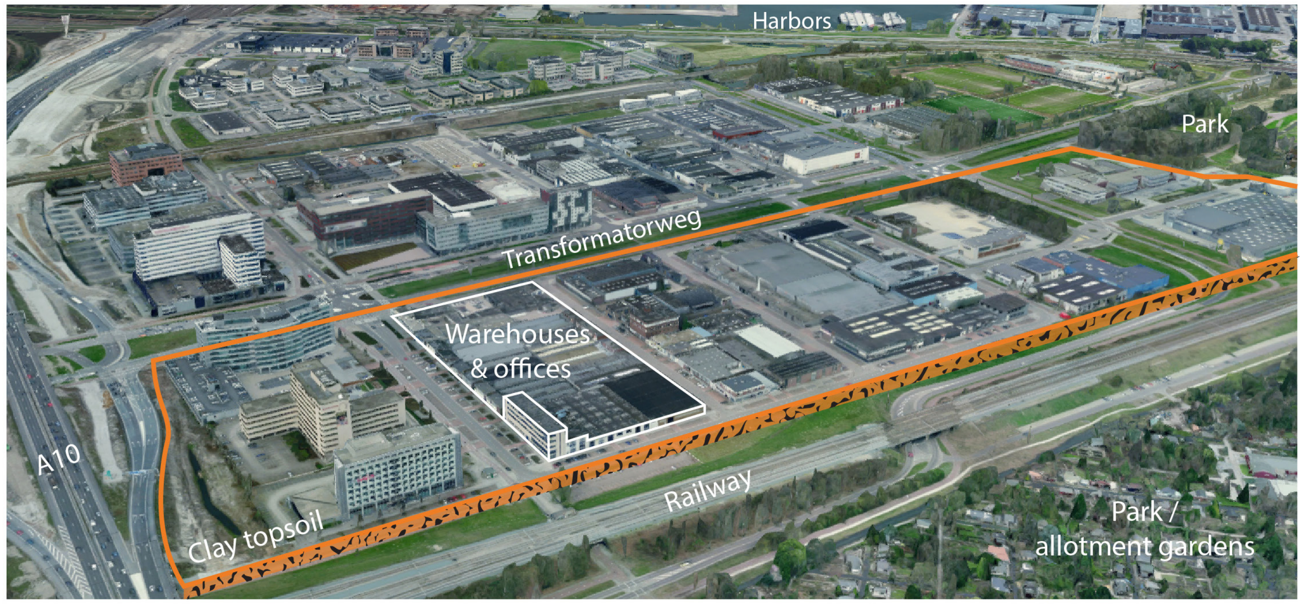




*Figure 9.7*. Context and characteristics of Sloterdijk I South. Background from: (Google Maps, n.d.).

**Have plans already been made for the focus area?**
Because the development of Sloterdijk I South is taking place in an earlier phase (than the Coenhaven), plans for Sloterdijk have already been made by the municipality [note: the plans can be used in step 4 as starting point]. The framework of the public space, made by the municipality of Amsterdam, is shown in Figure 9.8. Sloterdijk I South consists of six main lots. The municipality is responsible for the development of the main streets and the cross streets. Private actors (the developers) are responsible for the realization of at least one public accessible intermediate street on their own terrain.

Some relevant requirements of the municipality of Amsterdam are:
- 70% is now paved, this percentage is not allowed to increase.
- Rainwater can be guided to the waterway of the Transformatorweg.
- Lots should be able to store 60 mm/h and to discharge it in minimal 24 hours with 2.5 mm/h.
- The whole area will be raised with 60-90 cm till +1.0 m NAP.
- The use of blue-green solutions (i.e. a minimum of 25% blue-green roofs).
- Base block till 30 m, high rise till 45 m, incidental accent till 60 m.
(Gemeente Amsterdam, 2019).

**What questions do the plans raise? Do you agree with the plans?**
I think it is positive (for pluvial flooding) that the paved area may not increase due to the development. However, I do think that a storage of 60 mm/h will not be enough on the longer term, as the current 1/100 years rainfall is already 58 mm/h. The whole lot, including the public accessible intermediate streets, will be developed by private actors. One of my questions (to an expert of the municipality) would be: Who performs the management of the public accessible areas and is responsible for any future adjustments? In any case, long-term requirements or public-private agreements will be needed [note: this information can be used in step 7]. I also wonder if an integral raise is the only solution [note: different alternatives can be integrated in the SAPP map in step 5].

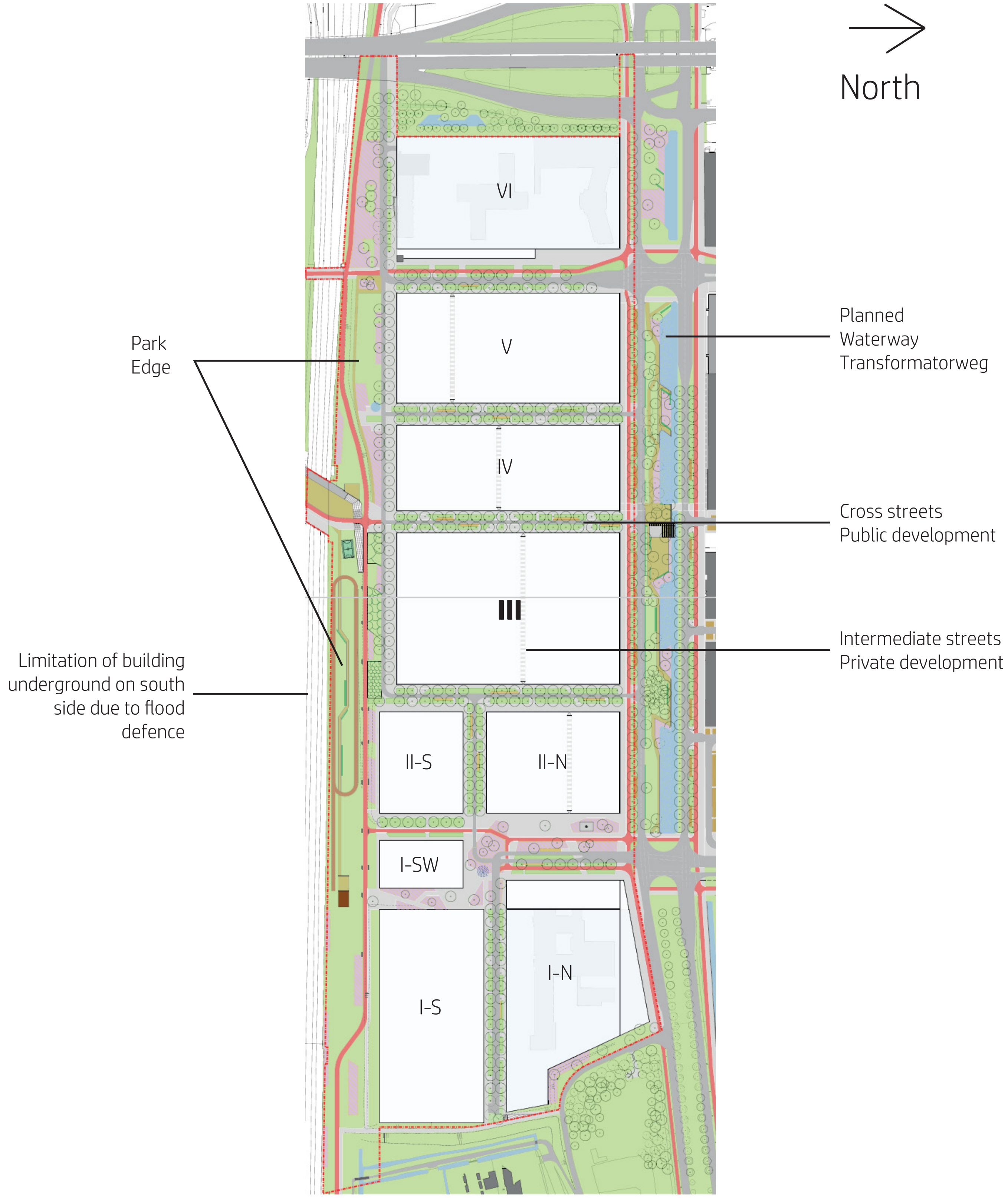



***Figure 9.8.*** Public space framework for Sloterdijk I South. Adapted from "Basisblokpaspoorten Sloterdijk I Zuid" (p. 10-11), by Gemeente Amsterdam, 2019, Amsterdam: Gemeente Amsterdam. Copyright 2019 by Gemeente Amsterdam.

### Step 2: Define the key components and the scope

In Chapter 6, the key components and scope are defined for Haven-Stad. The focus area zooms in on the defined scale and focusses on a specific stressor. In this case from the Haven-Stad district to the Sloterdijk I South neighbourhood, and pluvial flooding.

*Questions in this step:*

**What is the dominant stressor in the focus area?**
In Sloterdijk I South, the dominant stressor is pluvial flooding. The site analysis [step 1] has shown that water nuisance is already occurring, and this can be expected to increase in the future.

**Which climate trends and climate objectives are linked to this stressor?**
In Chapter 6 the climate objectives are identified. Pluvial flooding is mainly caused by short high-intensity rainstorms. The relevant climate trend is thus the precipitation intensity. In Chapter 6, the 1/100 years 1 hour rainstorm is selected, as this is the current acceptable risk. This acceptable risk can be changed if deemed necessary (for instance, if the risk perception changes). The objective is a certain amount of fast storage [m3], which increases with an increasing precipitation intensity [note: use in step 5d].

**Is the defined starting point [a design for 2050] also relevant for the focus area? Or is another starting point needed?**
A design for 2050 is a relevant starting point for the focus area. Sloterdijk I South will be developed in the first phase, and plans are already made. Currently, the worst case climate scenario of 2050 is often used to base designs on [note: use in step 5d].

### Step 3: Identify the adaptation measures

In Chapter 7, adaptation measures are identified and summarized in adaptation tiles. For the focus area and focus stressor (pluvial flooding), not all adaptation measures are relevant or applicable. In this step, a first exploration is made to find adaptation measures for the designs and SAPP map. Extra adaptation measures can be added to the adaptation tiles if needed [note: the information from this step is used in step 5e].

*Questions in this step:*

**Which adaptation principles are relevant for the dominant stressor?**
For pluvial flooding, the most relevant adaptation principles are 'materialization', 'storage', 'flexible water levels', 'infiltration', 're-use', and 'robust urban design'. These principles connect to the sponge-city concept, which tells to delay, retain, store, and re-use the rainwater, and only to discharge it when necessary. All principles do also apply for Sloterdijk I South. However, due to the clay soil, the infiltration capacity can be expected to be low. This should be considered in the design.

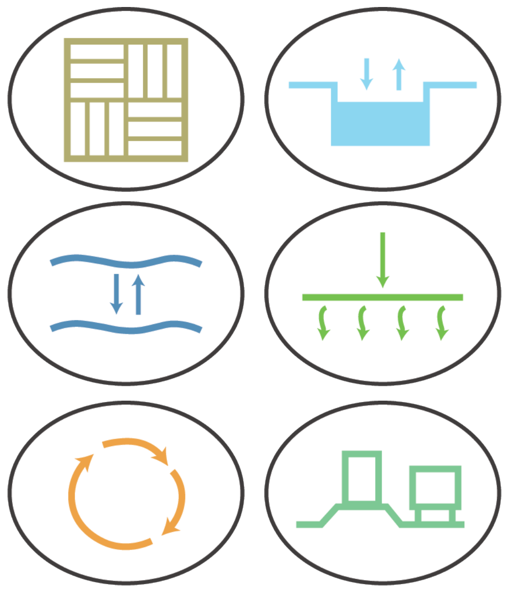


*Figure 9.9*. Most relevant adaptation principles for pluvial flooding.



**Which design layers are the most relevant?**
Each design layer should be considered, as each design layer could potentially contribute to the prevention or limitation of water nuisance. The layer 'water system' can contribute to the adaptation principles storage, flexible water levels, infiltration, and re-use. The layer 'soil' can contribute to materialization (soil type), storage (in soil), flexible water levels (height strategy), and infiltration (soil type). The layer 'vegetation' contributes to materialization (less pavement), infiltration (open up soil structure), and re-use (natural purification). The layer 'urban design' can contribute to water storage (on or in the building), re-use (use of purified rainwater), and robust urban design (flexible buildings or water proof typologies). The layer 'flood defences' is less relevant for pluvial flooding, but bulkheads can for instance be used to protect a part of the neighbourhood or to block the building entrances.

**Which adaptation measures can be used in the focus area?**
To answer this question, the adaptation principles can be used, but also reference projects. For pluvial flooding, a lot of different adaptation measures can be used, such as:

*Soil layer:*
- S2 Height strategy (differentiation in heights for storage)
- S3 Infiltration facilities (soil improvement needed!)
- S4 Reduce/limit paved area
- S5 Use geomorphology and soil for design (low clay soil)
- S7 Deep infiltration

*Water System layer:*
- W1 Water square
- W2 Groundwater management
- W4 Natural storage facilities (such as wadi's)
- W5 Technical storage facilities (such as crates)
- W6 Blue roofs (combination with green roofs possible)
- W7 Open water

*Urban Design layer:*
- U1 Flexible plinth
- U3 Floodproof buildings
- U4 Living on water
- U5 Demontable/modular buildings
- U9 (Semi-)Closed blocks with courtyards
- U10 Build without crawlspace (high groundwater levels)

*Flood Defences & Calamities layer:*
- F8 Water robust vital and vulnerable functions
- F10 Bulkheads

*Vegetation layer:*
- V1 City Park or Forest
- V5 Green roofs & Vertical green
- V7 Grassfields & Green roadsides
- V8 Cooling park & Green courtyards

At the same time, measures that combine well, but in themselves have less influence on pluvial flooding, can also be considered, such as:

- V9 Urban farming
- V6 Street trees
- W3 Purification

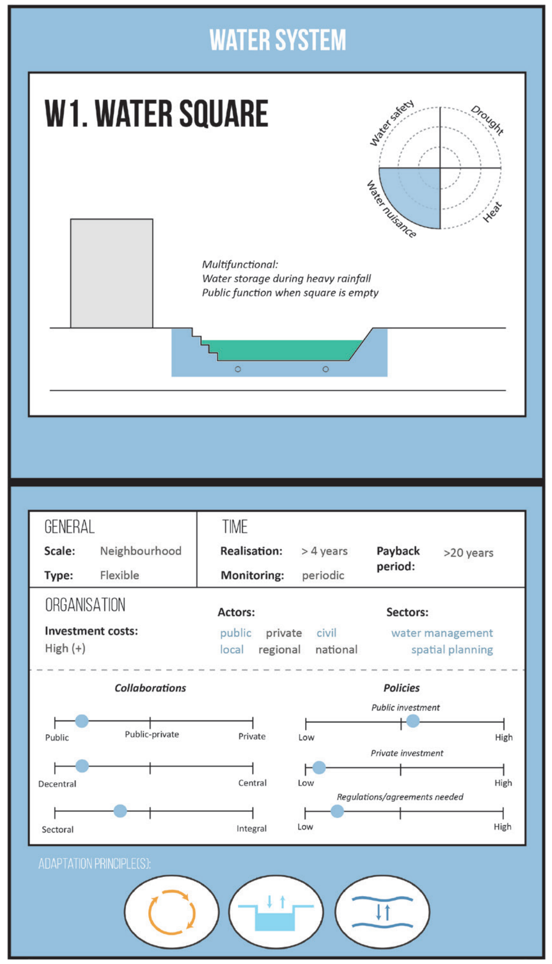



*Figure 9.10.* One of the adaptation tiles that can be used in Sloterdijk I South.

## Step 4: Design the starting point

In Chapter 8, the adaptation principles are translated to Haven-Stad in each design layer. These ideas can be used to design the starting point (in this case a design for 2050) for the focus area. In addition, the starting point is created in iteration with step 5. New insights from the pathway development can give input to change the starting point. Figure 9.11 shows an example of a possible starting point for lot III in Sloterdijk I South. The other lots can be developed similarly.

*Questions in this step:*

**What are the current plans and requirements for the focus area?**
In the current plans, a high-density neighbourhood is planned in Sloterdijk I South [step 1]. Almost each lot is surrounded by the Transformatorweg, two cross streets, and a street along the park edge. A requirement for the development of the lots is to make at least one intermediate street to connect the two cross streets and to store 60 mm/h on the lots. The configuration of the buildings in Figure 9.11 is inspired by an example of the municipality (Gemeente Amsterdam, 2019). Note that the starting point does not need to reflect the current plans, if the SAPP map gives enough arguments to change them.

**How can the adaptation principles/measures be translated to the focus area?**
See Figure 9.11 for an example. Due to the low clay soils in Sloterdijk I South, infiltration will not be as effective. That is why it is important to create storage in the water system (and possibly open water). A height strategy can create storage in low areas and keep buildings dry in higher areas. Water can also be stored on the roofs. A wadi-like structure can optionally be added if the starting design can no longer provide enough storage. To be on the safe side, vulnerable functions can be placed on higher floors [note: use information from Chapter 8 & step 3].

**Are space reservations or other flexible components needed? Where and how can these be implemented?**
These questions can often only be answered later in the process, when more has already been discovered about the needed future adaptations [note: iteration with step 5]. For example, it can be useful to reserve space for future storage facilities, or to work with modular buildings. In the start scenario (60 mm/h) it is probably possible to store all the water on the lot. However, it is also important to think about the surrounding areas and whether they can offer a solution in case more storage is needed (for example the surrounding parks).

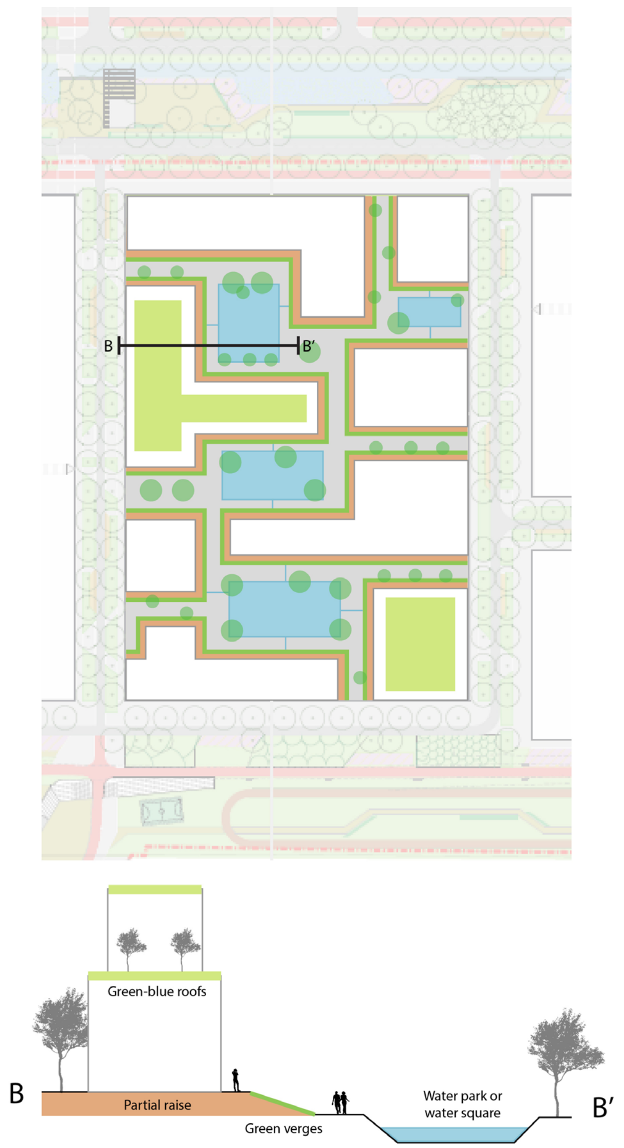



*Figure 9.11.* Example of a design for the starting point. Lot III as example. Background map: (Gemeente Amsterdam, 2019).



## Step 5a: Draw conceptual pathways

In Section 9.1, conceptual pathways are made for each design layer. The conceptual pathways are design exercises to explore how each design layer can change over time to adapt to climate change. For the development of SAPP, the conceptual pathways can give inspiration about the change of space over time.

*Questions in this step:*

**Which concepts from the conceptual pathways can potentially be used in the focus area?**
For Sloterdijk I South, multiple concepts can be interesting. The conceptual pathways for the soil layer (Figure 9.12) show how a height strategy can be implemented and adjusted over time. A height strategy is particular interesting for the pluvial flooding focus, as it can shape storage areas. For Sloterdijk I South this concept can be further investigated to see whether the planned integral raise [step 1] is the only option, or whether an height strategy (which can change over time) is also an option [note: this idea is used in the example of step 4]. In addition, the conceptual pathways for the water system layer (adding storage), vegetation layer (adding infiltration and storage), and urban design (storage on roofs, flexible buildings) layer can also be important.

**How can the concepts be combined (in the focus area)?**
Adding storage (watersystem) can be combined with adding green areas (vegatation) and with a height strategy (creating high and low areas). Storage can also be added in the buildings. And demontable/modular buildings could potentially reserve space, for instance by first placing a building somewhere and later removing or moving it (for example on top of an existing unit).

**Which other concepts/options can you think of?**
The conceptual pathways in Section 9.1 show the outcomes of my design exercise. But these pathways can be can be supplemented and expanded with new ideas.

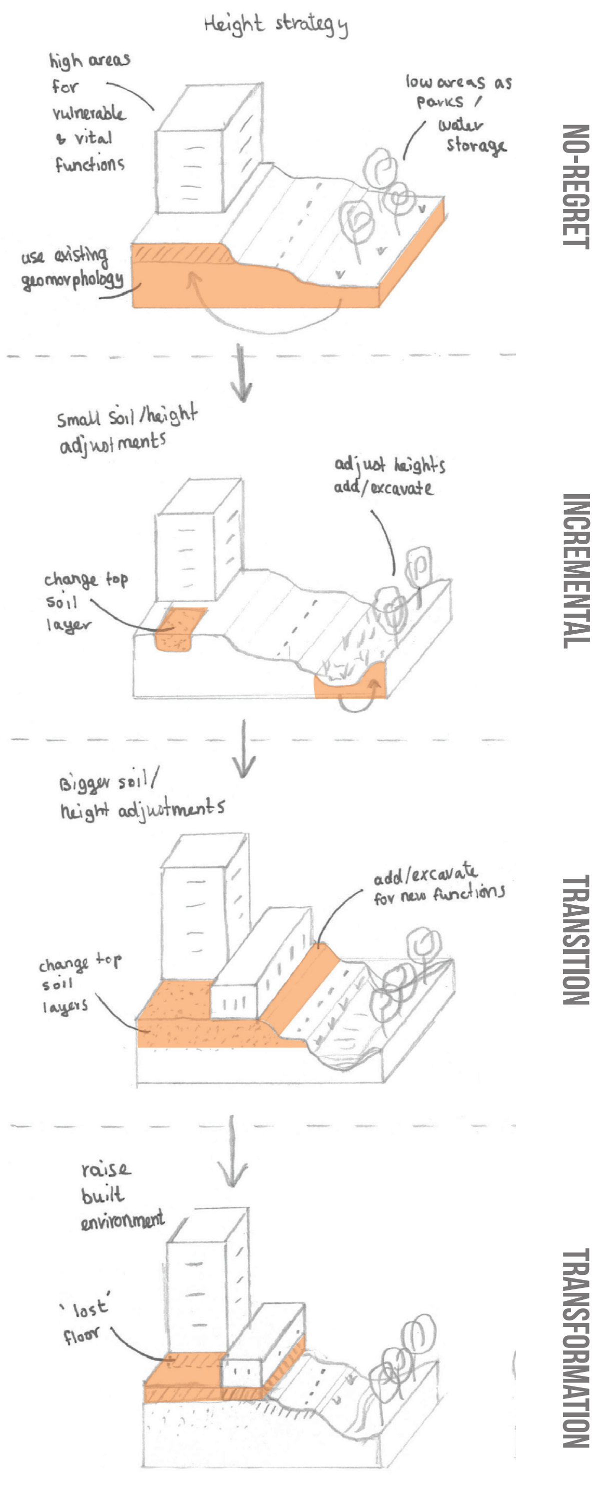



*Figure 9.12.* A part of the conceptual pathways for the Soil layer.

### Step 5b: Identify possible future developments

In this step, the possible future developments need to be identified that can potentially influence the focus area (related to the dominant stressor). It is important to look at developments on different scales.

*Questions in this step:*

**Which future developments could be possible in the focus area?**
In relation to pluvial flooding, it is important to consider the potential increase of rainfall intensities due to climate change. This increases the need for fast storage in the focus area. There is increasing attention for water retention on the location where it falls (the sponge city concept), and this will probably be continued in the future. If more water is stored in the area, there are more opportunities for the re-use of water. In addition, new functions may be required in the long term or more/fewer buildings may be needed. This could possibly be included in the pathways, but entail additional uncertainties.

**Which future developments could be possible in the district and how do they influence the focus area?**
The possible discharge to the North Sea Canal can also be reduced in the future. The system is already under pressure and this pressure is expected to increase in the future due to climate change (more rainfall in total and more heavy summer rainfalls). Various measures will probably be used to relieve the system. Such as retaining water (also in Haven-Stad) and creating retention areas. To simplify the pathways, the assumption can be made that no water may be discharged into the canal. Another development that could be relevant is the mobility transition. Areas that are now designed for cars (parking lots, parking garages, wide roads) can later be used for water storage, if cars disappear in Haven-Stad.

**Which future developments could be possible in the regional or national scale and how do they influence the focus area?**
If the water levels of the North Sea Canal are raised (to relieve the system), the groundwater levels in the focus area can also rise, which has consequences for pluvial flooding. In addition, as came foreward in Section 9.2, the part of Haven-Stad which is located in the North Sea Canal boezem, can either stay a boezem area or become a polder in the (far) future (this decision is made on the regional/national scale). A dike on the waterfront of Haven-Stad, would also mean that Sloterdijk I South turns into a polder. This has consequences for the water system in Sloterdijk I South.

### Step 5c: Connect future developments to transition phases

To integrate the possible future developments [step 5b] in the SAPP map, it could be helpfull to connect the development to the transition phases. [note: this information is input for step 5d and 5e].

*Questions in this step:*

**What could happen in each transition phase? How big is the difference compared to the current/start situation (an incremental change or a bigger change such as a transition/transformation)?**

*No-regret phase (design for 2050)*
In the first phase Haven-Stad is developed. The idea is to make no-regret choices and to keep all options open to the future. It is unsure how the precipitation trend will continue and Sloterdijk I South must be able to adapt to different possible futures. Because the area will already be developed in the first phase of Haven-Stad, the situation for the start design will not differ much from the current situation.

*Incremental phase*
In the incremental phase, incremental measures could be taken to increase the fast storage capacity of the area. The incremental measures should be reversible or no-regret. In the incremental phase, it could be possible that the possible discharge from Haven-Stad to the North Sea Canal is reduced. If a certain discharge has been included in the calculations for the starting design, extra storage will have to be created.

*Transition phase*
A large increase in precipitation intensities can initiate a transition to create a lot more storage in the area. In addition, Sloterdijk I South could stay a boezem area or could become part of a polder. This decision will depend on the national and regional decisions about the delta strategy and on local circumstances and preferences. Also the mobility transition could be given a place here, for example by making an assumption of a certain percentage fewer cars (and thus more space for other functions such as water storage).

*Transformation phase*
In the transformation phase the chosen strategy is enhanced and developed further. This can be initiated by increased rainfall intensities and/or by societal needs. The transformations are connected to the defined transitions.



### Step 5d: Define the x-axis

To define the x-axis, information from step 2 (dominant stressor, climate trend, climate objective) and 5c is used. Figure 9.15 shows an example of how the x-axis for pluvial flooding can be defined (with lot III as example, area = 30.000 m2).

*Questions in this step:*

**Which trend is placed on the main axis? How are the climate trend and objective related?**
The fast storage objective (m3) is selected as main axis. This makes it easier to link the needed storage (objective in m3) to the effect of the adaptation measures (storage in m3). It also ensures that the entire area is considered integrally; all measures taken together must reach a certain amount of storage. Below the main axis, the trend of the precipitation intensity (1 hour, 1/100 years) is shown (this intensity x m2 area = m3 needed storage). The fast storage objective thus increases with the precipitation intensity. [note: if the public and private areas should be treated separately, it is easier to put the precipitation intensity on the x-axis (as the areas will probably have different m2).

**What are the starting point and end point?**
The starting point is the current situation. The current 1/100 precipitation intensity for a 1-hour rainstorm is 58 mm/h (see Figure 9.13). The current needed fast storage on lot III is thus (rounded) 60 mm * 30.000 m2 (area of lot III) = 1800 m3. The endpoint is could be determined by (for instance) the climate resilient objectives of RIONED (RIONED, 2016):

| | |
|---|---|
| Not climate resilient | 60 mm/h |
| Moderately climate resilient | 90 mm/h |
| Medium climate resilient | 120 mm/h |
| Very climate resilient | 150 mm/h |

150 mm/h is selected as endpoint, because it is considered as very climate resilient and it exceeds the maximum intensity from the KNMI'14 climate scenarios (82 mm/h). This connects to a fast storage of 150 mm * 30.000 m2 (area of lot III) = 4500 m3.

**What is the best-case and worst-case climate scenario?**
Figure 9.13 shows the increase in precipitation intensities in the best-case (lower) and worst -case (upper) climate scenarios. In Figure 9.14 the projected precipitation intensities are calculated. This information can be used to add the related years (2050, 2085) under the main x-axis (see Figure 9.15). This component adds two time scales to the adaptive pathways map.

| T [jaar] | 10 min | 30 min | 60 min | 2 uur |
|---|---|---|---|---|
| 0.5 | 8.1 | 10.4 | 12.6 | 15.3 |
| 1 | 10.2 | 13.5 | 16.2 | 19.5 |
| 2 | 12.2 | 16.6 | 20.0 | 24.0 |
| 5 | 15.1 | 21.2 | 25.8 | 30.7 |
| 10 | 17.5 | 25.3 | 31.0 | 36.8 |
| 20 | 20.3 | 30.2 | 37.2 | 44.2 |
| 25 | 21.3 | 32.0 | 39.5 | 46.9 |
| 50 | 24.7 | 38.2 | 47.7 | 56.5 |
| 100 | 28.7 | 45.8 | 57.7 | 68.4 |
| 200 | 33.4 | 55.0 | 70.0 | 81.3 |

TABEL 2 BASISSTATISTIEK VOOR HET JAAR; NEERSLAGHOEVEELHEDEN (IN MM) BIJ VERSCHILLENDE HERHALINGSTIJDEN EN NEERSLAGDUREN TUSSEN 10 MINUTEN EN 8 DAGEN. NB DE HOEVEELHEDEN IN DEZE TABEL KUNNEN VOOR PRAKTISCH GEBRUIK AFGEROND WORDEN OP HELE MILIMETERS. HIER IS DAT BEWUST NIET GEDAAN OM AFRONDINGSFOUTEN TE VOORKOMEN WANNEER DEZE GETALLEN GEKOMBINEERD WORDEN MET KLIMAATSCENARIOFACTOREN IN DEELRAPPORT 2 EN/OF DE REGIONALE SCHALINGSFACTOREN IN DEELRAPPORT 3

| Scenario | KNMI'14 scenario 10 min t/m 2 uur | Neerslag-verandering tov 2014 [%] |
|---|---|---|
| 2030 "lower" | 2030____lower | 3.9 |
| 2030 "upper" | 2030____upper | 7.7 |
| 2050 "lower" | 2050_GL_lower | 3.9 |
| 2050 "upper" | 2050_WH_upper | 21.3 |
| 2085 "lower" | 2085_GL_lower | 6.4 |
| 2085 "upper" | 2085_WL/WH_upper | 41.1 |

PROCENTUELE TOENAME IN EXTREME NEERSLAG VOOR DE LOWER EN UPPER SCENARIO'S VOOR 2030, 2050 EN 2085 (GELDIG VOOR NEERSLAGDUREN VAN 10 MINUTEN T/M 2 UUR)

*Figure 9.13*. STOWA statistics about current (top) precipitation intensities and future changes (bottom). Reprinted from *"Neerslagstatistiek en -reeksen voor het waterbeheer 2019"* (p.15 & p.43), by STOWA, 2019. Copyright 2019 by STOWA.

| 2014 | 60 min, T = 100 | 57.7 mm | |
|---|---|---|---|
| | Scenario | Change from 2014 | mm |
| best case | 2030 lower | 3.90% | 60 |
| | 2050 lower | 3.90% | 60 |
| | 2085 lower | 6.40% | 61 |
| worst case | 2030 upper | 7.70% | 62 |
| | 2050 upper | 21.30% | 70 |
| | 2085 upper | 41.10% | 81 |

*Figure 9.14*. Calculation of precipitation intensities for different climate scenarios (best case & worst case).

### At which points does a phase shift occur?

The start design is assumed to be dimensioned on the climate in the worst case scenario for 2050. This connects to a precipitation intensity (1 hour, 1/100 years) of 70 mm/h (58 + 21.3%). (The current rule in the plans of the municipality is however 60 mm/h). The phase shifts can (for instance) be connected to the RIONED objectives.

The start phase ends at 70 mm/h, when the worst-case scenario for 2050 is reached. It is assumed that 20 mm/h extra, till a total of 90 mm/h can be solved with incremental measures. Above 90 mm, a transition is needed. And above 120 mm, a transformation is needed.

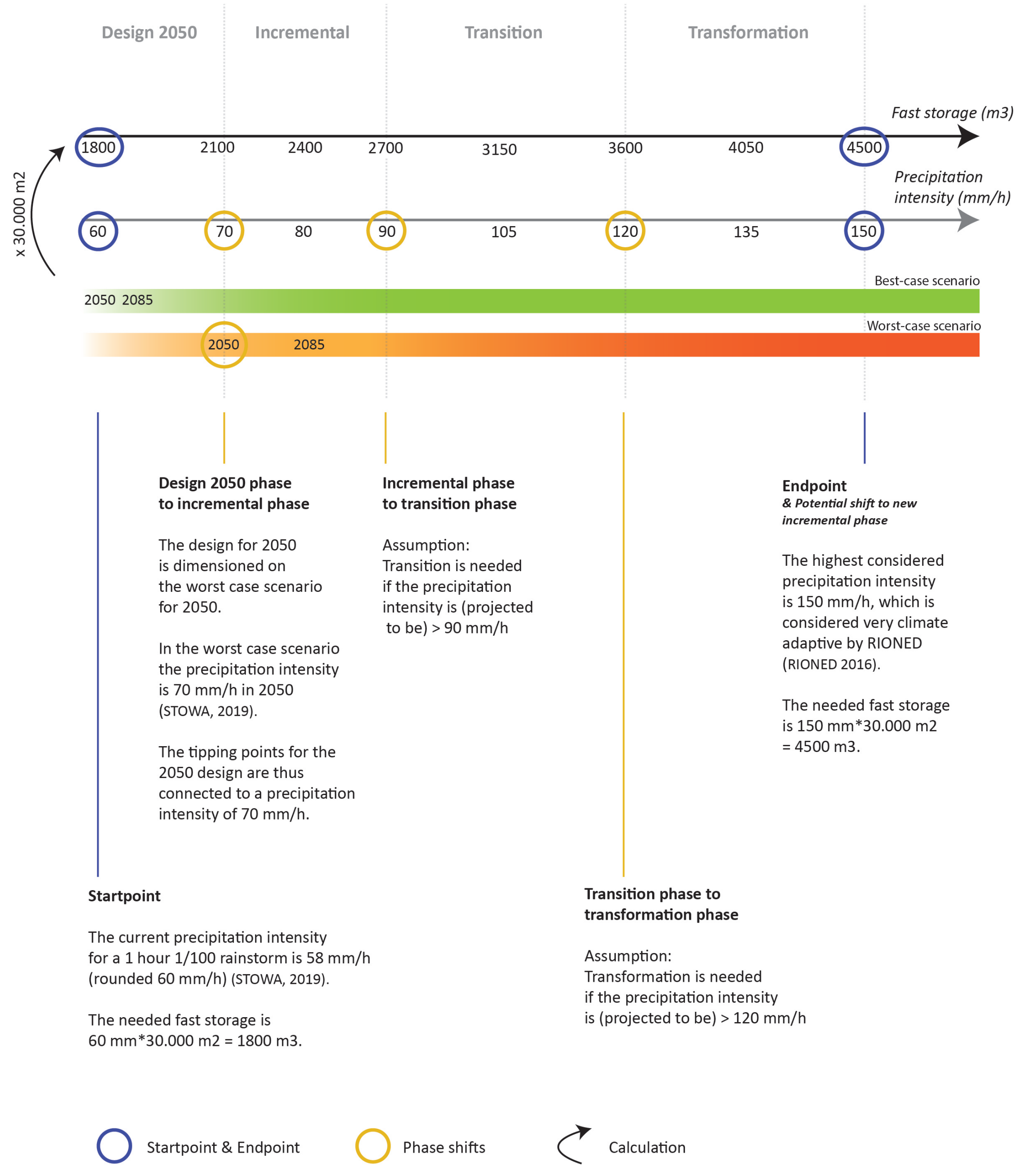



*Figure 9.15*. Example of a possible x-axis for a SAPP map for pluvial flooding (example: Lot III Sloterdijk I South).



## Step 5e: Select and sequence relevant adaptation measures

In this step, all information from the previous steps is combined to create the SAPP map. This is a research-by-design process, in which different concepts can by tried out by sketching them in the context of the site, by calculating (or estimating) the effects, and by drawing the adaptive pathways in the SAPP map. Insights from this process can generate new questions for the previous steps of the SAPP approach. Figure 9.16 shows a possibility for one single adaptation pathway for Sloterdijk I South. To make the SAPP map, alternative pathways need to be added.

*Questions in this step:*

### Which adaptation measures can be used in the focus area? Which adaptation measures can be combined?

These questions ask to make a selection of measures for the design of the focus area. This involves looking at various alternatives, which are, for example, more or less relevant depending on certain future developments [note: use information from step 3, 4, 5b, and 5c]. For this quick test, only a single pathway has been devised (see Figure 9.16). In this pathway, the height strategy, green roofs, and water parks or water squares are the main measures in the start design.

### Which adaptation measures can be linked to each transition phase? Which adaptation measures can be sequenced (to follow each other in time)?

To answer these questions, the future developments and transition phases, and the adaptation measures need to be combined in designs that show adaptation over time. The conceptual pathways can give inspiration for this [note: use information from step 3, 4, 5a, 5b, and 5c]. Figure 9.16 shows an example for one single pathway for Sloterdijk I South, lot III. The buildings and main streets are located on raised areas and the intermediate streets are on the old level (so deeper). There are also four water squares or parks for water storage. In addition, 25% of the roof surface is green-blue (the current requirement of the municipality). In the incremental phase, the percentage of green-blue roof can be expanded and wadi structures can be created in the intermediate streets. In a transition, the wadis can be extended over the entire surface of the intermediate streets (except from the raised sidewalks along the buildings). In a transformation, even more storage can be created by turning all intermediate streets into open water.

### How can the effect of the adaptation measures on the y-axis be linked to the objectives on the x-axis?

[note: use information from step 3 and 5d].
A combination of measures is often used to prevent or limit pluvial flooding. This has consequences for the arrangement of the y-axis and the connection with the x-axis. The x-axis shows the fast storage objective; the amount of storage in m3 required for a given precipitation intensity. All the different storage capacities of the different measures in a design must be added together to determine the total storage of the focus area. But at the same time, individual measures can be preserved or replaced by a new measure in later phases. Therefore there must be room on the y-axis for both the individual measures and the combinations of measures. Figure 9.17 shows two different options to handle this in the SAPP map. Option A is to create packages of measures. Only the packages, not the individual measures, are connected to a pathway and a tipping point. The advantage of this option is the simplicity; the disadvantage is that preserved measures (over phases) must be repeated in each package (for instance the water squares). Option B works with vertical addition and a shared tipping point. Each individual measure has its own pathway line, but the tipping point is shared. The tipping point shows which measures are combined in a certain phase, and at which point the combination of these measures does not yield enough storage anymore. To see how much storage the combination has, the storage of the measures needs to be added (vertically over the SAPP map). The advantage of this option is that there is more insight into the sequence of certain measures, and that the repeation (of option A) is not needed. The disadvantage is that this option can become very complex if more measures and alternative pathways are added.

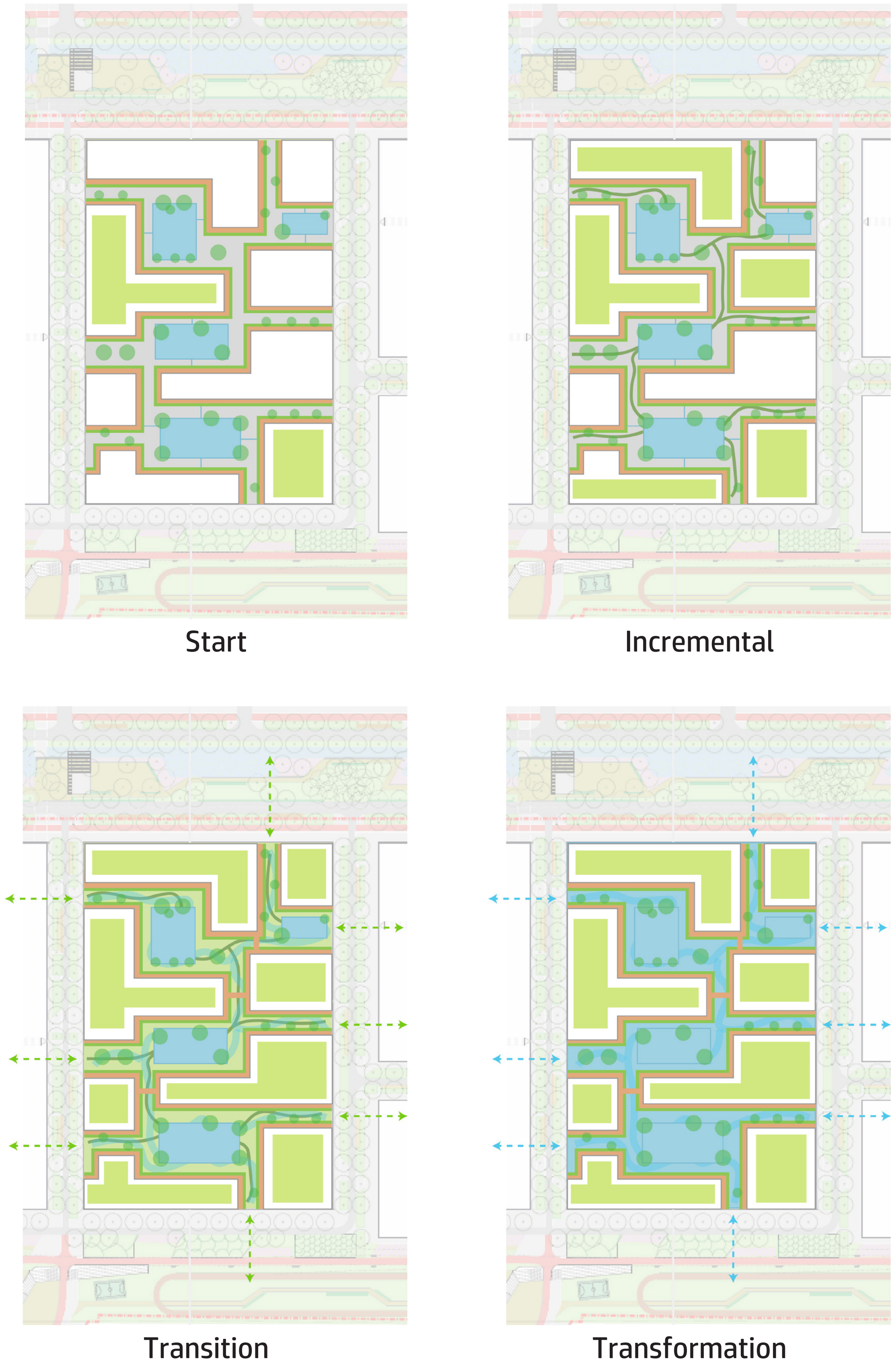



*Figure 9.16.* Example of one possible pathway for Sloterdijk I South (example: Lot III). Background map: (Gemeente Amsterdam, 2019).

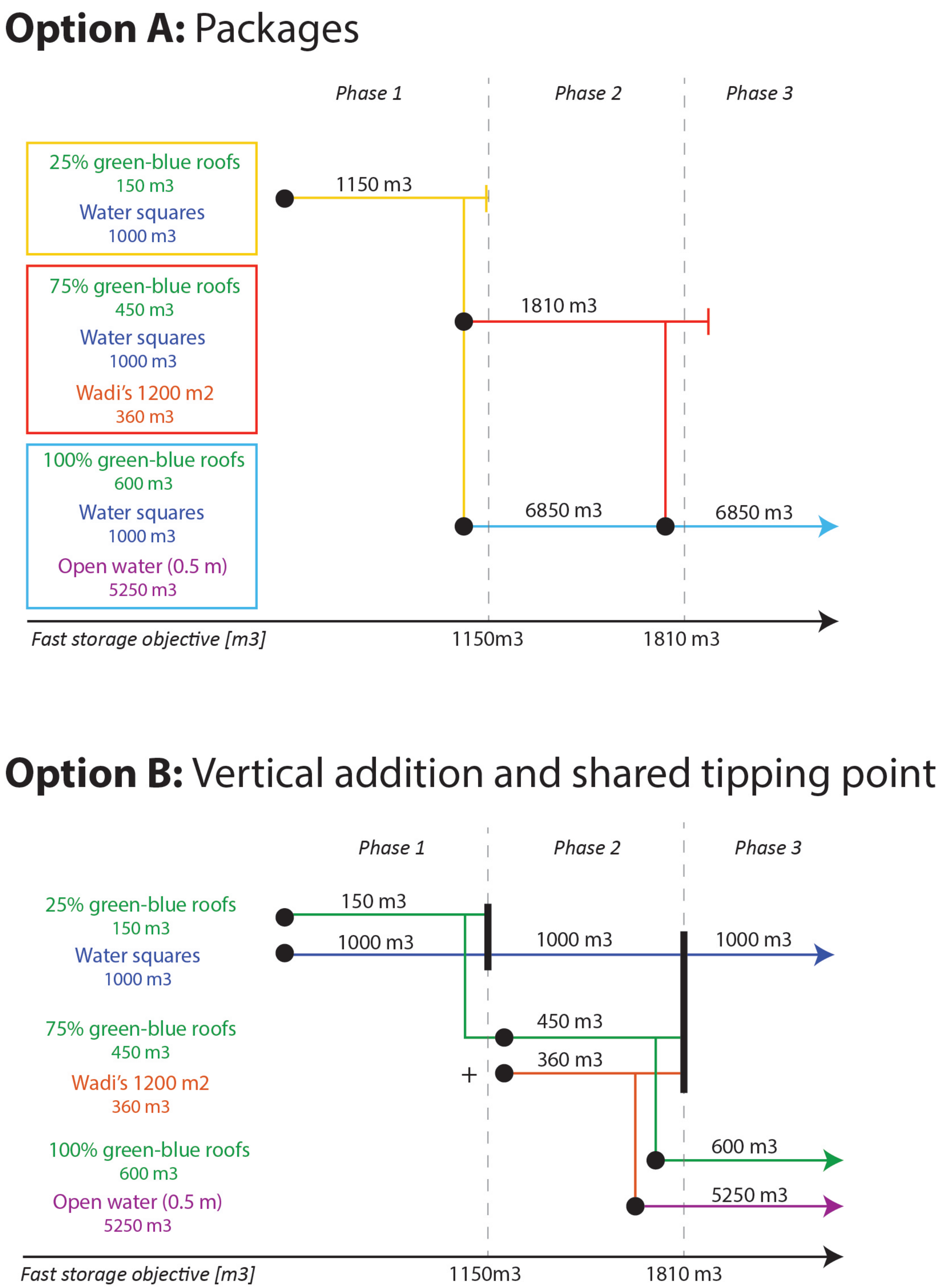



*Figure 9.17.* Different options to show both the individual measures and the combinations of measures on the y-axis. Note: The storage values and tipping points/phase shifts are indicative.

## Step 6: Analyse the implications for design

By making the SAPP map spatial, the implications for the design become more clear, and the pathways are easier to communicate.

*Questions in this step:*

**How can the initial design be prepared for possible future adjustments?**
The start (initial) design should contain the answer to this question. The SAPP map shows which components of the initial design can be adjusted over time to adapt to climate change. For Sloterdijk I South it is (probably) mainly about creating the possibilities to add extra storage in the future. In addition, it could be possible that the SAPP map shows a tipping point at which it is not possible anymore to store all water on the lot itself. If this is the case, a strategy on a larger scale is needed, for example by linking all lots with each other, with the waterway at the Transformatorweg, and/or with the surrounding parks (which can possibly be set up as storage facilities).

**What should be taken into account in the design of the focus area?**
As with the Coenhaven, certain space reservations and, for example, underground infrastructure must be taken into account. For example, for flexibility it is best if as little infrastructure as possible is constructed underneath the intermediate streets. As much as possible the underground infrastructure can be implemented in the main and cross streets. It may also be important to think about the public-private ownership ratio and its consequences for the flexibility of the focus area.

**Which trajectories are a good example or need to be emphasized?**
This is dependent on the SAPP map and the goal. For example, it is possible to put forward the range in possible futures, by working out the two most different trajectories. Of course, it is also possible to visualize all possible trajectories.

**What is the goal of the drawings/visualizations?**
The main goal of the drawings is to make the SAPP map easier to communicate and to bring forward the spatial implications of the pathways. The drawings can also be used to show arguments for the initial design (show the flexibility).

**What kind of drawings are needed to explain the trajectories?**
Again, this is dependent on the SAPP map and the goal. However, at least a map and section are recommended. The map can be used to show the context and to show where the adaptation measures are located. The section is relevant to show the vertical connections and can contain different information, such as the soil profile, height differences, and the groundwater level (all important in the case of pluvial flooding).

**Which information can integrated in the drawings?**
A drawing can display a lot of information. For the visualizations of the SAPP map, the context and adaptation measures are the most important components. In addition, the climate trend can be visualized throughout the transition phases (for instance a 'growing' cloud above the area, more full storage facilities, or a higher groundwater level). Also space reservations can be highlighted, and functions can be visualized.

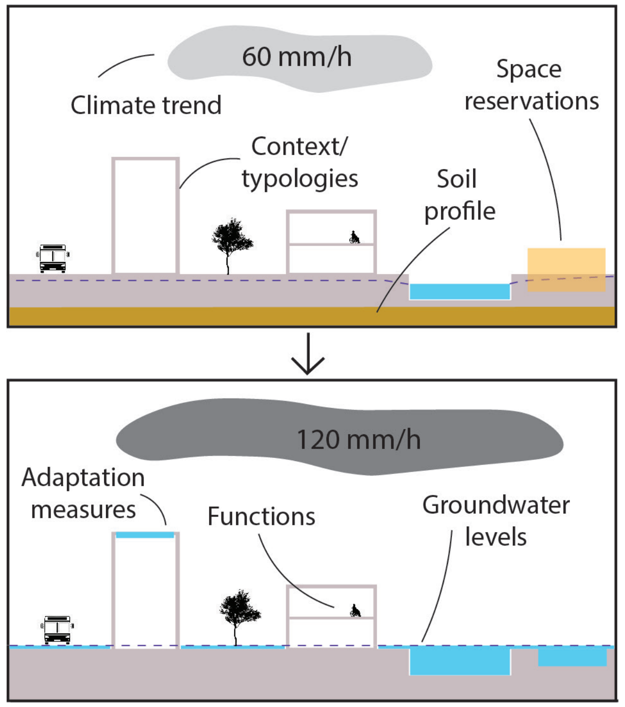



*Figure 9.18.* Possible components for the visualizations of the pathways.



## Step 7: Analyse the implications for governance

By analysing the SAPP map on the implications for governance, possible issues or needs can come forward.

*Questions in this step:*

**How is the current governance for adaptation to more intense rainfall? Which actors are responsible for which part of the focus area?**
The municipality has the legal responsibility to take care of the rainwater in the public areas. In Amsterdam, Waternet carries out the tasks of the municipality. Private owners are responsible for the rainwater on their lots. In Sloterdijk I South, the developers are also responsible for the development of the public accessible intermediate streets and courtyards, and the municipality requires 60 mm/h storage on the lots. However, it is not clear (for me), who is responsible for adjustments of this area in the future, if 60 mm/h is not enough anymore (this could be a question to the municipality) [note: use information from step 1 and add when necessary].

**Which actors need to be involved to implement the measures of the pathways? Which investments are needed to implement the adapation measures?**
This depends on the selected adaptation measures [note: use the information about the organization on the adaptation tiles]. Most likely the following actors should be involved: the municipality of Amsterdam, the regional water authority AGV, the developers and building/lot owners, residents (after the development).

**What implications do the pathways have for the current governance? What should be changed to bring the pathways to practice?**
This depends on the selected adaptation measures. The implications come forward by comparing the needed governance for the pathways with the existing governance.

Possible outcomes/themes **could** be:

*- Public-private responsibility for the public area*
The intermediate streets and squares will be developed by private actors, but need to be publicly accessible. The municipality plans to set requirements for the storage on the lots for the initial design. The question is: who has the responsibility when adjustments are needed (for instance: more storage)? Who needs to invest in these adjustments? This could be the municipality, because the areas are publicly accessible. But the responsibility can also be shifted to the private actors (the owners of the lots) by making long term agreements (for instance about adding storage to the lot if precipitation intensities increase). The advantage of the private responsibility is that the buildings and public space can be designed and adjusted more integrally. In this case, strong cooperation between Waternet and the private actors is of great importance. The disadvantage is that the municipality has less say and this could possibly lead to problems if the private actors do not comply with the agreements.

*- Fixed to flexible agreements and processes*
In such a case as described above, flexible agreements are also possible (whereby the municipality can take over again, for example). It can be expected that the SAPP map (as in the Coenhaven case) will address the need for flexible agreements and processes if the urban area has to be adapted in the long term.

*- Lot scale to district/regional scale*
In the initial design it is probably possible to create 60 mm/h storage within the lot itself. However, there may come a point where it is no longer possible to create all the necessary storage on the lot itself. Then a strategy on a larger scale is needed. Decisions about the water level of the North Sea Canal can also influence the groundwater levels at Sloterdijk I South. So collaboration and communication on the regional scale is also important.

*- Best-case and worst-case scenario*
For pluvial flooding, the differences between the best-case and worst-case scenario can potentially cause discussions. In the best-case scenario, the precipitation intensity (1/100 years, 1 hour) does hardly increase towards 2050 and 2085. This would mean that an initial design based on storage of 60 mm/h is enough. In the worst-case scenario, the intensity increases with 10 mm/h towards 2050 and again with 10 mm/h towards 2085. In this case, extra storage needs to be added, and the initial design of 60 mm/h is not enough. This uncertainty makes it extra important to make a flexible initial design and to combine functions. If a certain (reserved) area turns out to be not necessary for water storage, it still needs to fullfill other functions (such as recreation or the creation of habitats).

*- Long-term coordination*
Because pluvial flooding is quite local, the municipality of Amsterdam and Waternet are the logical actors to take care of the long-term coordination. If solutions need to be found on the district or regional scale, Waternet can take the lead, as it has expertise about the regional water systems.

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